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A CASE STUDY OF TRAFFIC CHARACTERISTICS AND PROPOSED IMPROVEMENT SCHEMES FOR AN ARTERIAL ROAD

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ABSTRACT

This case study represents a typical example of surveying and assessing traffic characteristics along a local ring road in Doha City. Expected impacts of possible short-term (5-year) traffic management schemes for two main intersections were evaluated utilizing available PC software programs.

Results indicate variations in traffic characteristics among different directions, sections and segments of the studied ring road. An optimum short-term management scheme was chosen for each of the two main intersections under study and the corresponding queuing delays and volume-to-capacity ratios were assessed.

The study recommends more comprehensive traffic surveys in the future that should be undertaken as an integral part of a traffic master plan for Doha City. This master plan is a must for taking sound decisions concerning needed traffic management schemes.

INTRODUCTION

The road hierarchy of Doha city consists of a set of ring and radial roads. One of the important arteries in this system is the "C" Ring Road, which stems its importance from the type of areas it serves, the several roundabouts it passes, its intermediate location within the street network of the city and its direct access to the Doha Corniche stretching along the pleasant scene of the Gulf. Some roundabouts along this artery are currently suffering excessive delays and long queues on their approaches during peak- and some off-peak periods (1,2). These problems resulted in an increasing trend of public complaints expressed in various mass media streams.

The "C" Ring Road was chosen in this case study as an example for other ring roads in the network and also because limited traffic studies were undertaken on this main artery.

The main objective of this study is to assess traffic characteristics along main sections of the "C" Ring Road and predict possible impacts of proposed management schemes on the short-term (5-year) future performance.

STUDY PROGRAM AND METHODOLOGY

Data Collection

Results of previous surveys and studies (1,2) were collected from the Traffic Engineering Section, Ministry of Industry and Public Works (MOIPW), as follows:

a) 24-hour traffic counts at specific locations along the "C" Ring Road for the years 1986 to 1988, inclusive.

b) Spot speeds at a specific location on the "C" Ring Road in 1990.

c) Turning-movement counts on three roundabouts during 1990.

d) Feasibility studies of alternative layouts and control schemes at two main intersections on the "C" Ring Road.

Data were collected from the Central Census Bureau comprising distribution of vehicle registration by type for the years 1986 to 1990, inclusive. Cadastral maps (scale 1:1000) for the road sections under study were secured from Doha Municipality, Ministry of Municipal Affairs and Agriculture.

Field Surveys

The following field surveys were performed during this study to determine the following traffic characteristics along the road:

a) Peak- and off-peak spot speeds at eight specific stations.

b) Peak- and off-peak travel times and delays.

c) Classified intersection delays at four roundabouts during morning and noon peak periods.

d) Classified turning movements at three roundabouts during morning and noon peak periods.

Assessment of Levels of Service

Based on data collected and results of field surveys, specially travel time and delay surveys, the level of service (LOS) was assessed in the following order (3):

a) Determine the "segmental" LOS for the road sections.

b) Determine the "sectional" LOS for the number of sections investigated.

c) Define the datum LOS to be used in comparisons.

d) Define the problem areas (bottle necks) in those segments with LOS lower than the datum.

Selecting Improvement Alternate Schemes

Results of field surveys and LOS assessment indicated the necessity to introduce improvements to the intersections concerned. The improvement schemes for the 1997 target year comprised changes of the layout and/or traffic control.

The chosen alternate schemes were evaluated utilizing ARCADY 2 (Assessment of Roundabout Capacity and Delay - Version 2) (4) and OSCADY (Optimized Signal Capacity and Delay) (5) software programs, for alternatives involving roundabouts and traffic signals, respectively. All the improvement alternatives were compared to the existing situations in 1992 so as to conclude the extent of improvement that may be expected in 1997.

RESULTS AND DISCUSSIONS

Volume Studies and Turning Movements

Due to shortage of trained manpower and mechanical counters, the survey of turning movements was performed using a video camera from a vantage point that covered all traffic movements within the studied intersection. The 2-hour video cassette was displayed later and four persons monitored the four approaches of the intersection to define each movement by following the passage of specific vehicles from their points of entry till exit. Special forms were used to record the counts

of vehicles by number and type. The peak periods considered in this survey were those experienced by Doha city dwellers: 6:00 - 8:00 a.m. and 11:00 a.m.- 1:00 p.m.

The study covered three roundabouts; namely: Al-Sadd, Al-Sletah, and the Cinemat. For other important junctions of the "C" Ring Road; namely: Ramada, White Palace and Al-Mana, previous data obtained from the Traffic Section of the Civil Engineering Department, MOIPW, were used. These data involved 1990 volumes and a growth factor of 2.45% per annum (6) was used to obtain the target 1997 volumes.

Table 1 presents summary results of traffic movements for the above six roundabouts and/or junctions during the peak periods, given in passenger car units per hour.

These results indicate the large shares of traffic volumes carried by the "C" Ring Road approaches. A thorough investigation of these shares would indicate the high percentage of U and left turning volumes. This finding is considered a main factor that should be looked upon before choosing the type and design of traffic signal. For instance, Ramada roundabout has 52% of its morning-peak volume carried by the "C" Ring Road approaches, more than 50% of which was for U and left turners. The same trend was evident for all the studied roundabouts, except that U and left turns of Ramada and Al-Mana intersections were remarkably higher than others.

Spot Speed Surveys

These surveys were performed in a very similar way. Two video cameras were used to photograph the traffic flow passing by two 70-m apart control stations. This method has the main advantage of providing continuous observation with the least required manpower to complete the study on site. Test courses were chosen as far away as possible from roundabouts, pedestrian crossings, side road intersections and curved sections. For each segment, two spot-speed study strips were identified, one for each direction. All precautions were undertaken to eliminate the possibility of any effect on drivers performance.

The two video cassettes were simultaneously displayed. Once the same built-in timing indicator appeared, the observer started his stop watch marking a specific vehicle passing by the starting control station. The observer stopped his watch as the same vehicle passed the ending control station. The speed was then calculated from the known distance and lapsed time.

