Current situation of traffic congestion in Kabul city: case study and proposed solutions

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Abstract

This paper will study one of the seven congested places in Kabul city, is called Makroryan road. It connects Abdul Haq and Masood intersections and is considered a vital area. Therefore, Makroryan road had been well investigated in aspect of all congestion parameters, analyzed carefully to find the adequate solutions. The traffic volume and average speed had been observed digitally using three video camera stations from 6:00 am up to 10:00 pm, we observed two peak hours' form (08:00-09:00 am) and from (17:00-18:00 pm). The results reported that the average speed was estimated to be (10 km/h), free flow speed was 55 km and the density was calculated to be 109 (pc/km/ln) which is very high. The level of service was found to be F (worst) according to the highway capacity standard manual. Thus, it is necessary to point out the real causes of congestion in the Makroryan road and propose solutions for short term and long term. Accordingly, the same traffic data of Makroryan road was analyzed in AIMSUN software, was simulated and traffic management plan was applied based on the simulation results. The average speed and density were found to be (48 km/h), (26 pc/km/ln) and (53 km/h), (23 pc/km/ln) in A-B and B-A directions, respectively, after applying road widening, road surface marking and traffic lights on the road in AIMSUN software. Interestingly, the level of service was enhanced from F to B. This is promising to solve the congestion problems for the short term; however, a sophisticated strategy is needed for the long term including extra land use readjustment and providing public transportation for example, BRT system is a proposed from city center to the Airport which will pass through Makroryan road, will effectively reduce congestion for long term.

Key Words: *Kabul city, Makroryan road congestion, traffic volume, level of service, proposed solutions*

1. Introduction

Kabul city; capital and the largest city in Afghanistan with 6 million populations, is fifth world fastest growing city in the world[1)]. Kabul city is suffering from highly traffic congestion problems that exacerbates overtime till reaching to the worst conditions. According to the JICA report, there are seven most congested and dense places in Kabul city[2)], which make Kabul city uncomfortable for living. The main causes of congestion are the dramatic increase in population, absence of public transportation, deficiency in traffic operational system, the inadequate structure of urban road system, using side walk and road shoulder as shops and parking zones, lack of road networking, ignoring traffic role by drivers, high demand of private vehicles, and closing the road networking by concrete wall for security reasons, which paralyze the whole transportation motion. This study will focus on the causes of the traffic congestion in a specific road in Kabul city named Makroryan road as well as introducing solutions to reduce the traffic congestion. Makroryan road is the main interlinked road between two important squares, Abdul Haq and Masood squares with high strategic location. Moreover, the Masood square is linking the airport with the central zone of Kabul city such as president palace, embassies, central high court and central hospitals which are the most congested places in Kabul city. Abdul Haq square is also linking the central zone of Kabul city with Kabul Torkham highway which is the highest rank of densest road around 100,000 trip/day daily[3)].

This paper manipulates the current situation of congestion in Makroryan road and puts the light over some short term solutions to achieve shorter trip time which will shorten peak period driving. The main

problems were examined with the expected solutions.

2. Area under consideration

The study area is the Makroryan road, connects two major squares in Kabul city which is Abdul Haq and Masood square. The distance between the two intersections is 800 m, with 21 m width and 1.5m shoulders in both right sides of road. The road is bidirectional with two lanes in each direction and both squares are rotary with 30m diameter with no traffic light or road marking in any routs or intersections. In the middle the right side of B-A direction, shash Darak road (road, D) is interlinked to president palace which is the host of vehicles to the city center. There is 2m green area along the road to separate A-B and B-A direction, but this green area is also used for passing as well as, the shoulder is used for parking. Therefore, the side parking is also a reason for congestion. Road (G) is connecting the city center to the airport in Massod intersection while, road (A) is called Kabul jalal abad highway which is connecting with Abdul Haq square, as shown in Fig 1.

