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Evaluation of Traffic Performance of Ahmed Urabi Square in Baghdad City

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ABSTRACT

At present, smooth movement on the roads is a matter which is needed for each user. Many roads, especially in urban areas geometrically improved because of the number of vehicles increase from time to time.

In this research, Highway capacity software, **HCS, 2000,** will be adopted to determine the effectiveness of roundabout in terms of capacity of roundabout, delay and level of service of roundabout.

The results of the analysis indicated that the Ahmed Urabi roundabout operates under level of service F with an average control delay of 300 seconds per vehicle during the peak hours.

The through movements of Alkarrada- Aljadiriya direction (Major Direction) represent the heaviest traffic volumes in Ahmed Urabi intersection. The use of underpass to serve the through movements in Alkarrada-Aljadiriya direction will lead to release the traffic volume in the Ahmed Urabi intersection with a rate 51 % .After the adoption of the proposed geometric design, it will operate at LOS B in the design year (2037). The proposed circulatory roadway width for the roundabout is 16m and the required number of lanes equal to three lanes for each side of the underpass and four lanes for all the approaches of the roundabout.

Keywords: roundabout, delay, HCS, peak hour, level of service.

تقييم الأداء المروري لساحة احمد عرابي في مدينة بغداد

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الخلاصة

في الوقت الحاضر، الحركة الانسيابية للطرق هو شئ مهم لكل مستخدمي الطريق. العديد من الطرق سوف يتم تطويرها نظرا لأزدياد عدد المركبات من وقت الى اخر في الطرق الحضرية.في هذا البحث، سيتم استخدام برنامج Highway Capacity Software، **HCS, 2000** لتحديد فعالية الساحة من حيث سعة الساحة والتأخير ومستوى الخدمة للساحة.وأظهرت نتائج التحليل أن ساحة أحمد عرابي تعمل بمستوى خدمة F وبمتوسط تأخيرمقداره 300 ثانية لكل مركبة خلال ساعات الذروة.

ويمثل اتجاه الكرادة - الجادرية (الاتجاه الرئيسي) أعلى حجم مروري في تقاطع أحمد عرابي. سوف يؤدي استخدام النفق لخدمة الحجم المركبات باتجاه الكرادة والجادرية إلى تقليص الزخم المروري في تقاطع أحمد عرابي بنسبة 51٪ بعد اعتماد التصميم الهندسي المقترح، سوف يعمل التقاطع بمستوى خدمة LOS B للسنة الهدف (2037).عرض الطريق الدائري المقترح للساحة هو 16 متر وعدد الممرات المطلوبة ثلاثة ممرات لكل جانب من النفق وأربعة ممرات لجميع طرق الساحة.

الكلمات الرئيسية: الساحة،التأخير،HCS،ساعة الذروة،مستوى الخدمة.

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1-INTRODUCTION

1.1 General

Ahmed Urabi intersection (roundabout) is located in Alkarrada district in the southern east of Baghdad. It lays on the road that connect the Ring Road No.1 (Mohammed Al-kasim expressway) near the Camp-sara district on Alrisafa side with the Ring Road No. 3 (Salah Aldein expressway) in Albaya district at Alshibab interchange in Alkarkh side of Baghdad. This road is classified as principal distributor and pass through the following districts: Alwihda, Alkarrada, Aljadiriya and Albaya. It represents the east-west direction in the Ahmed Urabi intersection. Whereas the south-north direction is represented by the road which currently operates as minor arterial (classified as Ring Road No.1 according to Baghdad comprehensive transportation study) and it connect the suspension bridge with the two level bridge.

The Ahmed Urabi intersection is considered as one of the major intersection in Alrisafa side of Baghdad city, it serves more than 12 million vehicles per year. Ahmed Urabi intersection is unsignlized intersection with roundabout form to control the conflicting volumes through the entry approaches as shown in **Fig.1** and **Fig.2** is abstracted from the comprehensive transportation study of Baghdad.

The excessive traffic volume during the peaks hour leads to disorderly turning maneuvers that can contribute to the vehicle crash experience through the roundabout. Further, as through volumes are required to reduce speeds due to the entering and circulating traffic, increased travel times and congestion often result.

Beside the psychological effects for the road users and the adverse environmental effects, the long delay values resulting from the oversaturation of the Ahmed Urabi roundabout have great economical damage associated with the increased user cost and the vehicle operating cost (fuel consumption and depreciation). Simply, for the time value of travelers of (30 ID/ vehicle.minutes) one can conclude that the existing condition in Ahmed Urabi roundabout results in extra expenditure nearly of 150,000,000 ID per month.

Also the location of the Ahmed Urabi roundabout is shown in **Fig.3**.It is obvious from the figure that the Ahmed Urabi intersection is four legs roundabout. The traffic controlled by converting all movements to right turns to eliminates vehicle-vehicle crossing conflicts. Also, it's evident from the figure that the entries for the roundabout are flared in all the approaches to three lanes to increase the traffic capacity which can be accommodated by the intersection, also it can be shown that the roundabout has two lanes circulatory roadway to accommodate more than one vehicle traveling side by side.

1.2 Research Objective

The main objectives of this research work are:

1. Evaluate the traffic performance at Ahmed Urabi square by the estimation the existing level of service at the study area.
2. Preparation the best-proposed geometric design at study area to achieve a suitable level of service at the current time and during the design period.

2. REVIEW OF THE LITERATURE

A similar studies of previous researches are shown below that is related to roundabouts improvement and intersection in Iraq.

