

Economic design volume for isolated traffic signals in saturated flow conditions

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ABSTRACT: Design of isolated signals depends on traffic flows at the approaches. Since flows vary along the day, it is important to select an economic design flow. In situations where two peaks occur, the design volume is the average off peak. Such design would not optimize delay during peaks but it would be appropriate for other hours. The problem prevails in congested networks of cities in the developing world is different. More than two peaks occur. This raises the question of the need to use saturated flows for design but is it economically feasible? The paper addresses this question.. Using measured hourly flows at selected congested intersections in Cairo, comparison are made between signal design at peak, average off peak and each hour volumes. The consequences of these designs economically evaluated based on delays, lost time on the network and fuel consumption. Recommendations will be presented.

RÉSUMÉ : La Conception de signaux isolés dépend des flux de trafic dans les approches. Dans la mesure où les flux varient tout au long de la journée, il est important de choisir un flux de conception économique. Dans des situations où deux heures de pointe ont lieu, le volume de conception est la moyenne en dehors des heures de pointe. Une telle conception n'optimiserait pas le retard pendant les heures de pointe mais elle serait appropriée aux autres heures. Le problème qui règne dans les réseaux encombrés des villes des pays en voie de développement est différent. Il y a plus de deux heures de pointe. Cela soulève la question du besoin d'utiliser des flux saturés pour la conception mais est-ce économiquement faisable ? La communication pose cette question. En utilisant des flux horaires mesurés à certaines intersections encombrées au Caire, la comparaison est faite entre la conception de signal à l'heure de pointe, la moyenne en dehors des heures de pointe sommet et chaque volume d'heure. Les conséquences de ces conceptions économiquement évaluées de manière économique sont basées sur les retards, le temps perdu sur le réseau et la consommation de carburant. Des recommandations seront présentées.

1 INTRODUCTION

The objectives of the current research is to define the proper traffic flow rate for optimum signal timing design at pre timed isolated intersections in saturated flow conditions where the peak period is dominated for more than one hour during the day, with application to Cairo. This flow rate is selected based on quantitative evaluation in terms of the generated traffic delay and fuel consumption and on qualitative evaluation in terms of the intersection Performance Index. First, a special survey was carried out to study the traffic fluctuation during the day and to identify the peak volume, peak period and the design volume. Optimum cycle length and the associated

evaluation measures are defined for the volume of each hour. Emphasis is given for the analysis results of both the peak volume and the design volume. The traffic simulation software "Synchro (1)" is used. Different cycle lengths are applied for the volume of each hour to investigate the evaluation measures. A trade off between the associated evaluation' measures resulted due to the application of the signal design that suits each of three different cases is established. These three cases are the application of the signal design of each hour actual volume, the peak volume and the average off peak volume. The totals of these measures are calculated over the measuring period (7 a.m. to 9 p.m.). The differences between these volumes help in the identification of the eco-

conomic traffic volume that can be applied over the day. This evaluation helps also in selecting the best signal design technique to be applied such as pre-timed and traffic actuated techniques. The differences between these totals are monetarily evaluated over a hypothetical number of operational years to assess the benefits of the application of the economic volume.

2 BACKGROUND

Traffic signals may be defined as power operated signal displays used to regulate or warn traffic (Synchro 4, 1999). In a broad sense, traffic signals include displays for intersection control, flashing beacons, lane directional signals, and ramp metering signals. When traffic signals are installed and properly operated, they can provide specific advantages in traffic control and safety. Signal installations, however, also have certain disadvantages that may or may not apply at a particular location. The objectives of traffic signals are many, such as they reducing the frequency of certain types of accidents, increasing traffic handling capacity of the intersection, bring about considerable economy over manual control at intersections where alternate assignment of right of way is required and finally, promoting driver confidence by assigning right of way. On the other hand, signal installation at intersections increases the intersection total delay and fuel consumption and Performance Index especially during the off peak periods. The Performance Index PI is function of the intersection percentile delay D in sec, the queue penalty QP and the vehicle stops St . The function is given in equation 1.

$$PI = (D * 1 + St * 10 + QP * 100) / 3600 \quad (1)$$

Signal installation may be associated with probable increase in certain types of accident such as rear/ end collisions. Improper signal timing may cause excessive delay, increasing driver irritation (1).