3. Methodology

To understand the exact congestion problems and traffic level of service situation, we put video cameras on three stations to determine the traffic volume by counting the vehicles which are passing through these stations in 15 minutes, one - hour and one - day traffic in the road. The first Station (point A) was located 100 m away from Masood intersection, the second station (point B) was positioned 30 m far from Abdul haq square and the third station (point C) was located 20m from the interlink (road D) to shash Darak road. The traffic flow rate in the A-B station was less than that in B-A station. This difference is caused by the Shash darak sub road (point C) which is commuting to the city center through the presidential palace road, As shown in Fig 1. From this counting, we found out the Traffic volume, average speed and LOS, Moreover, we figured out the capacity of the road using highway capacity manual[4)] and two solutions were proposed as short term and long term actions. Finally, the whole results and short term plan have been implemented in AIMSUN software to analyze and simulate the effectiveness of the proposed solution through putting two detectors in the same last positions of video cameras. In AIMSUN, we apply some enhancements to the road such as widening, traffic light and road surface marking for both intersections and all connected routes, then LOS was recalculated after modification and compared with the original LOS on the mentioned routes.

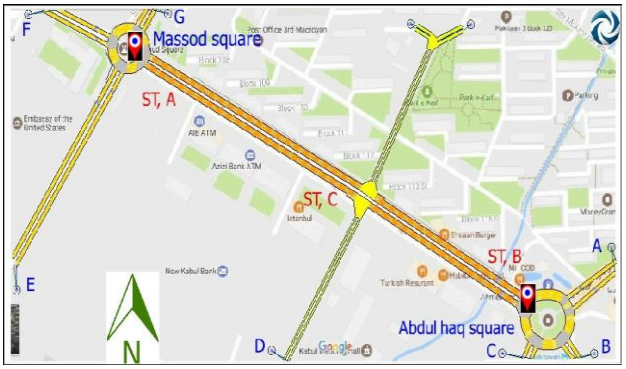

Fig.1 shows the vedio camera station placed in point A, B and C.

4. Results and discussion

Video recording, numerical calculation and observation were used to determine the traffic volume, average speed, density (passenger car per mile per lane) and volume-to-capacity v/c ratio of the targeted road which are high at peak hour. In addition, the calculation shows that the road is class III according to the FFS of the road which is 55 kph and the average vehicle speed in peak hour is 10 kph, therefore the LOS of the road is F, as shown in Table 3. The level of service F is the worst level and needs further enhancement. To enhance the service of the road, we used traffic management process by applying traffic lights on both roundabout and connected routs. The road data had been applied on AIMSUN software to design the traffic lights and traffic management plan. Many changes had been made to reach the adequate solution and better LOS of the targeted road.

4.1 Travel speed

Travel speed is an effective parameter of LOS measurement. License plate method was used to observe and note the four digits license plate and time of passing vehicles from one station A until station B on recorded video to find out the (mean passenger–car speed) or average speed for the makroryan road. The different between two recorded time (station A until station B) is the travel time. We repeated this process for many cars to find out the mean speed. It is not possible to do this process for all vehicles, only some vehicles travel time are recorded in both stations. Then, we calculate the mean travel time for different vehicles, and Eqn (1) was used to determine the average travel speed to be 10 kph.

$$V_s = \frac{n * L * 3.6}{\sum_1^n t_i} \qquad (1)$$

Where: S is the average travel speed in (kph), n is number of matched plates, L is the length of the test section (m), in this case L= 670 m, t is the recorded time in (sec.).

Note: in the peak hour the speed was very low around 5 kph from (07:30 am-10:30am and 15:30 – 19:00).

4.2 Traffic volume

The traffic volume was measured using the video recorded data of vehicles counting for 15 minutes interval, one hour and one day. In this case study, the traffic volume was calculated from 6:00 am – until 10:00 pm, we can see clearly that there is two peak hours during the day, one from (8:00-9:00 am) and the second one from (17:00-18:00 pm. Late night was not counted because of the small amount of traffic. Table 1. shows the sample sheet used for counting the traffic volume.