Al –Kubaisy, **2008** : Kahtan square in Baghdad city was the point of interest in this study where the researcher studied operation traffic of it, information were gathered manually for the traffic volumes of the mentioned square , which is essential for geometrical and traffic analysis, sidra software was implemented to process traffic analysis. The researcher gave two options to improve traffic volume for the square under study. Option 1 suggested exchanging the existing roundabout by 4 legs signalized intersection to increase the number of lanes possible in each direction and make use of the area. Option no. 2 suggested a fly over on the main course of traffic movement (from al yarmok hospital through kahtan square and finally al bayaa district) the researcher found out that option no. 2 was the best proposal.

Al-Ubaidy, 2010, the researcher studied Al-Thawra signalized intersection in Al -Hilla city, which is a four legs main street. It was required to evaluate the performance of the traffic operation in the mentioned intersection as the main purpose of this study, discovering present LOS, proposing the best suggested geometrical design at study area to acquire a proper LOS at present and future time. The **HCS, 2000** software was used in this study and the intersection was found to be working at LOS F with average delay of 263.7 sec/veh. The concluded result revealed that a construction of an overpass from north south direction (Baghdad – 60st), is the best resolution to improve the intersection capacity. It was found that with the suggested geometrical design, LOS will achieve level C with (22.8 sec/ veh.) and a cycle time of 58 seconds till.

Jasim , 2012, Examined the operational analysis of AL-Mustansireyah Intersection in Baghdad city by using the highway capacity software (HCS,2000) it was found that the current LOS at that time of AL-Mustansireyah intersection is LOS E with delay of 57.4 sec/veh. She found that the best solution is a flyover between AL-Mustansireyah University Street / Al-Talebia Street to enhance the traffic operational of AL-Mustansireyah roundabout intersection.

Abdulkareem, et al., 2016, Al -Furat intersection in Baghdad was studied by the researcher, the purpose of the study was to evaluate traffic performance operation in the mentioned square. Finding the current LOS , proposing the best suggested geometric design at study area to acquire an appropriate LOS at present time by using, **HSC2000** software , the intersection LOS was level F with an average delay of 190.7 sec/ veh. A fly over from the southbound to westbound was found to be the best proposal to enhance the capacity and traffic operation in the mentioned intersection. By applying this proposal, the intersection would function under LOS D level and a cycle time of 112 Sec.

3. TRAFFIC SURVEY

To achieve the objective of this study, the necessary traffic survey has been made for the collection of the following traffic data:

3.1 Traffic Volume Counts

In order to determine the traffic volumes for all the movement in Ahmed Urabi intersection, traffic counts had been carried out three times during the days of Sunday, Monday and Wednesday in order to take into consideration the variation in the traffic volume during the

weekdays. A period of the count extends from 7am to 5pm by video recording in order to determine the peak hour which represents the single hour of the day that has the highest hourly volume. In this study, the highest peak hour volume within the course of counting days is selected for each movement in the intersection to simulate the worst case in the capacity analysis of the existing intersection and to keep the geometric design of the proposed interchange in the safe side.

Table 1 shows the traffic volumes for all the movements in Ahmed Urabi intersection during the counting period. In order to specify the peak hour for the above movements, the hourly volumes during the course of day-hours are plotted in a histogram fashion as shown in **Figs. 4 to 7**. From these figures, it is obvious that traffic volume in the directions of Alkarrada, Aljadiriya and two level bridge are peaked in 8-9 am while the peak hour for the suspension bridge direction is 3-4 pm.

4. HIGHWAY CAPACITY SOFTWARE

The Highway Capacity Software, **HCS, 2000,** beside the Highway Capacity Manual are used for the purpose of this traffic study to perform all the operational analyses of the current (existing geometry) as well as the future condition (after geometry modification) of Ahmed Urabi intersection. The primary result of operational analysis is the assignment of levels of service to traffic facilities under various traffic flow conditions. The methodology which is followed by the HCS program to analyze the performance of the intersection can be summarized as follow:

4.1 Unsignalized Intersections (Roundabout)

The steps required to perform a roundabout operational analysis are identified below. In order to assist the analyst in completing the computations, a worksheet is provided as a supplement in the manual.

1. Enter the volume data (leg-to-leg flow rates) for each entry and compute the total entering flow rate for each lane.
2. For multilane entries, compute the flow for each entry lane.
3. Compute the conflicting flow for each entry.
4. Determine the capacity of each entry using the following equation for the critical lane multilane and single lane entries respectively. **NCHRP 3-65**

$$C_{cr} = 3200\, e^{-0.0009vc} \quad (1)$$

$$C_{cr} = 3200\, e^{-0.0007vc} \quad (2)$$

Where:
C_{cr} =Capacity of the critical lane
vc = Conflicting flow

5. Compute the volume-to-capacity ratio (V/C) for the critical lane on an entry.
6. Compute the delay for each entry lane based on the following equation (HCM,2000).

$$D = \frac{3600}{C_{cr}} + 900\left[\frac{v}{C_{cr}} - 1 + \sqrt{\left(\frac{v}{C_{cr}} - 1\right)^2 + \frac{\left(\frac{3600}{C_{cr}}\right)\frac{v}{C_{cr}}}{950}}\right] \quad (3)$$

Where

D = Control delay (sec/veh)
v = flow (veh/hr)

7. Determine the Level of Service for each entry lane using the criteria shown in **Table 2** below.
8. Compute the delay for each approach and for the roundabout as a whole.

4.2 Signalized Intersections

In the signalized intersection, the traffic signals are used to control the traffic movements and the right of way is assigned successively for the intersecting movements in order to eliminate the traffic conflicts. The methodology which is followed by the **HCS, 2000** for the operational analysis of the signalized intersection is illustrated through the scheme shown in **Fig.8**. traffic signal operation for signalized intersections. The level-of-service criteria for the signalized intersection are the same as for unsignlized intersections which is shown below in **Table 2.**

5. ANALYSIS RESULTS FOR THE EXISTING CONDITIONS

The following table and discussion illustrate the results of the analysis performed on existing 2017 volumes under the existing geometric configurations of Ahmed Urabi intersection. The roundabout was analyzed in accordance with the above methodology and the result is summarized in **Table 3.**

A Hand calculation was used in the worksheets due to the fact that the HCS program can only handle one lane entry roundabout although the multilane entry roundabout analysis approach was existed in the HCM 2000 draft.