Table 1: Summary of Turning Movements on the Surveyed Intersections

Time	Approach	Approach Volume (PCU)	Percentage Approach of total	Percentages			
				U-Turn	Left Turn	Through	Right Turn
White-Palace Roundabout							
Morning peak	C-Ring Road North	1414	16.8	1.3	24	61.5	13
	Rayyan Road West	2123	25.2	4.1	8.4	62.6	24.8
	C-Ring Road South	2549	30.3	5.6	36.3	43	15.1
	Rayyan Road East	2328	27.7	1.8	12.6	75.8	9.6
Noon-peak	C-Ring Road North	1473	17.8	1.0	26.5	59.3	13.2
	Rayyan Road West	1663	20	2.7	9	66.4	21.9
	C-Ring Road South	2340	28.2	5.7	28.5	46.5	19.3
	Rayyan Road East	2813	34	2.1	15.3	74	8.6
Ramada Roundabout							
Morning-peak	C-Ring Road N-W	3361	29	6.3	28.5	54	11.2
	Salwa Road West	2108	8.2	3.7	15.6	56.7	24
	C-Ring Road S-E	2717	23.5	3.0	13.8	63.4	19.7
	Salwa Road (Doha)	3374	29.3	1.9	8.5	51	38.3
Noon-peak	C-Ring Road N-W	3458	29	4.8	44.9	38.9	11.3
	Salwa Road West	2310	19.3	3.1	25	54.7	17
	C-Ring Road S-E	1609	13.5	2.5	18.7	65.3	13.5
	Salwa Road (Doha)	4560	38.2	1.8	13.5	51.2	33.5
Al-Mana Intersection							
Morning-peak	C-Ring Road West	2022	21.3	12.5	24.3	37.4	25.8
	Al-Wakraha Road	3837	40.5	3.4	17.1	53.2	26.3
	C-Ring Road East	1893	20.0	4.1	49.1	45	1.8
	Airport Road	1709	18.2	0.9	8.3	76.8	13.8
Noon-peak	C-Ring Road West	1580	17.7	9.6	19.3	43.6	27.5
	Al-Wakraha Road	3164	35.5	5.4	20	47.2	27.4
	G-Ring Road East	2455	27.5	1.75	54.8	42.6	0.85
	Airport Road	1705	19.3	1	5.4	67.3	26.3

Table 1: (Contd.) Summary of Turning Movements on the Surveyed Intersections

Time	Approach	Approach Volume (PCU)	Percentage Approach of total	Percentages			
				U-Turn	Left Turn	Through	Right Turn
Al-Sadd Roundabout							
Morning-peak	C-Ring Road North	2248	28.5	2.8	27.2	58	12
	Al-Sadd Road West	1883	24	8.0	21	44	27
	C-Ring Road South	2222	28	2.2	16.5	50	22.1
	Al-Sadd Road East	1512	19.5	0	19.2	52	28.8
Noon-peak	C-Ring Road North	2405	30.8	3.9	18.2	58.4	19.5
	Al-Sadd Road West	2184	28	34.6	16.8	17.6	31
	C-Ring Road South	2109	27	2.8	16.7	57.8	22.7
	Al-Sadd Road East	1098	14.2	0	33.3	43	23.7
Al-Sletah Roundabout							
Noon-peak	C-Ring Road N-W	1945	25	2.7	19.5	52	25.8
	Al-Sletah Rd. West	1945	25	3.0	20.2	59.8	17
	C-Ring Road S-E	2107	27.1	3.1	17.6	54.3	25
	Al-Sletah Rd. East	1782	22.9	2.5	15.1	47.2	35.2
Al-Cinemat Roundabout							
Morning-peak	C-Ring Road West	1574	30.8	1.8	14.2	67.2	16.8
	Al-Najmah Rd. South	739	14.5	0	32.0	42.0	2.6
	C-Ring Road East	1690	33.0	1.7	15.1	65.4	17.8
	Al-Najmah Rd. North	1105	21.7	0.1	25.4	53.0	21.5
Noon-peak	C-Ring Road West	1433	29.5	2.9	11.2	65.0	20.9
	Al-Najmah Rd. South	1042	21.4	0.2	16.8	60.2	22.8
	C-Ring Road East	1348	27.7	2.0	24	62.0	11.0
	Al-Najmah Rd. North	1031	21.4	0.1	33	39.4	27.5

Table 2 presents a summary of off-peak spot-speed results obtained for two segments on the "C" Ring Road. Results indicate the rather uninterrupted-flow nature along the northbound direction of both sections of the "C" Ring Road. Also, the effect of congestion along Ramada and Al-Muntazah approaches is very pronounced in the mean speed results (Section I, Stations 2N and 2S,respectively).

Table 2: Summary of Off-Peak Spot Results in Km/hr on Different Sections of the C-Ring Road

Section	Station	85-percentile	Mean	Std. Dev.	% of Veh in Pace
I	St. 1S	86.5	76.6	9.3	48
	St. 1N	87.5	77.4	10.8	51
	St. 2S	78.5	69.8	10.0	54
	St. 2N	80.0	71.3	10.3	52
II	St. 3E	91.0	79.0	13.5	40
	St. 3W	92.5	80.6	15.3	38
	St. 4E	90.0	79.8	12.8	44
	St. 4W	90.5	78.3	14.1	44

Sec. I. From White Palace to Al-Sletah Roundabout.
Sec. II. From Al-Saletah Roundabout to Al-Mana Intersection.

Travel Time and Delay Surveys

The "Average Car Technique" (7) was followed where the test car was driven according to the driver's judgement of the average speed of the traffic stream. To achieve this objective, the test car's driver was instructed to always try to keep driving along the middle lane of the travelled way.

Prior to field surveys, the starting and ending points were identified. Major intersections and other control points, like stop signs, yield signs and branch entrances and/or exits, were selected as reference points. Time readings were taken at these locations to enable determining speeds by sections.

Figure 1 shows an example of travel time, speed and delay diagrams for the studied sections of the "C" Ring Road. Figure 2 illustrates comparisons between the peak- and off-peak mean results. Comparing off-peak and peak delays on different approaches shows the prominent effect of congestion on some specific roundabouts. For instance, Ramada roundabout had a peak-period delay on one

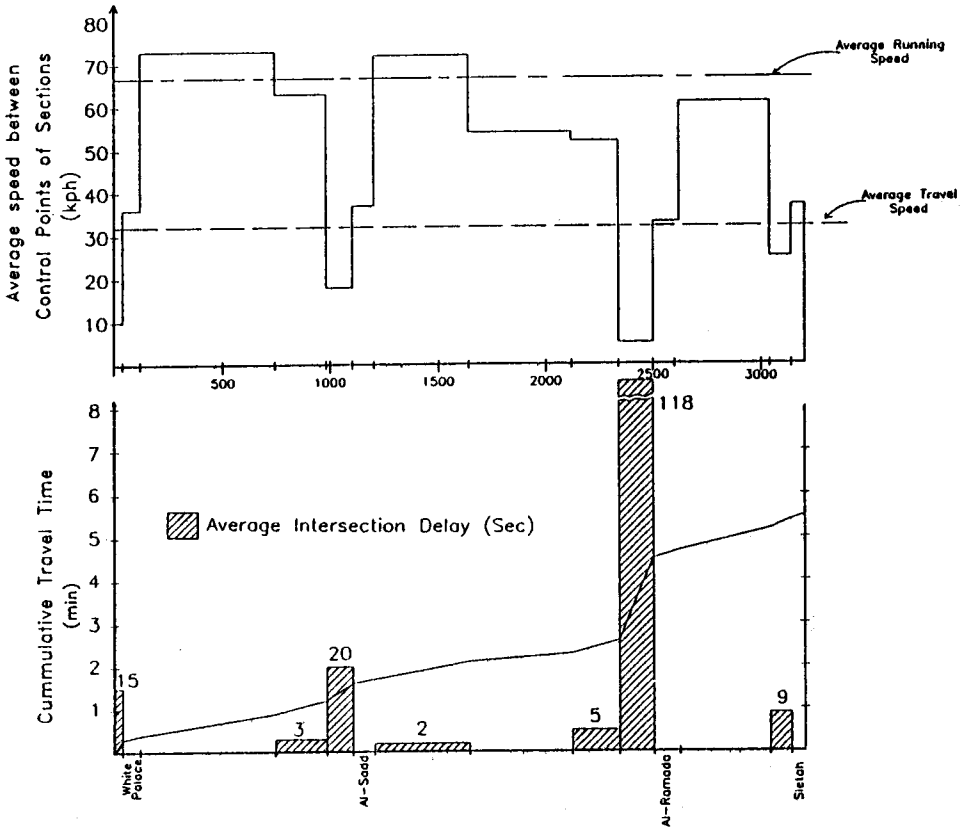


Figure 1: Travel time, speed and delay study results (e.g., White-Palace, Al-Sletah sec. on C-ring road SB - noon peak).