Table 1: shows the sheet sample for counting traffic volume.

Time	A-B v/15 min	B-A v/15 min
6:00-6:15		
6:15-6:30		
6:30-6:45		
6:45-7:00		
7:00- 7:15		
7:15-7:30		
7:30- 7:45		
7:45- 8:00		

To find out the daily traffic volume, the type of vehicle is multiplied with the passenger car equivalent factor to have one kind of vehicles volume. Table 2. shows the passenger car equivalent factor for every type of vehicles.

Table 2. shows passenger car equivalent.

Passenger cars (private cars, taxi)	1
Bus, tractor, truck	3.5
motorcycle	0.5
bicycle	0.2
Horse – drown vehicles	4

Moreover, the observed flow rate in A-B direction is more than B-A direction because of shash Darak road (road E) as shown in Fig 2.

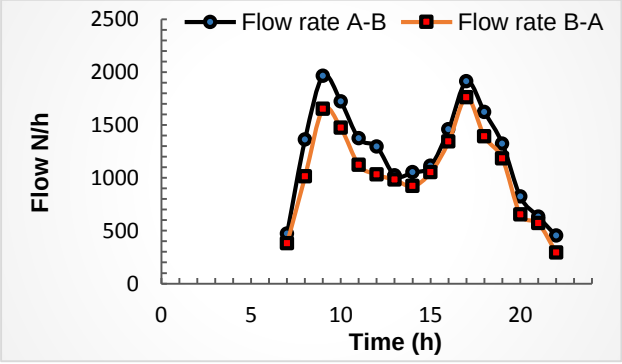

Fig 2. Shows the traffic Flow rate A-B and B-A directions

4.3 Level of service:

The LOS is qualitative measure describing operational conditions within a traffic stream. This parameter describes the quality of operation on facility such as, density (veh/mile/lane) and speed (average speed). Each facility can be measured on the six levels of services, from A to F. A represents the best level of services and the LOS F is the worst (Khisty, Lall)[5]. The calculation shows that the road is class III according to the FFS of the road which is 55 kph and the average vehicle speed in peak hour is 10 kph, therefore the LOS of the road is F, as shown in Table 3.

4.3.1 Flow rate:

The equivalent flow rate in peak hour was applied in (Eqn. 2) to estimate the flow rate in the peak 15 minute period within the high peak hour due to that the traffic flow are not sustained over the entire hour.

$$v_p = \frac{V}{PHF * N * f_{HV} * f_p} \qquad (2)$$

where, v_p = (1093 pc/h/ln) passenger car flow rate, v = (1951 veh/h) hourly volume, PHF = peak hour factor PHF= (urban, 0.92),N=number of lanes (N=2), f_{HV} = heavey-vehicle adjustment factor (f_{HV}=0.97) and f_p = driver population factor (urban, f_p = 1.0).

Table 3: level of service according to free flow speed .

Street class	I	II	III	IV
FFS	89 to 72 kph	72 to 56 kph	56 to 48 kph	56 to 45 kph
Typical FFS	80 kph	64 kph	56 kph	48 kph
LOS	Average travel speed (kph)			
A	>68	>56	>48	>40
B	>55-68	>45-56	>39-48	>31-40
C	>43-55	>34-45	>29-39	>21-31
D	>34-43	>27-35	>23-29	>14-21
E	>26-34	>21-27	>16-23	>11-14
F	>26	>21	>16	>11

4.3.2 Density:

The level of service was determined from density of road in one lane using (Eqn 3). From the value of (Density), we can find out the exact LOS as shown in Table 4. (A) represents the best level of service and (F) is the worst. In Makroryan road case, the level of service was (F) in the peak hour.

$$D = \frac{v_p}{s_{pc}} \qquad (\text{Eqn. 3})$$

D = density (pc/km/ln) D = 109.3
V_p = flow rate (pc/h/ln) V_p = 1093
S_{pc} = average speed (km/h) S_{pc} = 10 kph