The results shown in **Table 3** below indicate that the Ahmed Urabi roundabout operates under level of service (F) with an average control delay of 300 seconds per vehicle during the peak hours studied. Also the through movements from Jadiriya onto Karrada direction and the reverse movement (major direction in the intersection) operate with capacity constraints (LOS F) under current traffic-volume conditions during the peak hours. Therefore, Improvements are recommended at this direction to improve the overall intersection operation.

6. ANALYSIS FOR THE PROPOSED INTERCHANGE GEOMETRY

6.1 Future Traffic Volume

Geometric design of new highway facilities or improvements to existing highways should not usually be based on current traffic volumes alone, but should consider future traffic volumes expected to use the facility. Economically to justify any improvements to the existing condition, a highway should be designed to serve the traffic volume that is likely to occur within the design life of the facility. Many highway agencies believe the maximum design period is in the range of 15 to 24 years. Therefore, a period of 20 years is widely used as a basis for design. Traffic cannot usually be forecast accurately beyond this period on a specific facility because of probable changes in the general regional economy, population, and land development around the facility, which cannot be predicted with any degree of assurance.
With this preface, the selected design life for the Ahmed Urabi interchange is 20 years with an annual growth factor of 3 percent which reflects the socioeconomic nature of the Baghdad city.

The necessary calculation for the projection of the current traffic volumes to represent the traffic in the design year of 2037 is shown below.

$$TPF = (1 + r)^n \quad (4)$$

$$future\ traffic\ volume(2037) = Current\ volume(2017) \times Traffic\ projection\ factor$$

Where

TPF = Traffic Projection Factor

r = Annual Rate of Traffic Growth,%

n = Design Life, years

for Ahmed Urabi Interchange: $TPF = (1 + 0.03)^{20} = 1.8$

The future (2037) traffic volumes for all the movements in the Ahmed Urabi Intersection are shown in **Fig. 10**

6.2 The Proposed Geometric Design

After considering the future traffic volumes for the different movements in the Ahmed Urabi intersection and the availability of free land within the intersection area which can be utilized in the interchange construction beside the existence of future project to construct an overpass through the intersection to connect the two level bridge with the suspension bridge, the proposed geometric design for the Ahmed Urabi Interchange will be as shown in **Fig. 11**.The design represents the unique solution to improve the performance of the intersection after considering the restrictions mentioned above.

The proposed design is based on the concept of eliminating the heaviest traffic volumes from the intersection through the introduction of underpass for them and hence there will be enough space for the remaining traffic volume which can be served by the intersection. The heaviest traffic volumes in Ahmed Urabi intersection are represented by the through movements of Alkarrada-Aljadiriya direction (Major Direction). The proposed 6-lane underpass will accommodate the future traffic volume in this direction with an acceptable level of service (LOS/B). The use of traffic signals to control the traffic movements in the Ahmed Urabi intersection (roundabout) besides the improvements for turning radii and channelization will participate into large extent in intersection performance betterment and make the intersection operate under an acceptable level of service in the design year (2037). Level of service not less than D is required in the design year as stated by the **AASHTO, 2004**.

In the recommended geometric design shown in **Fig. 11**, the roundabout (with circulatory roadway width of 16m) will be remain in order to control the conflicting traffic movements since the ordinary 4- legs intersection type could not be used because there is no way to keep the through movements (from the two level bridge to suspension bridge and vice versa) in the same path, the distance between the entrance and exiting ramps of two level bridge is 48m while in the opposite direction (suspension bridge) there is only 4.0 m (median width) splitting between the arrival and departure directions.

The use of underpass to serve the through movements in Alkarrada-Aljadiriya direction will lead to release the traffic volume in the Ahmed Urabi intersection with a rate shown in the calculation below (based on the design year):

The future traffic volume in Aljadiriya Direction = 3069 veh/hr.
The future traffic volume in Alkarrada Direction = 2988 veh/hr.
Sum= 6057 veh/hr.

The total traffic volume in the intersection = 11725 veh/hr.
The release rate = (6057/11725) x 100
= 51 %

Though, the underpass will release the traffic volume from the intersection with a rate of 51% which consider approximately half the volume served by the intersection, this will provide both space and time (signal cycle) to be used for the remaining movements in the intersection and also by eliminating half of the traffic volume there will be a remarkable reduction in the conflicts points.

6.3 Interchange Performance Analysis in the Design Year (2037)

In order to evaluate the performance of the interchange after considering the proposed geometric design, signal phasing plan and the design year (2037) traffic volume, operational analysis is performed using the highway capacity software (HCS,2000) and the summary of results is shown in **Table 4** below . The results indicate that the interchange will operate under level of service B in the design year with an average delay value 20 times less than that exist now before intersection geometry modification. Also, it can be concluded that the three phase signal with total cycle time of 120 sec is efficient to handle the traffic volume within the design life in Ahmed Urabi interchange. The required signal-timing plan is shown in **Fig. 12** below.

For the case of different distribution factor (distribution factor is the ratio of through movement traffic volume which is anticipated to use the underpass to the through movement traffic volume that pass through the intersection) it can be seen from the operational analysis results exhibited in **Table .5** there is no case within which the interchange level of service deteriorate to less than D which represents the threshold of an acceptable level of service as stated by AASHTO. The detailed results for the HCS outputs for different distribution factors are presented in appendices enclosed with this study. The setting of the signal timing should be done on the basis of distribution factor of 80 percent, which is mean 20 percent of the through movement traffic volume in Alkarrada and Aljadiriya directions will pass through the intersection (roundabout). The signal timing for this case is the same as that shown in **Fig. 12** below. For the underpass design, the worst condition was considered; this condition is represented by distribution factor of 100 percent.