Signals may be designed as pre-timed or traffic actuated. Actuated controller can be further defined as semi-actuated (coordinated or non-coordinated) and fully actuated. Under the pre-timed signal conditions, the signal assigns right-of-way at an intersection according to a predetermined schedule. The sequence of right-of-way (phases and splits), and the length of the time interval for each signal indication in the cycle is fixed, based on the historic traffic patterns. The major elements of pre-timed control are fixed cycle length and fixed phase length. Timing of pre-timed signals is easily adjusted in the field and under certain conditions can be programmed to handle peak periods. However the pre-time signals have these advantages, it does not recognize or accom-

modate short term fluctuations in traffic demand and can cause excessive delay to vehicles and pedestrian during off-peak periods ((Synchro 4 , 1999), (Homburger, Kell & Perkins, 1992), (Messer , 1998) , (TRB, 1994) & (Gerlough & Huber, 1975))

3 PROPOSED METHODOLOGY

A comparison between traffic actuated and pre-timed signal design techniques is carried in order to be able to recommend the best technique and the economic volume. Since the design of the pre-timed signals needs a volume to be based on, each "different" hourly volume is used and evaluated using the quantitative measures such as (delay and fuel consumption and PI). The steps of the proposed methodology of this research are as listed below:

- Make a selection of an example intersection with typical geometric and performance features.
- Establish a special directional traffic count survey by different hours of the day covering both peak and off peak conditions.
- Draw The traffic fluctuation to define the key volumes such as peak volume, average volume and average off peak volume.
- Use the average off peak volume in signal design and estimate the evaluation measures (Delay D_a , Fuel Consumption FC_a , and overall PI).
- Use results of signal design using the design volume with actual volume throughout the 14 hours and estimate the evaluation measures individually and compute the overall value of these measures.
- Use the peak volume as signal design volume and estimate the corresponding evaluation measures (Delay D_p , Fuel Consumption FC_p , and the overall PI)
- Repeat step number 5 using the results of using the peak volume as signal design volumes as well as the corresponding total evaluation measures.
- Identify each hour's volume and use these volumes as design volume for signal timing, estimate and study the signal design features.
- Apply the design features produced from step 8 over other hourly volume.
- Evaluate the performance measures due to using each one of these volumes for signal design.
- A trade off between the volume used for signal design and the overall value of the evaluation measures is made then the economic design volume could be identified and recommended.
- Economic assessment of the, resulting savings in delay and fuel consumption due to application of the economic design volume for signal design over different hours of the day is estimated.

4 DATA COLLECTION

A typical isolated four leg intersection is selected based on the common features of the street network in Cairo. The traffic count was carried out for 14 hours (7 am. to 9 pm.). The location of this intersection practices 13 directions of movements in its four approaches. Table 1 provides the traffic hourly volume for each approach.

5 SIGNAL DESIGN ANALYSIS

5.1 Traffic volume fluctuation and peak and average off peak volumes identification

Figure 1 shows the fluctuation of traffic volume for all directions throughout the survey fourteen hours. This fluctuation is studied to identify the peak hour, the average off peak volumes and other key volumes. Table 1 gives traffic volume by hour as values and as percentages of each of the peak and the average off peak volumes.

From the Figure and Table, it can be noticed that the peak volume is 5428 veh/hr and volumes within 95% of the peak volume are dominated for 50% of the counting period. The average off peak volume is estimated as 4916 veh/hr.. The minimum traffic volume represents about 85% of the peak volume. This observation emphasizes the necessity of the current research since the peak hour volume does not last only for one hour and consequently this affects the value of the signal design volume. The average of hourly volumes excluding peak volumes is calculated This percentage is found for 7 other hours during the counting hours.