of its "C" Ring Road approaches (Section I - southbound direction) that reached approximately ten times that of the off-peak period.

Intersection Delay Surveys

These surveys were performed at four of the "C" Ring Road roundabouts; namely, White Palace, Al-Sadd, Al-Mountazah and Al-Sletah, to assess the need for alternative control schemes.

A video camera was utilized to photograph the traffic flow on each intersection approach for 10 - 20 min during peak periods. The height of photography was adjusted so as to cover at least 200 m along each approach and

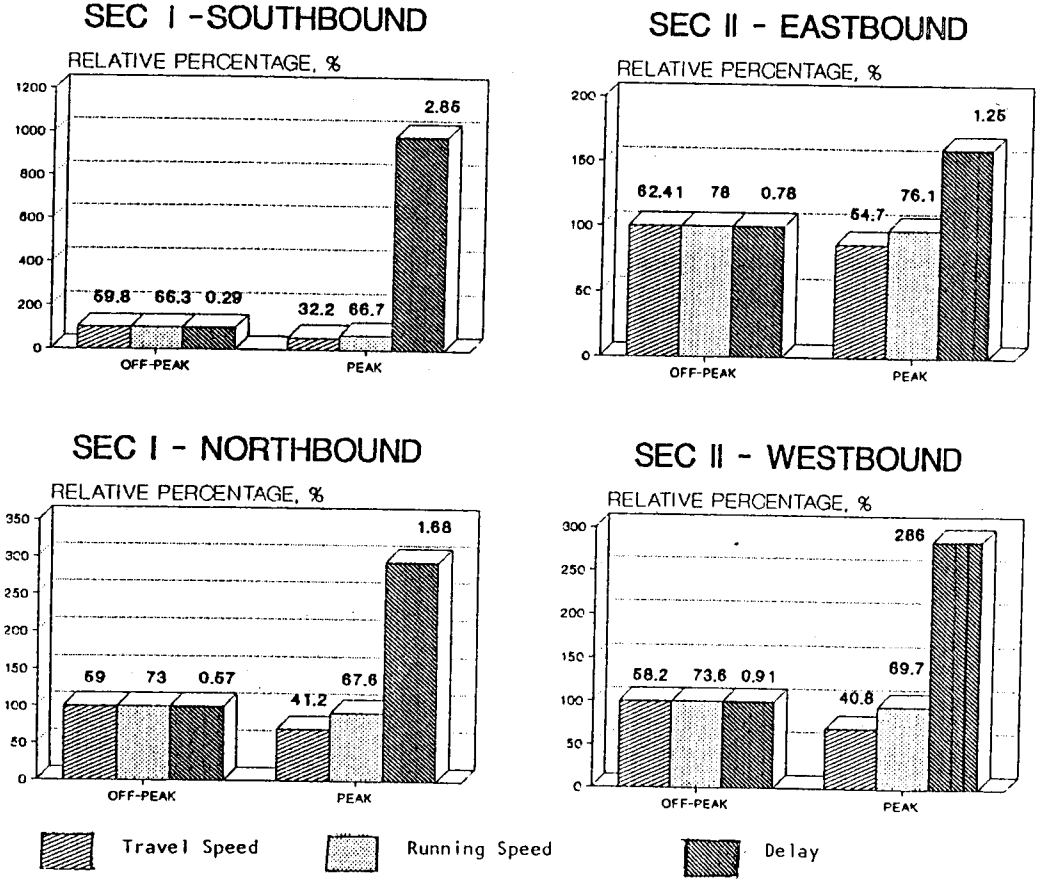


Figure 2: **Peak and off-peak mean results of overall, running and delay times surveys on the C-ring road.**

duration has been chosen so that the minimum sample size was achieved.

The "Sampling Procedure for Intersection Delay" (7) was utilized and the instantaneous densities every 15 sec together with approach volumes every minute, classified in terms of numbers of vehicles stopped and not stopping, were recorded in appropriate field sheets.

Figure 3 presents summary results for the averages of measured parameters for each approach of the four roundabouts under study.

Results clearly indicate the effect of traffic volume-to-capacity (v/c) ratio on experienced delays. For example, the highest average delay per approaching vehicle (49.4 sec) was found on the eastbound direction of the "C" Ring Road approaching Al-Muntazah roundabout. This finding is attributed to the high volume (approximately 1400 pcuph) coming from the rather crowded Al-Muntazah area and the relatively narrow approach width (8.5 m). On the other hand, the lowest average delay per approaching vehicle was that recorded on the westbound direction of Al-Sadd street approaching Al-Sadd roundabout (9.4 sec), where conditions were opposite to the above example.

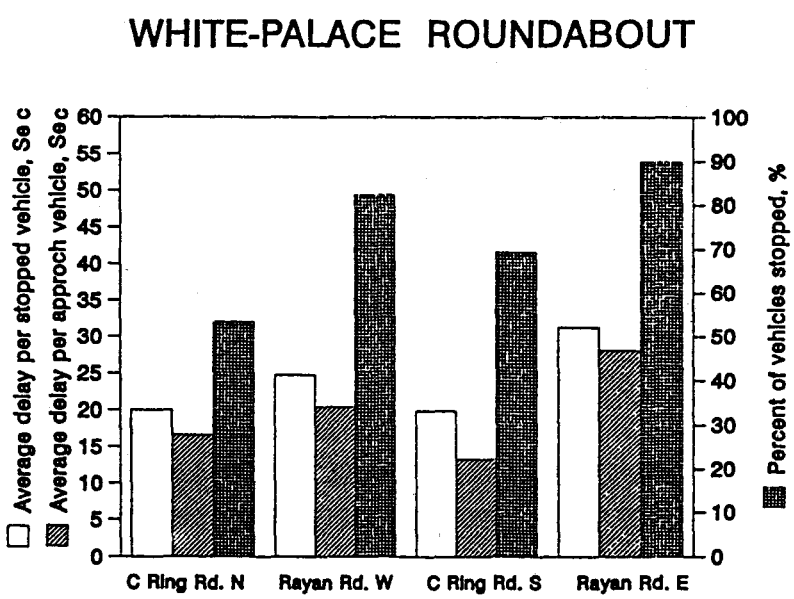
Level of Service Surveys

Based on the methodology described in the "Highway Capacity Manual" (3), different steps were followed to assess the level of service of the "C" Ring Road segments and sections under study. This survey was essential to determine the improvements needed, if any, to the existing facility .