6.4 Interchange Performance Analyses in (2017) and (2019)

Operational analyses have been performed to depict the effect of adoption of the proposed geometric design under two traffic conditions, the first represents the traffic volume of 2017 in order to make a comparison with the current intersection performance (LOS/ F with an average delay of 300 sec/veh) and the second for the traffic volume in the year of 2019 (end of project construction). The results summary is shown in **Table 6** for the first case and **Table 7** for the second case.

The results indicate that the interchange will operate at level of service B after considering the proposed geometric design for the current traffic volume with an average delay time of 10.6 sec/veh, for the 2017 traffic volume it will continue to serve the traffic under level of service B with an average delay time of 10.8 sec/veh. Therefore, the adoption of the proposed geometric

design for the Ahmed Urabi interchange will participate into great extent in improving the performance since the delay will be reduced approximately 28 times as compared to the existing situation represented by LOS F and delay time of 300 sec/veh.

6.5 Analysis of the Underpass

For the design year traffic volume and predetermined level of service (B), the required number of lanes for each direction of Alkarrada-Aljadiriya underpass will be as shown in **Table 8** below. and the proposed geometric of underpass will be shown in **Fig.13**

7. CONCLUSIONS

Based on the conducted traffic survey, the available free land and the operational analysis results for the Ahmed Urabi Intersection (roundabout) in addition to the existence of future project plan to connect the two level bridge with the suspension bridge via an overpass through the minor direction in the intersection, the following are the main recommendations:

1. The adoption of the proposed geometric design in this research shown in **Fig. 11**. The design concept is the construction of 6-lane underpass for Alkarrada and Aljadiriya directions and the use of signalization in the roundabout. The operational analysis conducted for performance evaluation shows that the intersection currently (2017) operate at LOS F. After the adoption of the proposed geometric design, it will operate at LOS B in the design year (2037).
2. The circulatory roadway width for the roundabout is 16m and the required number of lanes according to the proposed geometric design is as follow:

- Three lanes for each side of the underpass
- Four lanes for all the approaches of the roundabout.

3. The use of signalization to control the traffic movements within the intersection (roundabout) with 3 phase signal timing and total cycle time of 110 sec. distributed among the phases as shown in **Fig. 12.**

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Figure1. Photograph of Ahmed Urabi Square.

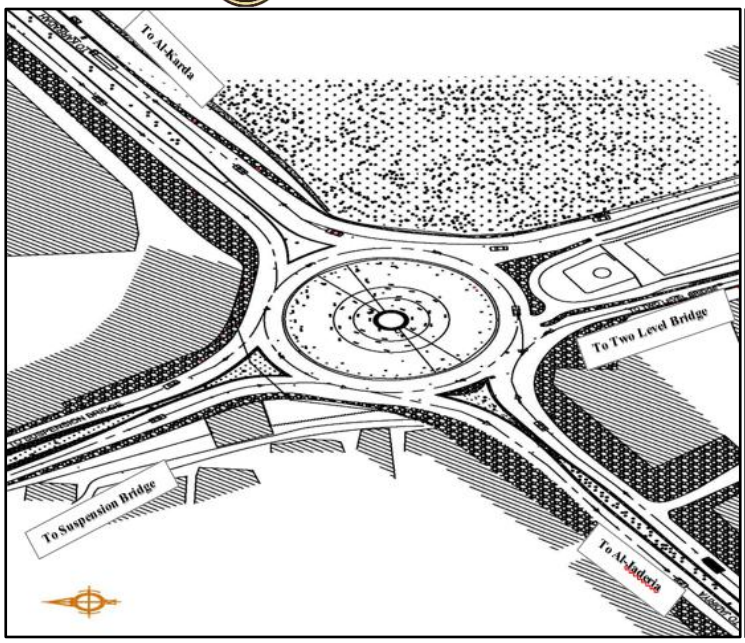


Figure 3. The existing geometry for Ahmed Urabi roundabout.

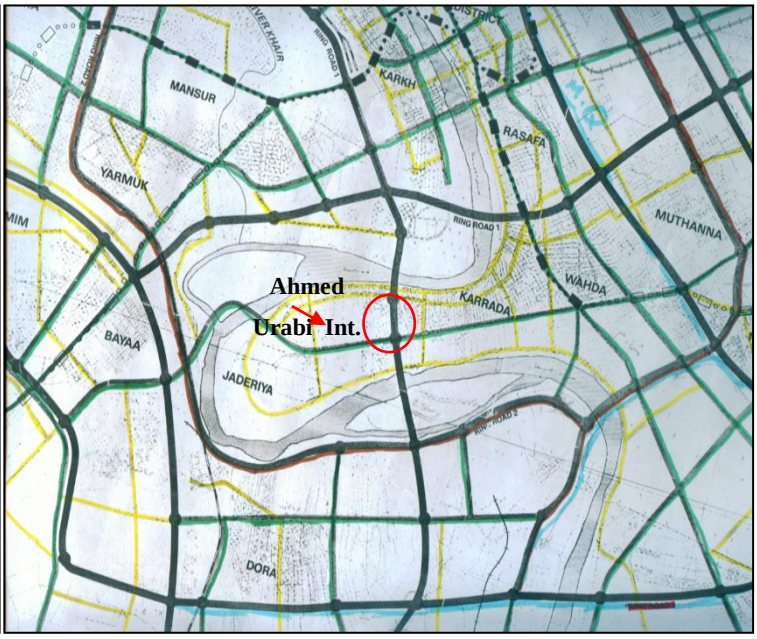


Figure 2. The location of Ahmed Urabi intersection related to transportation network.