Table 4 : shows the level of service from density range

Level of service	Density range (pc/mi/ln
A	0 – 11
B	12 – 18
C	19 – 26
D	27 – 35
E	30 – 45
F	> 45

5. Main reasons for excessive congestion

The main reasons for the excessive congestion could be summarized as:

1. lack of public transportation in kabul city which directly affect the studied area.
2. No parking places in the studied area and extra parallel parking in the Makroryan road.
3. Absence of traffic signals in both intersections and all linked routes.
4. Increasing in numbers of private cars.
5. the accumulation of many essential organizations and essential places such as president palace, schools, hospitals, ministries around the targeted area.
6. lack of infrastructure enforcement as well as maintenance.

6. Proposed solutions:

6.1 Road widening

When demand (traffic) is in excess on supply, by adding one lane or expand the road carriage way in existing road, we can balance the demand and supply. In Makroryan road case, the road has space to expand the road until 3 meter in both sides. In Makroryan road, the traffic volume is increasing rapidly, only road widening will be not the appropriate solution but just will solve the traffic congestion for the short term. Therefore, in the future the capacity of road will be constant but the traffic volume will increase. We should find an alternative solutions. In case of applying BRT or LRT system from Kabul city center to the airport through Makroryan road. The route has capability to apply BRT system, because the road (I, II, III,V) have place to be expanded until 3m both side and road, while (IV) is 10 lane road which has much more capacity to expand the road pavement or carriage way width, to accommodate the increase in traffic vehicles or BRT system as shown in Fig 11.

6.2 Operational improvement

Operational Improvements or changing in operational plan to the existing infrastructure also can increase the capacity[6]. It is one of the short term plan for solving the congestion problem. Road marking, or intelligent transport system are used to enhance the capacity. Road marking is used on surface of road to convey official information, and to minimize confusion and uncertainty. Road marking provides guidance and range of information for drivers, which is used for giving direction, safety and saving time as shows in Fig 3. In this case study, it is very important to use road marking for splitting the vehicles to the right, left and straight in the intersection or applying intelligent transport system to increase the road capacity and enhance the traffic volume that passing through the intersection.

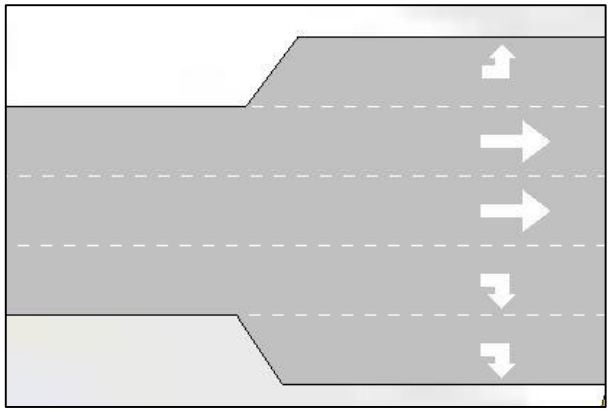

Fig 3. Shows the road surface marking.

6.3 Traffic light

Adding traffic lights will effectively control movement of vehicles and save time, which is lost in starting and stopping the vehicles in the intersection. Moreover, we can manage the movement and flow of the vehicles. In addition, we will apply road data in AIMSUN software and design the traffic lights and traffic management plan to analyze and compare the traffic volume and capacity of the road in A-B and B-A directions. The traffic light timing was adjusted in the AIMSUN software as shown in the Fig 4.

Fig 4. shows the signal timing in AIMSUN

6.4 Connectivity

Reducing the circuity (indirectness) of the network can take traffic-off from longer routes and reduce bottleneck. In this case, by adding new road network (road N) as shown in Fig 5, which can link the south of Kabul city (karti new) with the north of Kabul city (Kabul international Airport), it will reduce the traffic load from Makroyan road (road M). According to JICA report for Kabul city master plan, north-south axis will be constructed in future [7]. This arterial road will reduce the traffic volume in Makroryan road. Furthermore, the road (E) as shown in Fig 6, which is connecting the city center with airport through Masood square is currently closed for security reason. If this road network opens for traffic, the traffic volume will decrease and will help to reduce the congestion on Makroryan road.