Table 1. Traffic Volumes at Typical four Leg Intersection, Percentage from Peak Volume and Average off Peak Volume

| Hour | Direction | | | | Total |
|--------|-----------|------|------|------|-------|
| | A | B | C | D | |
| 7-8am | 978 | 107 | 1401 | 1185 | 4591 |
| 8-9 | 1362 | 1154 | 1495 | 1108 | 5119 |
| 9-10 | 1404 | 1012 | 1332 | 900 | 4648 |
| 10-11 | 1280 | 1384 | 1164 | 1116 | 4944 |
| 11-12 | 1372 | 1456 | 1272 | 1036 | 5136 |
| 12-1pm | 1432 | 1336 | 1212 | 980 | 4960 |
| 1-2 | 1416 | 1408 | 1268 | 1040 | 5132 |
| 2-3 | 1371 | 1479 | 1299 | 960 | 5109 |
| 3-4 | 1912 | 1292 | 1180 | 1148 | 5232 |
| 4-5 | 1528 | 1480 | 1252 | 1168 | 5428 |
| 5-6 | 1372 | 1440 | 1200 | 1132 | 5144 |
| 6-7 | 1252 | 1404 | 1212 | 1176 | 5044 |
| 7-8 | 1380 | 1544 | 1284 | 1144 | 5352 |
| 8-9 | 1484 | 1456 | 1260 | 1176 | 5376 |

Table 1. Traffic Volumes at Typical Four Leg Intersection, Percentage from Peak Volume and Average off Peak Volume (Cont.)

| Hour | Total | % PV | %Average |
|------|-------|------|----------|
|------|-------|------|----------|

| | | | off peak |
|---------|------|-----|----------|
| 7-8 am | 4591 | 85 | 93 |
| 8-9 | 5119 | 94 | 104 |
| 9-10 | 4648 | 86 | 95 |
| 10-11 | 4944 | 91 | 101 |
| 11-12 | 5136 | 95 | 104 |
| 12-1 pm | 4960 | 91 | 101 |
| 1-2 | 5132 | 95 | 104 |
| 2-3 | 5109 | 94 | 104 |
| 3-4 | 5232 | 96 | 106 |
| 4-5 | 5428 | 100 | 110 |
| 5-6 | 5144 | 95 | 105 |
| 6-7 | 5044 | 93 | 103 |
| 7-8 | 5352 | 99 | 109 |
| 8-9 | 5376 | 99 | 109 |

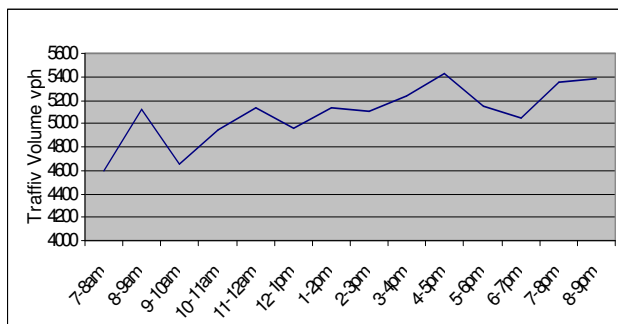


Figure 1. Hourly Fluctuation of Traffic Volume

5.2 Signal design using peak and average off peak volumes

Optimum signal timing for the intersection is investigated when using the peak volume (5428 veh/hr). The optimum cycle length is 43 sec. and the actual effective greens is 18 sec. with an intersection total delay of 201 hr. The fuel consumption is 822 liters. The PI is calculated using equation (1) and equals 250.

The optimum signal timing for the intersection is designed based on the average off peak volume (4916 veh/hr) also. The optimum cycle length is also 43 sec. and the actual effective greens is 17 sec. with an intersection total delay of 147 hr. The fuel consumption is 637 liters. The PI equals 184.

5.3 Signal design using each hour traffic volume

The optimum signal designs for each hour using that hour traffic volumes are estimated. The design is provided with all evaluation measures including the PI, delays, and the consumption. Table 2 provides

the results of the design. It is concluded from the Table that the optimum cycle length varies from 43 sec. to 65 sec. for all hours. The hourly delay values vary from 129 to 196 hrs. with total value of 2366 hrs. and hourly mean value of 169 hrs., with coefficient of variation equals 0.13.. The hourly fuel consumption varies from 565 to 801 liters with total value of 9885 liters , hourly mean value of 706 liters and with coefficient of variation of 0.109. Finally the PI varies from 155 to 244 with mean value of 207 and coefficient of variation of 0.136.