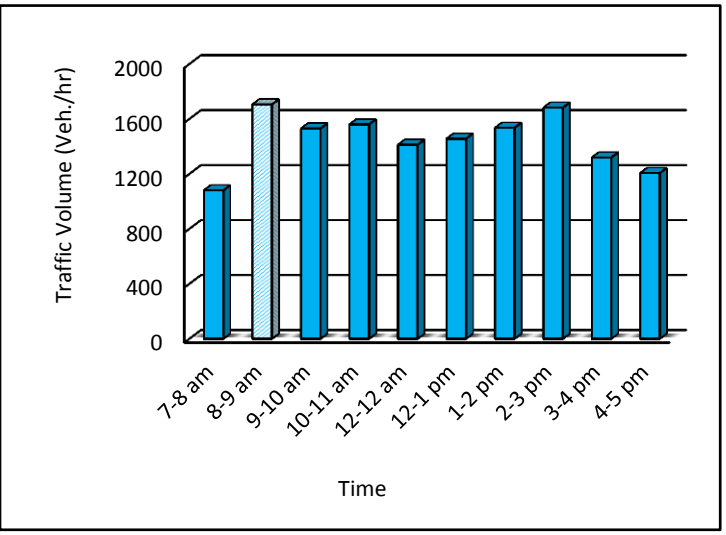


Figure 4. The Hourly traffic volume distribution for the through movement of Aljadiriya Direction

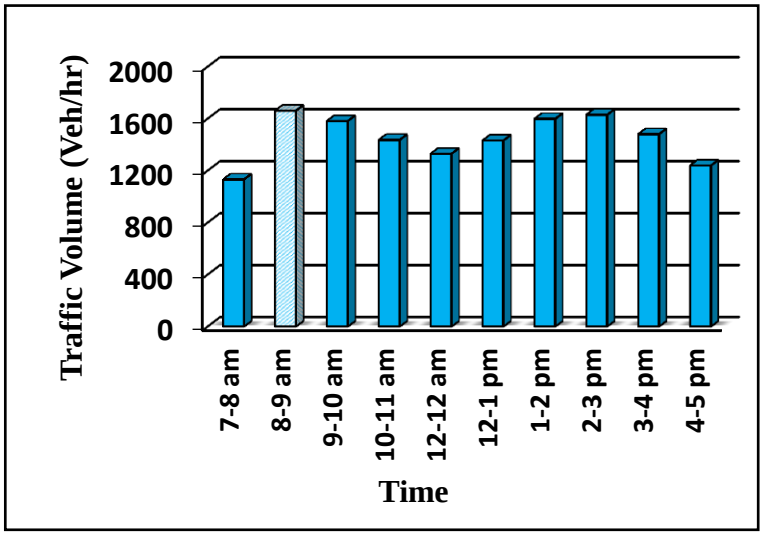


Figure 5. The hourly traffic volume distribution for the through movement of Alkarada Direction

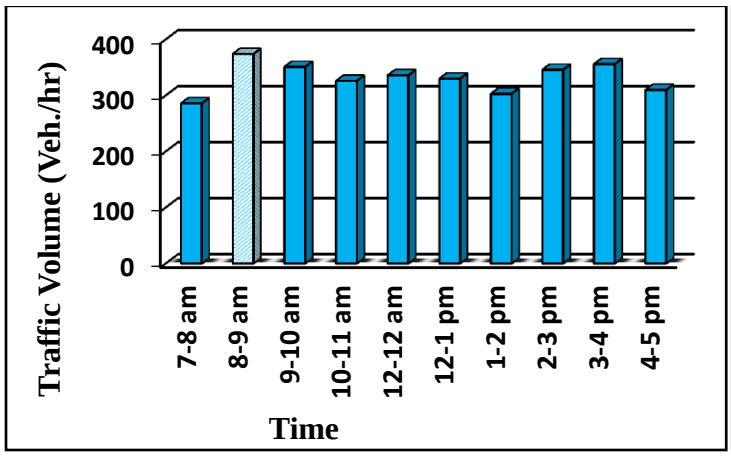


Figure 6. The Hourly traffic volume distribution for the through movement of the two level bridge Direction

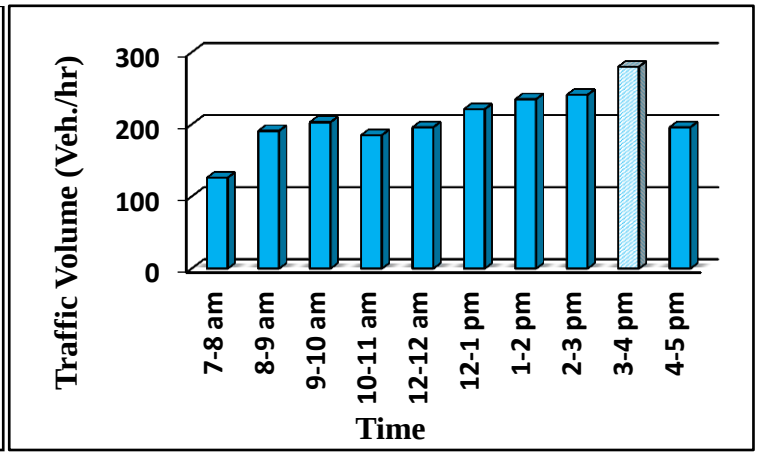


Figure 7. The Hourly traffic volume distribution for the through movement of the suspension bridge direction