Table 3 presents a summary of results of this phase of the study. Due to excessive delays on the southbound direction of the "C" Ring Road segment between Al-Sadd and Ramada roundabouts, respectively, the resulting LOS was very low (LOS E). This resulted in a drop of the LOS of this direction along the entire section to LOS D. For Section II, the same pattern is evident for the westbound direction between AL-Cinemat and Al-Muntazah roundabouts, respectively.

Examples of Proposed Improvement Alternatives and Evaluation Results

As indicated earlier, proposed improvement schemes may include changing layouts and/or traffic signalization plans. In this study, ARCADY 2 and OSCADY software programs were utilized to evaluate proposed alternatives for two intersections; namely, Ramada roundabout and Al-Mana signalized intersection.



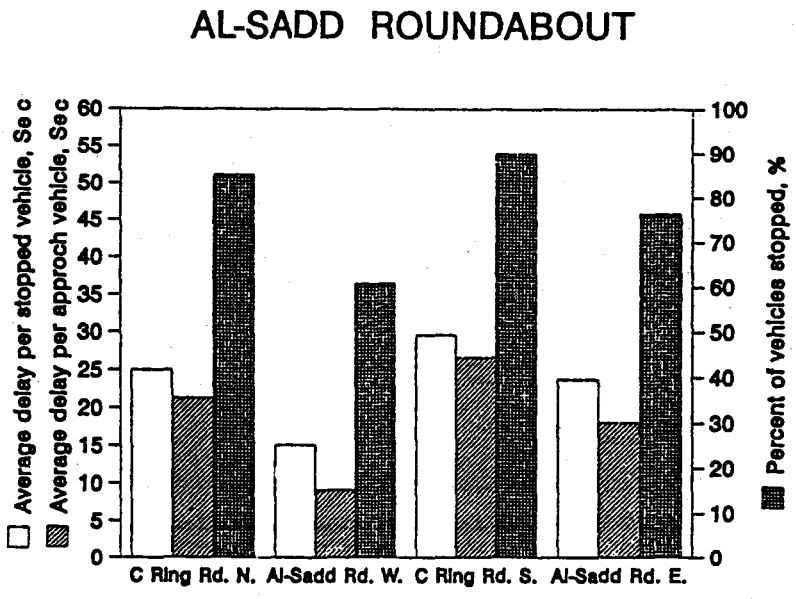


Figure 3: **Results of intersection delay studies.**

Table 3 — Summary of LOS Results

Section	Segment	Starting point	Ending point	Direction	Segment LOS	Section LOS
I	1 - S	S - Exit of White Palace roundabout	S - Exit of Al-Sadd roundabout	SB	B	D
	2 - S	S - Exit of Al-Sadd roundabout	S - Exit of Ramada roundabout	SB	E	
	3 - S	S - Exit of Ramada roundabout	S - Exit of Al-Sletah roundabout	SB	B	
I	1 - N	N - Exit of Al-Sletah roundabout	N - Exit of Ramada roundabout	NB	D	C
	2 - N	N - Exit of Ramada roundabout	N - Exit of Al-Sadd roundabout	NB	C	
	3 - N	N - Exit of Al-Sadd roundabout	N - Exit of White Palace roundabout	NB	B	
II	1 - E	E - Exit of Al-Sletah roundabout	E - Exit of Al-Muntazah roundabout	EB	B	B
	2 - E	E - Exit of Al-Muntazah roundabout	E - Exit of Al-Cinemat roundabout	EB	A	
	3 - E	E - Exit of Al-Cinemat roundabout	E - Exit of Al-Mana signal	EB	B	
II	1 - W	W - Exit of Al-Mana signal	W - Exit of Al-Cinemat roundabout	WB	A	B
	2 - W	W - Exit of Al-Cinemat roundabout	W - Exit of Al-Muntazah roundabout	WB	D	
	3 - W	W - Exit of Al-Muntazah roundabout	W - Exit of Al-Sletah roundabout	WB	A	

These programs helped to evaluate the extent of improvement achieved as compared to existing situations. These two cases served as examples to illustrate study methodology and evaluation procedures.

A. Ramada Roundabout Alternatives

The following alternatives were proposed and compared to the existing layout and 1992 traffic volumes (Alt. 0) :

Alt. 1 - The existing layout and 1997 traffic volumes.

Alt. 2 - Introduce a 4-phased traffic signal to control 1997 traffic volumes. This alternative was named as "Ramada Signal - 1997".

Alt. 3 - Suggest a flyover to serve through traffic of the "C" Ring Road and an at-grade roundabout for all other movements in 1997. This was named as "Ramada Flyover with Roundabout - 1997".

Figure 4 shows the results obtained from ARCADY 2 for Alternatives 0, 1 and 3, respectively, and OSCADY for Alternative 2. Traffic volumes input to these programs were the projections of the average turning movement counts of the noon peak period. Geometric design parameters required as inputs to these software programs were measured from the cadastral maps secured from Doha Municipality. Results are given in terms of total delay (min/veh.) for each approach. Also, Figures 5 through 7 show comparisons between the different proposed alternatives in terms of queuing delays and v/c ratios on the respective intersection approaches.

Results show that drivers approaching the intersection area from approach D (Salwa Road from Doha) were suffering 88% of the total delay of the entire roundabout in 1992 (Alt. 0). This finding may be explained by the effect of the relatively high v/c ratio of this approach in 1992 (4560 vehicles using a 2-lane approach).

If the do-nothing Alt. 1 is followed, the resulting delay in 1997 may reach double that experienced in 1992 (18.53 compared to 9.33 min/veh, respectively). This alternative would also result in significant increases in the percentage of delay to be suffered along the A and B approaches. These increased delays may occur due to the high proportions of U and left turners on these approaches, which usually require longer travelling times.