Table 2. Optimum Signal Design and Associated Evaluation Measures Based on Each Hour Traffic Volume

| Volume | C (Sec.)* | D (hr.)* | FC (L)* | PI* |
|---------|-----------|----------|---------|-----|
| 4591 | 50 | 129 | 565 | 158 |
| 5119 | 50 | 167 | 716 | 209 |
| 4648 | 65 | 130 | 569 | 155 |
| 4944 | 43 | 152 | 651 | 191 |
| 5136 | 50 | 173 | 717 | 211 |
| 4960 | 50 | 156 | 661 | 191 |
| 5132 | 50 | 173 | 710 | 211 |
| 5109 | 50 | 171 | 707 | 200 |
| 5232 | 43 | 182 | 759 | 226 |
| 5428 | 43 | 201 | 822 | 250 |
| 5144 | 43 | 172 | 719 | 215 |
| 5044 | 50 | 167 | 692 | 203 |
| 5352 | 50 | 197 | 795 | 240 |
| 5376 | 43 | 196 | 802 | 244 |
| Total | | 2366 | 9885 | - |
| Average | | 169 | 706 | 208 |

* C is the cycle length, D is the total delay, FC is the fuel consumption, and PI is the PI.

6 EVALUATION OF USING HOURLY TRAFFIC VOLUME ON SIGNAL DESIGN

6.1 Application of peak and average off peak volumes signal design

Since the optimum cycle length associated with both the peak and the average off peak volumes is the same, it is necessary to evaluate the application of this signal design with all other hourly volumes and assess the corresponding benefits and/or losses. Table 3 gives the results of this application. From the Table it can be noticed that the total delay during the measuring period is 2362 hrs. and the total fuel consumption is 9863 liters and the corresponding average PI is 208.2.

From Tables 2 and 3, it is observed that application of optimum signal design of the peak volume and the average off peak volumes over all other hours of the day instead of using each hour actual optimum signal features causes improvement in total fuel consumption, reducing it from 9885 to 9863 liters. In addition, the total delay slightly decreases (from 2366 to 2362 hrs.) while the PI remains constant at 208. It should be mentioned here that the cycle length of 43 sec. does not fit only the peak vol-

ume and the average off peak volume but also fits a group of volumes their mean value equals 5224 veh/hr.

6.2 Application of the signal design features based on the volume of each hour

Bearing in mind the analysis of the optimum signal timing design during the hours of the delay in the example intersection, it is noticed that only 3 different values of optimum cycle lengths are dominated. These values are the length associated with the peak and the design volumes (43 sec.) and 2 other values which are 50 and 65 sec. Table (3) gives the results of application of each of these values as a pre-timed signal design to all hours of the day to enable the evaluation and selection of the economic design volume. The selection process is based on the comparison between the total delay, total fuel consumption and the performance index. The Table shows that the application of cycle length of 43 sec. is more efficient than the other 2 values. This cycle length fits more the hour of traffic volume of 4591 and 4648 veh/hr. and provides the minimum of all delays, fuel consumption and PI. It is worth mentioning that the second optimum cycle length for the peak volume (5428 veh/hr) is 50 sec. which is associated with the same PI of 250 but only more by 5 hrs in delay (from 201 to 206 hrs.) and 6 units in fuel consumption (from 822 to 828 liters).