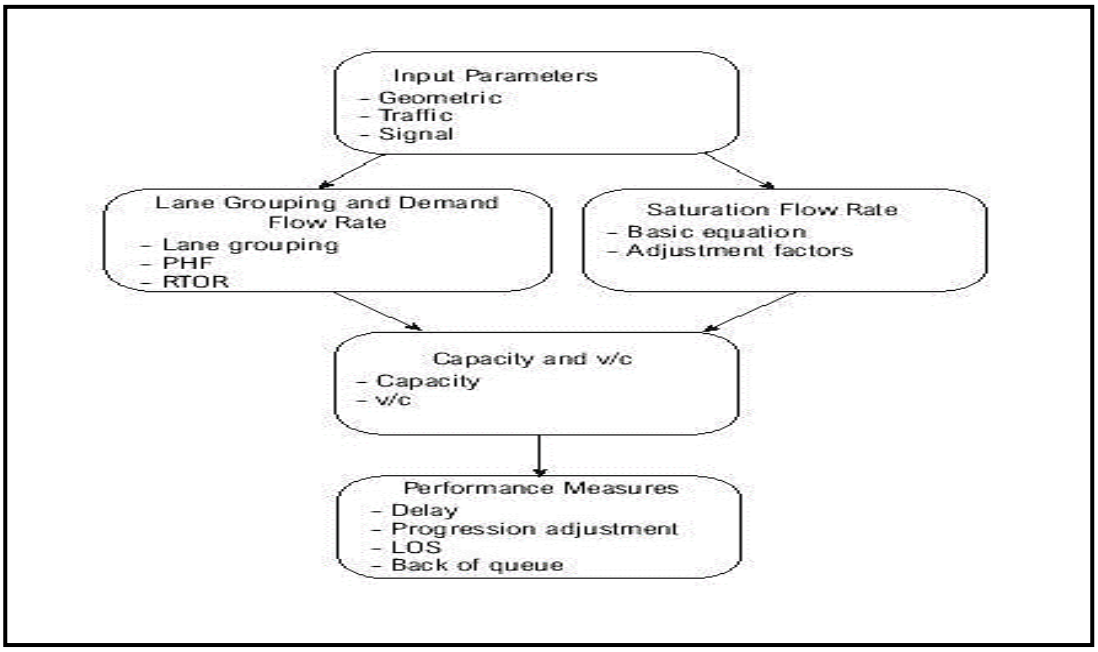


Figure 8. HCS Methodology for the Signalized Intersection Operational Analysis**.**

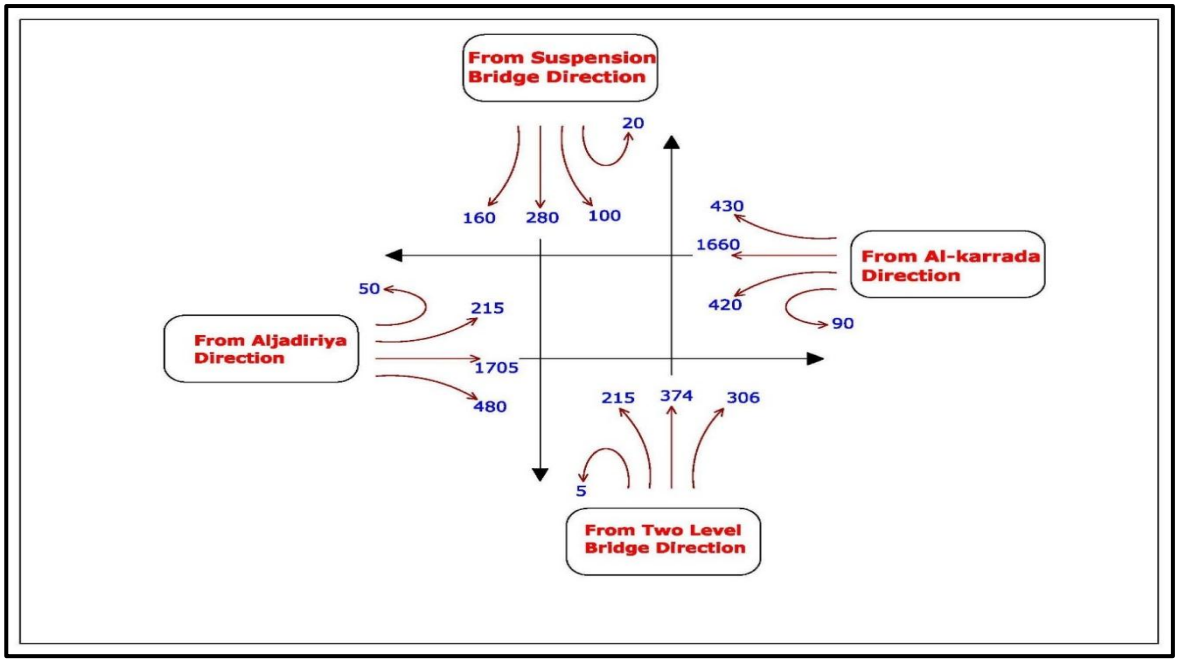


Figure 9. Current Traffic Volume in the Ahmed Urabi Intersection Volume in the Ahmed Urabi Intersection**.**