Alt. 1 would also result in v/c ratios greater than 100% for the "C" Ring

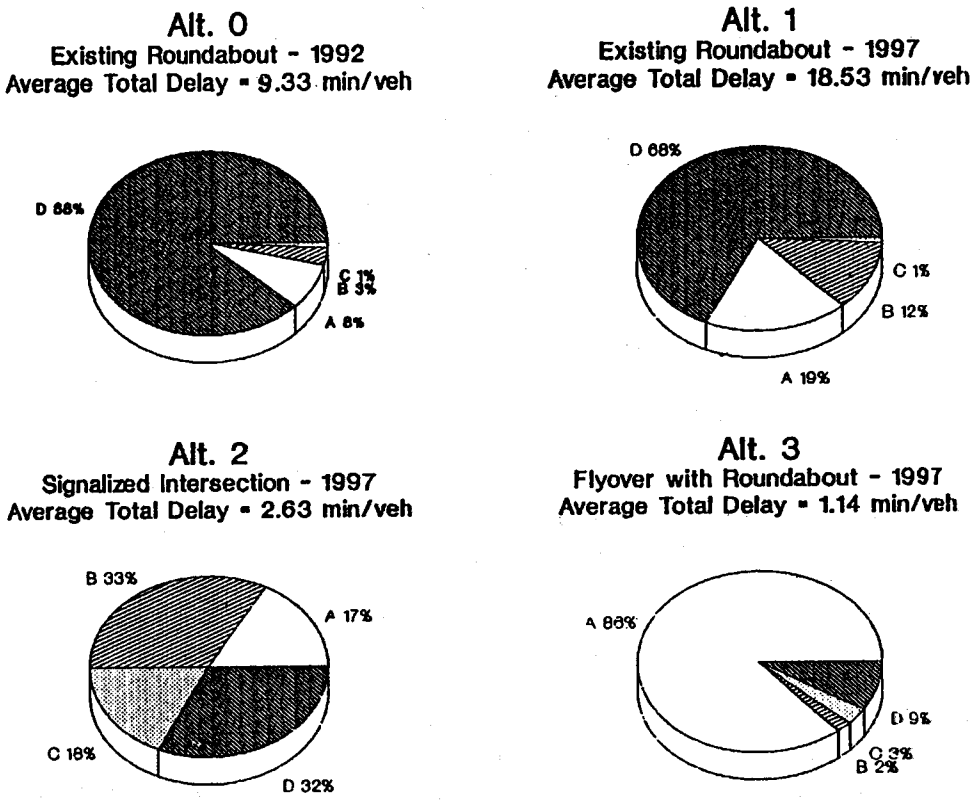


Figure 4: Total delay and its distribution among approaches for different Ramada intersection alternatives.

Road approaches (114.5% and 118% for approaches A and C , respectively). This clearly indicates that the current layout would not be adequate to accommodate the target 1997 volumes.

If Alt. 2 is followed, the total delays expected may drop to 28.2% of that experienced in 1992 (Fig. 5). Expected delays on approaches A and C of the "C" Ring Road for Alt. 2 would sum up to 35% of the total delay (Fig. 4). On the other hand, percentage of delays on Salwa Road approaches B and D may be expected to reach 65% of the total delay. These delays can be explained by the combined effect of the high volumes they would be carrying (57.5% of the total intersection volume) and the narrow 2-lane widths of these approaches.

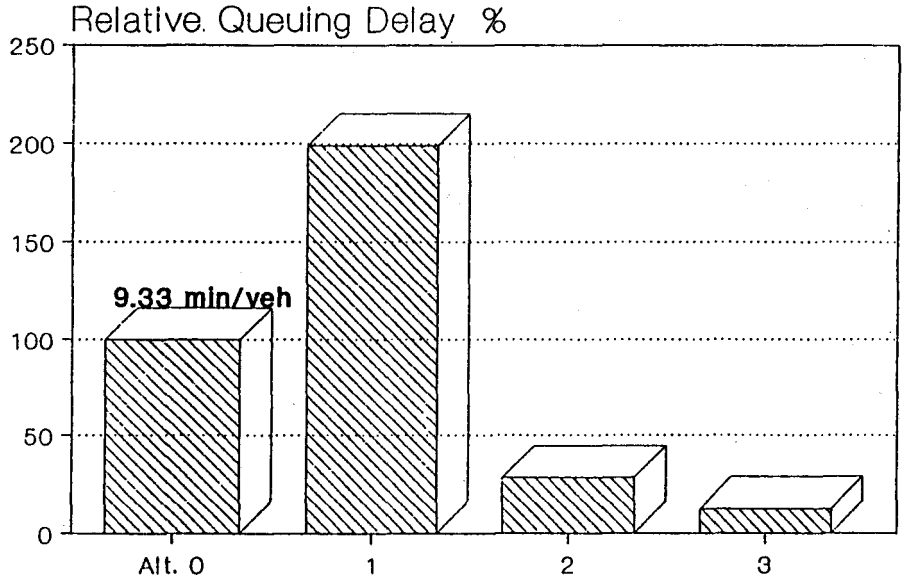


Figure 5: Comparison of overall queuing delays - Ramada intersection.

Results of evaluating the expected impacts of Alt. 3 indicate that a large drop in the average total delay may be expected (1.14 min/veh, representing 12% of that of Alt. 0). The high percentage of delay is expected to be experienced by drivers coming on approach A (86% of the total), as this approach would be utilized only for U and left turning maneuvers (49.7% of the total volume). However, this alternative would allow for more volumes to be accommodated on Salwa Road approaches B and D.

B. AL-Mana Junction Alternatives

The following alternatives were proposed in this study. Each of them was compared to the existing layout (4-leg at grade signalized intersection) with 1992 traffic volumes (Alt. 0):

Alt. 1 - Existing layout and signalization plan, but serving 1997 traffic flows. This alternative was named "Existing Signal - 1997".

Alt. 2 - Existing layout, but with a redesigned cycle length and phasing to serve 1997 traffic volumes. This alternative was named "Existing Layout with Cycle Redesigned - 1997".