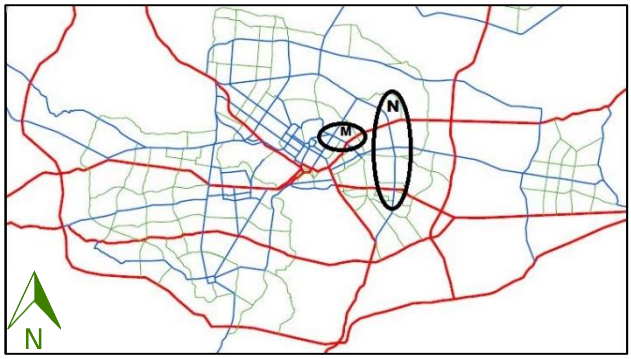

Fig 5. shows the new link road from south to North of kabul city connecting to Airport JICA[7].

6.5 Short terms solution:

For short term solution of this case study, the combination of the short term solutions such as, traffic lights for intersections, road widening and operational improvements (road surface marking and intelligent transport system) is applied in AIMSUN software to simulate the same traffic data which was collected from Makroryan road to design transportation management plan. In AIMSUN software, we put two detectors, one in the (A-B) direction and detector two in the B-A direction in the same places of video camera stations as shown in Fig 6.

Fig 6. The place of detectors for vehicle simulation in AIMSUN.

6.5.1 A-B direction:

After applying traffic light to the Makroryan road in AIMSUN software in the A-B direction, the density reduces to 26 (veh/km/ln) and at the mean while the average speed increases to 48 (km/h). Fig 7 shows the comparison between density and speed at A-B direction and Fig 8. Shows the traffic volume and speed in the period of peak hour time.

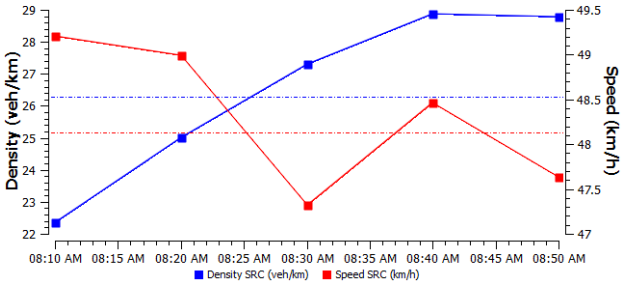

Fig. 7. Shows density and speed at A-B direction from AIMSUN.

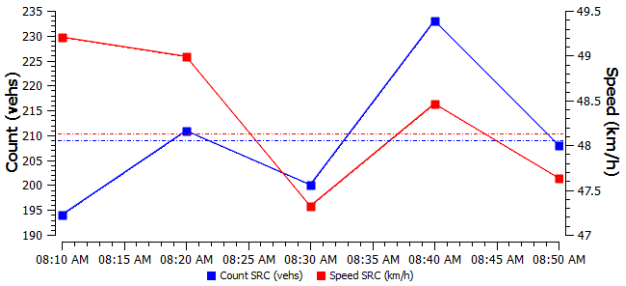

Fig 8. Shows the count and speed in A-B direction in AIMSUN

6.5.2 B-A Direction:

Moreover, the average density in the B-A direction becomes 23 (veh/km/ln) and the average speed increases to 53 (km/ln). Fig 9 shows the density and speed in the B-A direction and Fig 10. shows the traffic volume and speed in the B-A direction in the peak hour.