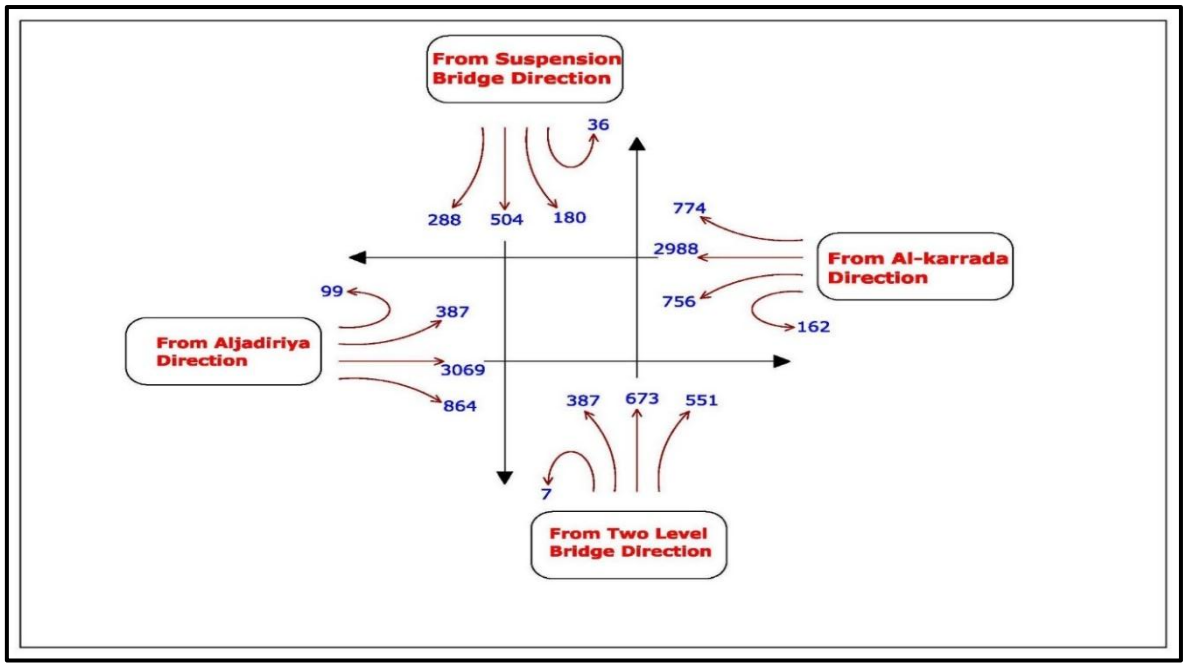


Figure 10. Future traffic volume in the Ahmed Urabi intersection.

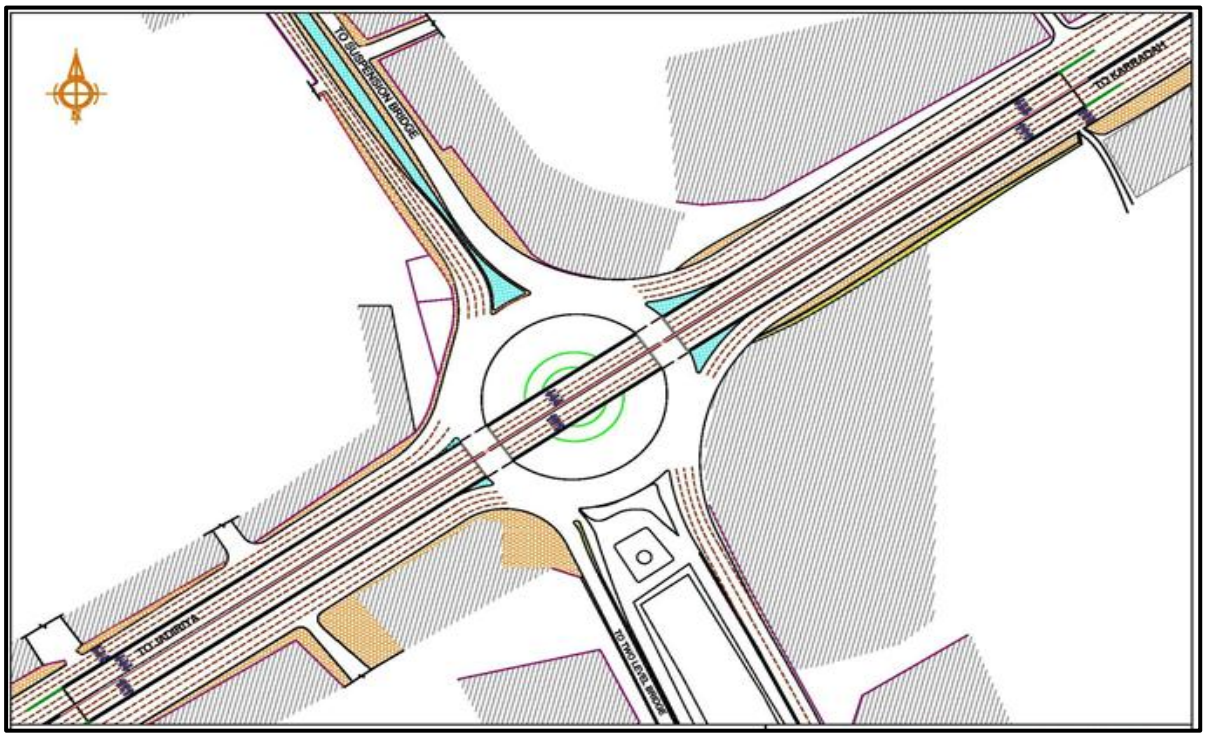


Figure 11. The proposed geometric design for Ahmed Urabi interchange.

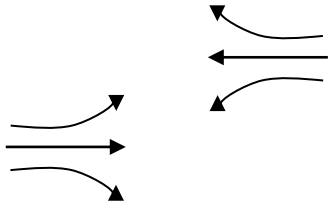
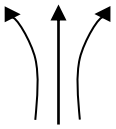
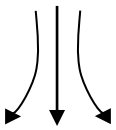
Signal Phasing Plan			
DIAGRAM	**Phase 1**	**Phase 2**	**Phase 3**
			
Movement	Alkarrada- Aljadiriya	To Suspension Bridge	To Two Level Bridge.
Timing	Green = 40 Yellow= 3	Green = 30 Yellow = 3	Green = 25 Yellow = 3

Figure 12. Signal phasing plan of Ahmed Urabi Interchange**.**

Figure 13. The proposed geometric design for Ahmed Urabi interchange.