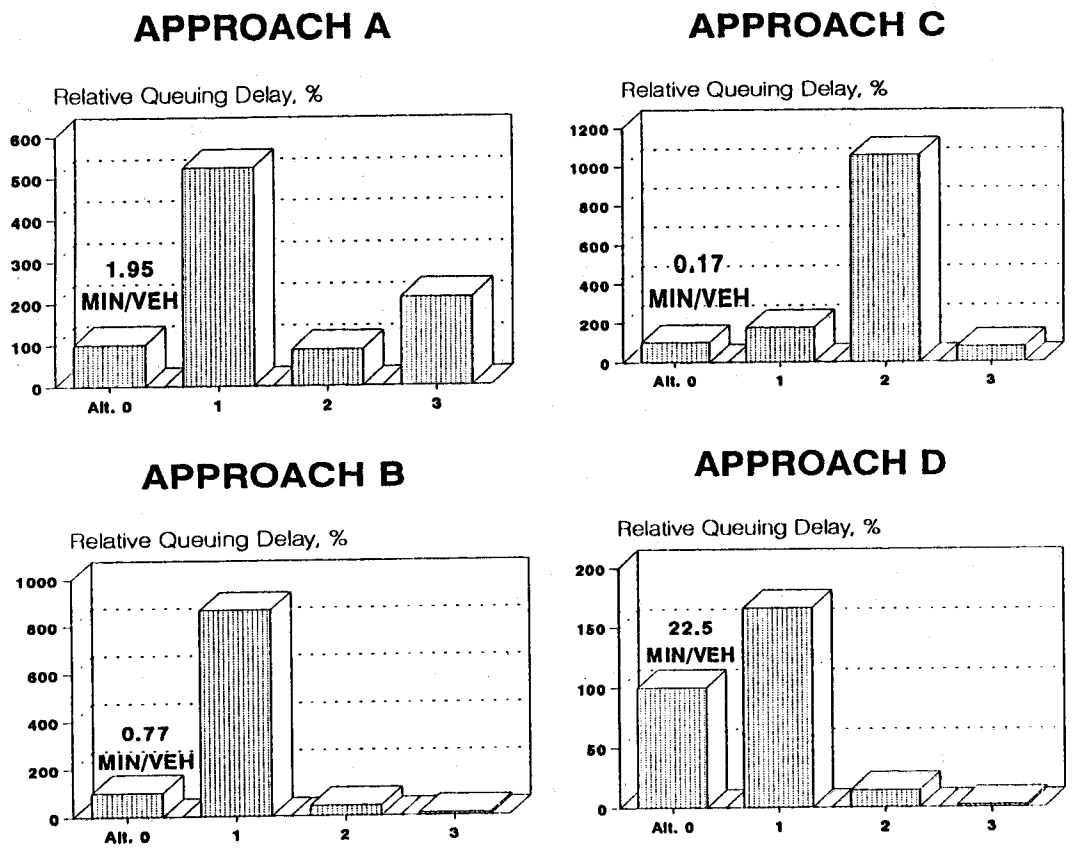


Figure 6: **Comparison of queuing delays on Ramada intersection approaches for the studied alternatives.**

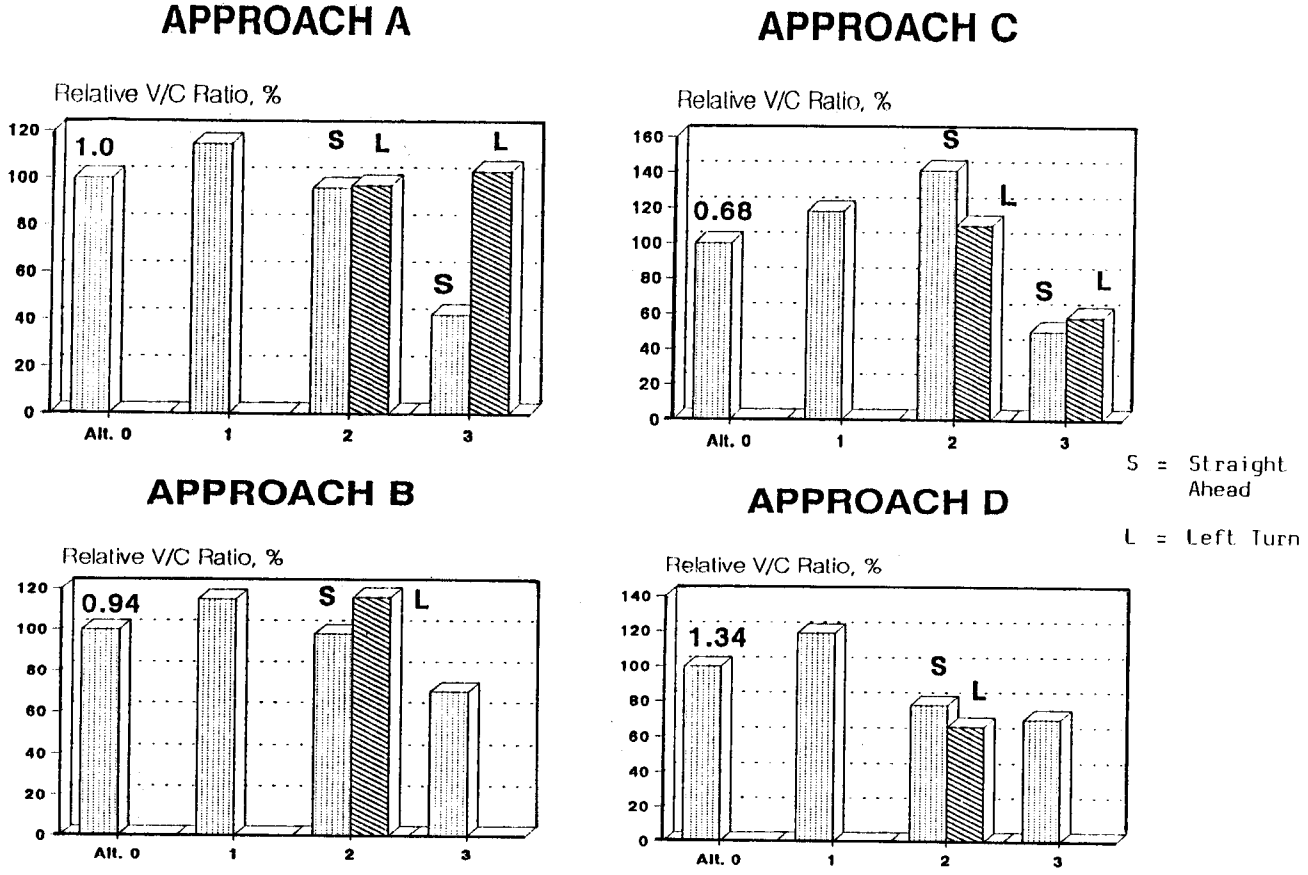


Figure 7: **Comparison of v/c ratios on the different Ramada intersection approaches for the studied alternatives.**

Alt. 3 - Introduce a flyover for the "C" Ring Road through traffic and an at-grade roundabout for all other movements to serve 1997 traffic volumes. This alternative was named "Flyover with Roundabout - 1997".

Again, OSCADY software program was utilized to assess the effects of the proposed Alternatives 1 and 2 as well as establishing a comparison datum from the results of Alt. 0. ARCADY 2 was used to evaluate the expected impacts that may result if Alt. 3 is applied.

Figures 8 through 11 summarize the obtained results in terms of total delay (min./veh) among the intersection approaches (Figure 8), comparisons between overall queuing delays (Figures 9 and 10) and v/c ratios for each approach in the different proposed alternatives (Figure 11).