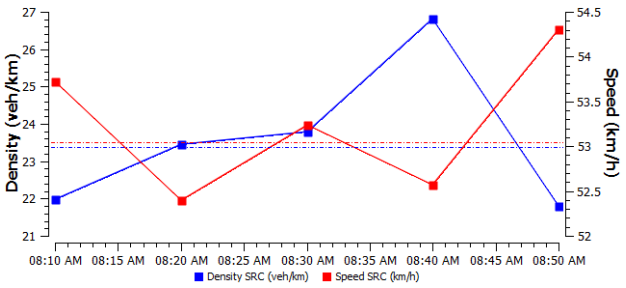

Fig 9. Shows density and speed in the B-A direction, AIMSUN.

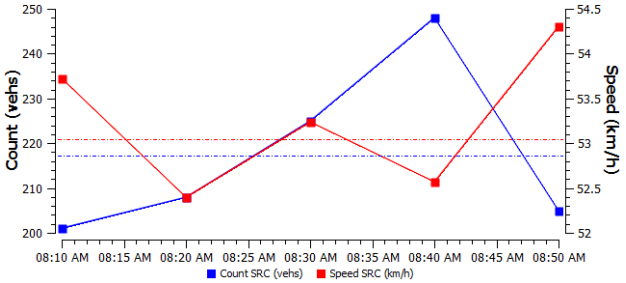

Fig 10. shows the count and speed in B-A direction, AIMSUN.

6.6 Long terms solution:

To solve the traffic congestion problems for the long term, wider strategy is required including , land use strategy that is compatible with the transport capacity or a strategy for public transportation, compatible with population density[8]. In Makroryan road case, we can apply computing mode or constructing highway or tunnel. Computing mode such as rapid transit (BRT, LRT) line from Kabul city center to the Airport which will pass through Makroryan road, will manage and reduce traffic volume in Makroryan road and accordingly will solve the congestion problem for the long term.

6.6.1 Computing mode

By constructing a rapid transit line (subway) or running an express bus (BRT) from Kabul city center to the airport, will deduct the traffic volume from makroryan road. Now the passengers are using private cars and minibuses from Kabul city center to the airport and residential area around the Airport, which increase the traffic volume and make Makroryan road more dense. Also, passengers accommodate from kabul city center to pol-e-yak paisagi bus stop by walking then taking cars or minibuses to the Airport. (BRT) system will reduce the traffic volume and travel time for long term as shown in Fig 11.

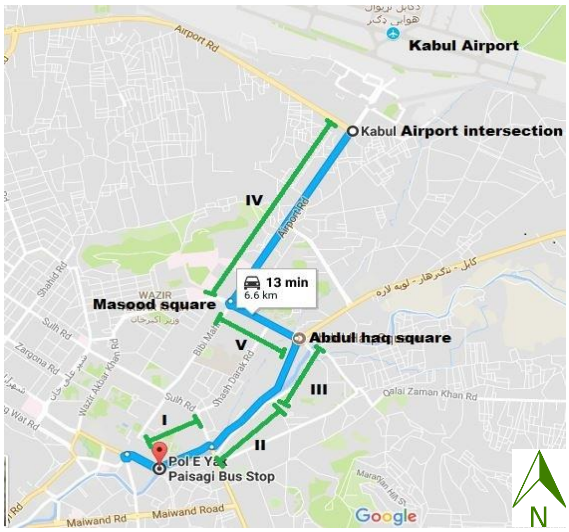

Fig. 11. shows BRT route from city center to Airport through Makroryan road.

6.6.2 Constructing highway or tunnel

For long term solution in this case study, constructing a highway or tunnel outside from city center to the airport will effectively reduce the traffic load on the study area for the long term.

7. Conclusion

This paper studied the congestion problems in Makroryan road linking Abdul Haq and Masood intersection and proposed solutions to decrease congestion problems. The level of services in the existing road is F at the peak hour. Traffic light, road Marking and road widening are good solutions for decreasing and managing the traffic volume, because it will rise the LOS from level from (F) to level (B) with a low cost. Second option is BRT system from city center of Kabul city to the airport which is a long term solution for Makroryan road with reasonable cost. Finally, constructing highway or tunnel may give the city a kind of urbanized look and also a long term solution but with higher costs.

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