Table 1. Traffic Volume for the Approaches of Ahmed Urabi Intersection.

Direction		East Bound				West Bound				North Bound				South Bound			
		From Aljadiriya				From Alkarrada				From Two level Bridge				From Suspension Bridge			
Movement		R	Th	L	U-T	R	Th	L	U-T	R	Th	L	U-T	R	Th	L	U-T
Traffic Volume (Veh/h)	8–7am	235	1080	113	21	310	1132	206	84	231	286	202	0	93	126	45	11
	9–8	480	1705	215	55	430	1660	420	90	306	374	215	5	142	191	63	13
	10–9	476	1530	206	42	421	1581	335	88	301	351	193	0	116	203	52	8
	11–10	432	1560	146	35	390	1436	287	86	295	326	186	1	123	185	41	5
	12–11	476	1412	118	38	382	1329	340	83	286	336	176	0	141	196	65	18
	1–12	465	1456	206	46	296	1431	395	76	300	330	189	2	135	221	93	12
	2–1	438	1535	152	42	285	1598	329	71	305	303	196	3	156	235	81	11
	3–2	414	1682	141	48	309	1629	306	79	282	346	184	1	158	241	93	12
	4–3 pm	391	1319	120	51	318	1480	291	73	261	356	165	0	160	280	100	20
	5–4 Pm	201	1206	96	43	282	1238	211	68	184	210	143	0	107	196	86	14

RT: Right Turning. LT: Left Turning. TH: Through movement. U-T: U-Turn

Table 2. Level of Service (LOS) Criteria (HCM,2000).

Level of Service	(Delay , sec/veh)
A	≤10
B	> 10-20
C	> 20-35
D	> 35-55
E	> 55-80
F	> 80

Table 3. The Operational analysis results for the existing condition of Ahmed Urabi intersection.

Direction		*Critical Movement*	*Degree of Saturation*	*Average Control Delay (Sec/Veh.)*	*Level of Service*
East Bound	From Aljadiriya	Through	**1.18**	**477**	**F**
West Bound	From alkarrada	Through	**1.09**	**276**	**F**
North Bound	From Two Level Bridge	Through	**0.79**	**48**	**D**
South Bound	From Suspension Bridge	Through	**0.78**	**52.19**	**D**
The Whole intersection				**300**	**F**

Table 4. The Operational analysis results for the Ahmed Urabi interchange in the design year (2037).

Direction		*Movement*	*Phase*	*Green Time,Sec*	*Avg.Delay Veh*	*Level of Service*
East Bound	From Aljadiriya	Right-T Through Left-T	**1**	**40**	**4.4**	**A**
West Bound	From alkarrada	Right-T Through Left-T	**1**	**40**	**8.8**	**A**
North Bound	From Two Level Bridge	Right-T Through Left-T	**2**	**30**	**21.9**	**C**
South Bound	From Suspension Bridge	Right-T Through Left-T	**3**	**25**	**22.7**	**C**
The Whole Intersection					**14.0**	**B**
Cycle time=110 Sec Amber Time=3 Sec./Phase All Red=2 Sec./Phase						

Table 5. Effect of Distribution Factor on the Intersection Performance during the Design Life.

Distribution Factor		100/0		90/10		80/20	
Year	**Signal Timing**	**Delay, Sec/Veh.**	**LOS**	**Delay, Sec/Veh.**	**LOS**	**Delay, Sec/Veh.**	**LOS**
2017	40[a]	10.6	B	12.5	B	13.08	B
	30[b]						
	25[c]						
2019	40[a]	10.8	B	13.1	B	13.6	B
	30[b]						
	25[c]						
2037	40[a]	14.0	B	44.2	D	45.7	D
	30[b]						
	25[c]						

Where
a: Karrada- Jadiriya Direction
b: Two Level Bridge Direction
c: Suspension Bridge Direction

Table 6. The Operational analysis results for the Ahmed Urabi interchange in the design year (2017).

Direction		*Movement*	*Phase*	*Green Time,Sec*	*Avg.Delay Veh*	*Level of Service*
East Bound	From Aljadiriya	Right-T	**1**	**40**	**3.9**	**A**
		Through				
		Left-T				
West Bound	From alkarrada	Right-T	**1**	**40**	**6.6**	**A**
		Through				
		Left-T				
North Bound	From Two Level Bridge	Right-T	**2**	**30**	**15.1**	**B**
		Through				
		Left-T				
South Bound	From Suspension Bridge	Right-T	**3**	**25**	**19.1**	**B**
		Through				
		Left-T				
The Whole Intersection					**10.6**	**B**

Table 7. The Operational analysis results for the Ahmed Urabi interchange in the design year (2019).

Direction		*Movement*	*Phase*	*Green Time,Sec*	*Avg.Delay Veh*	*Level of Service*
East Bound	From Aljadiriya	Right-T Through Left-T	**1**	**40**	**3.9**	**A**
West Bound	From alkarrada	Right-T Through Left-T	**1**	**40**	**6.7**	**A**
North Bound	From Two Level Bridge	Right-T Through Left-T	**2**	**30**	**15.3**	**B**
South Bound	From Suspension Bridge	Right-T Through Left-T	**3**	**25**	**19.3**	**B**
The Whole Intersection					**10.8**	**B**

Table 8. The Required Number of Lanes for the Alkarrada- Aljadiriya Underpass.

Direction	Future Traffic Volume, Veh/hr.	Level of service	`Design Capacity, Veh/hr./lane	Required No. of Lanes
Alkarrada	**3069**	**B**	**1080**	**3**
Aljadiriya	**2988**	**B**	**1080**	**3**