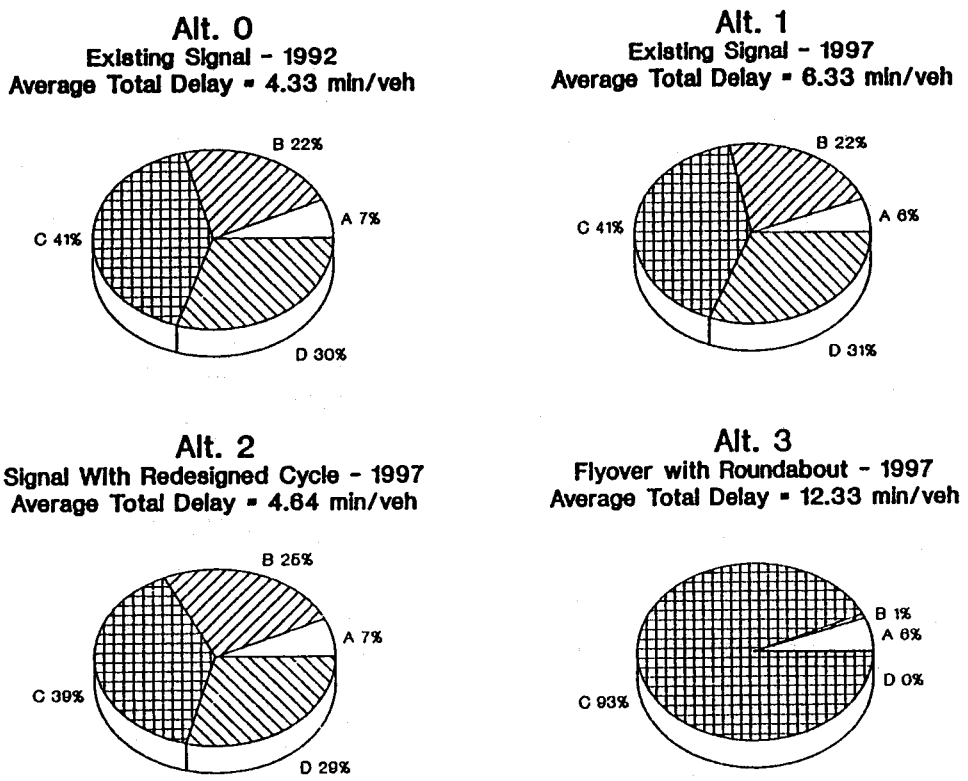


Figure 8: Total delay and its distribution among approaches for the different Al-Mana intersection alternatives.

The average total delay in 1992 for Alt. 0 was estimated using OSCADY software program as 4.33 min/veh. The existing signalization plan evenly distributed the queuing delays among the respective intersection arms. Drivers using approach C in 1992 noon peak were estimated to suffer 41% of the total

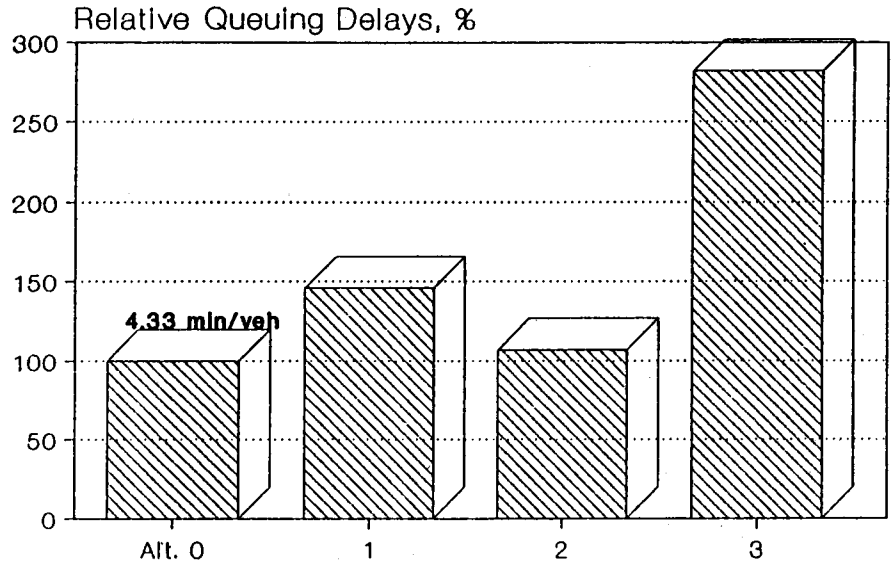


Figure 9: Comparison of overall queuing delays - Al-Mana intersection.

intersection delay, mainly because of the high percentage (56%) of left turning movements. On the other hand, the high percentage of delay on approach D (30%) can be attributed to the restricted 2-lane width of the Airport Road.

Alt. 1 would result in remarkable increases in the average total delay (146% of that of Alt. 0), with subsequent increases in queuing delays on all the respective intersection approaches in comparison with Alt. 0. (118%, 149%, 142% and 150% of those of Alt. 0 for approaches A, C, B and D, respectively).

The alternative to maintain the same layout and increase signal cycle length to accommodate 1997 traffic volumes (Alt. 2) seems to yield results comparable to those of Alt. 0. The expected average total delay would be 4.64 min/veh and almost the same distribution of percentages of delay among respective approaches may be expected. Also, the v/c ratios for approaches A and C of the "C" Ring Road and for straight movements of the intersecting approaches B and D for this alternative are approximately equal to those of the current situation (Alt. 0).

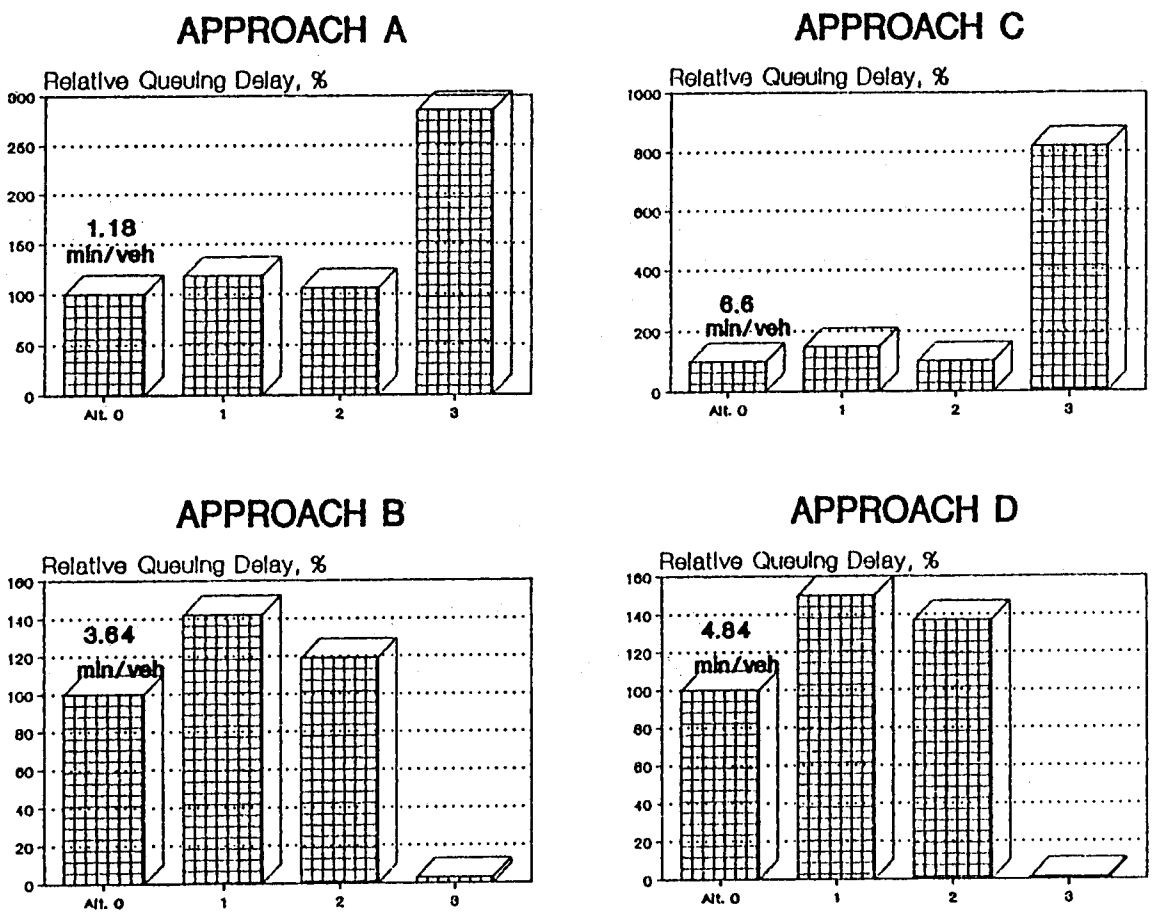


Figure 10: **Comparison of queuing delays on Al-Mana intersection approaches for the different alternatives.**

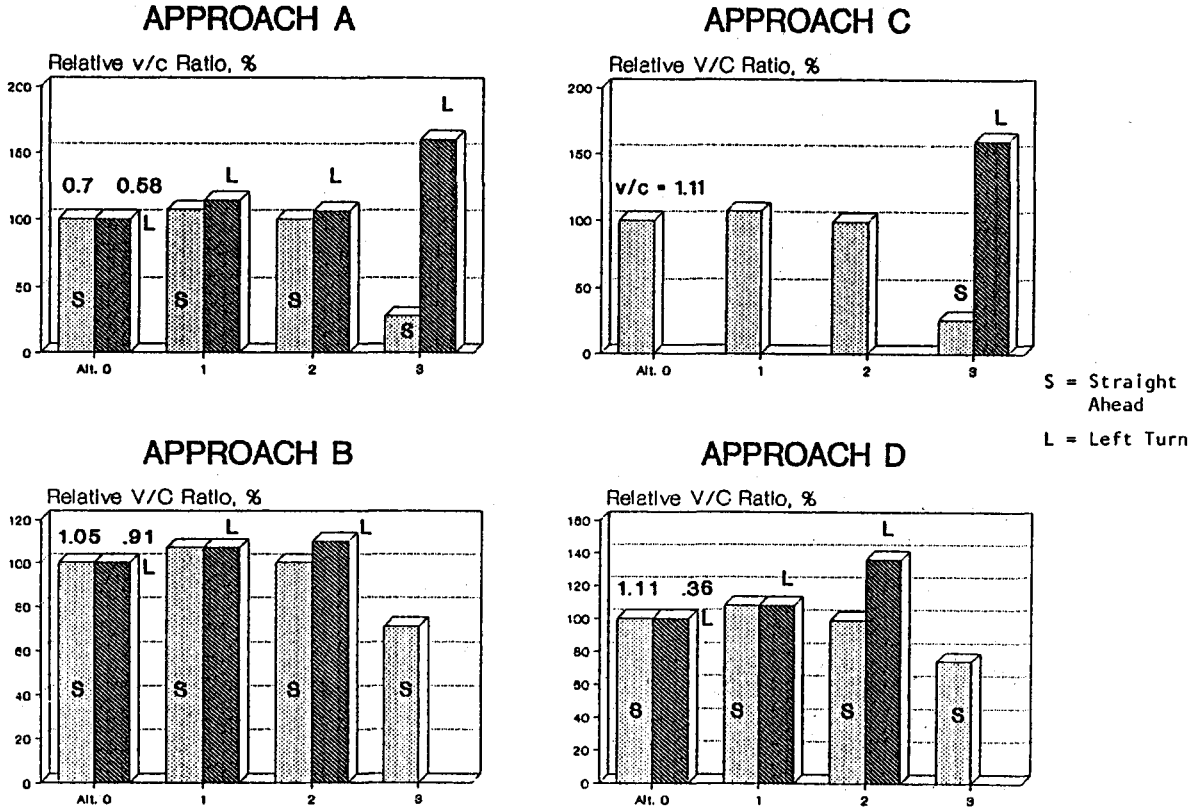


Figure 11: **Comparison of v/c ratios on the different Al-Mana intersection approaches for the studied alternatives.**

However, increases in v/c ratios may be expected for left turning movements utilizing approaches B and D (110% and 136%, respectively).

The average total delay involved with Alt. 3 is expected to be remarkably high (12.33 min/veh). This finding is explained by the fact that the proposed flyover will serve only 19.4% of the total intersection flow moving straight ahead along approaches A and C, while the right, left and U turning movements utilizing these approaches will be confined to the remaining limited widths. Therefore, these confined maneuvers are expected to suffer considerable delays (285% and 819% for left turns using approaches A and C, respectively, compared to those of Alt. 0 - Fig. 10). These delays consequently affected the overall average delay value. Contrarily, delays on the intersecting approaches B and D are expected to be drastically reduced to 3% and 1.2%, respectively, of those of Alt. 0 (Fig. 10). The respective v/c ratios of the different approaches follow the same above trend (Figure 11).

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of field surveys undertaken in this study together with those obtained utilizing ARCADY 2 and OSCADY computer software programs to assess the expected impacts of proposed improvement alternatives, the following conclusions and recommendations may be drawn:

Conclusions

a) Variations in traffic characteristics were noticed between the different "C" Ring Road segments, sections and directions. Some roundabouts are still providing adequate levels of service (e.g., Al-Cinemat, Al-Sletah and Al-Sadd), while others are characterized by poor service levels (e.g., Ramada and Al-Muntazah). These poor service levels are attributed to the high proportions of U and left turning maneuvers utilizing the rather limited-capacity approaches.

b) For Ramada roundabout, the existing layout and geometrics are expected to result in sever delays for 1997 traffic volumes. This will result in an even worse LOS than the existing poor one. A 4-phased traffic signal rather than a roundabout at this intersection will improve the LOS in 1997, compared to that of 1992, and distribute the expected delays evenly. However, delays to be experienced during off-peak periods for this alternative will be more than those experienced in 1992. The optimum alternative for this roundabout was found to be a flyover along the "C" Ring Road to serve through traffic of

both directions and an at-grade roundabout for all other movements.

c) The existing signalized Al-Mana intersection is adequately serving traffic flows of the Airport road. However, flows on the intersecting "C" road are not equally served. Expected delays and v/c ratios in 1997 for the respective approaches of this intersection will be significantly higher, unless the signal cycle and phasing is re-designed. If so, it is expected that conditions in 1997 will be generally similar to those experienced in 1992. A flyover along the "C" Ring Road is anticipated to improve the service qualities for the Airport road approaches, but it may severely affect the turning movements of the "C" Ring Road approaches.

Recommendations

a) More comprehensive traffic surveys are generally needed to record and monitor existing traffic characteristics. All these efforts should be undertaken as an integral part of a traffic master plan for Doha City.

b) Improvement alternatives discussed in this case study are just typical examples for how such localized problems are generally dealt with. However, the final decision on which alternative to implement should take into consideration the effects on other links and/or intersections of the street network. This goal can only be achieved through the use of a well-designed traffic master plan.

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