Table(3). Evaluation Measures Due to Application of Repeated Optimum Cycle Length (C=43, 50, 65)

| Hourly Volume | D at 43 | FC at 43 | PI at 43 | D at 50 | FC at 50 | PI at 50 |
|---------------|---------|----------|----------|---------|----------|----------|
| 4591 | 126 | 562 | 158 | 129 | 565 | 158 |
| 5119 | 167 | 713 | 209 | 171 | 716 | 209 |
| 4648 | 126 | 570 | 158 | 127 | 569 | 156 |
| 4944 | 152 | 651 | 191 | 156 | 657 | 191 |
| 5136 | 196 | 713 | 211 | 173 | 717 | 211 |
| 4960 | 153 | 658 | 191 | 156 | 661 | 191 |
| 5132 | 169 | 714 | 211 | 173 | 718 | 211 |
| 5109 | 167 | 705 | 208 | 171 | 709 | 208 |
| 5232 | 182 | 759 | 226 | 186 | 764 | 227 |
| 5428 | 201 | 822 | 250 | 206 | 828 | 250 |
| 5144 | 172 | 719 | 215 | 176 | 724 | 215 |
| 5044 | 163 | 686 | 204 | 167 | 692 | 203 |
| 5352 | 192 | 789 | 240 | 197 | 785 | 240 |
| 5376 | 196 | 802 | 244 | 200 | 808 | 244 |
| Total | 2362 | 9863 | - | 2388 | 9913 | - |
| Average | 168.7 | 704.5 | 208.3 | 171 | 708 | 208 |

Table(3). Evaluation Measures Due to Application of Repeated Optimum Cycle Length (C=43, 50, 65) (cont.)

| Hourly Volume | D at 65 | FC at 65 | PI at 65 |
|---------------|---------|----------|----------|
| 4591 | 135 | 575 | 160 |
| 5119 | 182 | 738 | 214 |
| 4648 | 130 | 569 | 155 |
| 4944 | 165 | 676 | 195 |

| | | | |
|---------|------|-------|-----|
| 5136 | 183 | 739 | 216 |
| 4960 | 165 | 680 | 195 |
| 5132 | 183 | 740 | 216 |
| 5109 | 179 | 726 | 211 |
| 5232 | 196 | 785 | 231 |
| 5428 | 217 | 849 | 254 |
| 5144 | 185 | 744 | 218 |
| 5044 | 176 | 712 | 208 |
| 5352 | 207 | 816 | 244 |
| 5376 | 211 | 829 | 242 |
| Total | 2514 | 10178 | - |
| Average | 180 | 727 | 211 |

Figure 2 shows the variation of the PI which takes into considerations the total delay, queue penalty and vehicle stops, at different possible design cycle lengths (C = from 40 to 70 sec.) throughout the 14 hours of the counting period. Table 4 gives the average of each evaluation measure at the above cycle lengths. The Table and Figure indicate that the application of cycle length of 43 sec. and 50 sec. is associated with minimum value of all considered evaluation measures for different volumes.

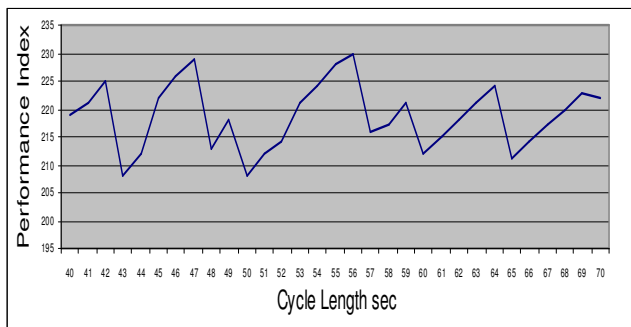


Figure 2. Variation in PI at Different Possible Cycle Length

Table 4. Evaluation Measures Associated with Application of Different Cycle Length over the Day

| CL | PI | FC | D | CL | PI | FC | D |
|----|-----|-----|-----|----|-----|-----|-----|
| 40 | 219 | 727 | 173 | 55 | 228 | 762 | 189 |
| 41 | 221 | 734 | 176 | 56 | 230 | 769 | 192 |
| 42 | 225 | 746 | 180 | 57 | 216 | 729 | 179 |
| 43 | 208 | 705 | 169 | 58 | 217 | 737 | 182 |
| 44 | 212 | 716 | 171 | 59 | 221 | 745 | 185 |
| 45 | 222 | 741 | 179 | 60 | 212 | 726 | 178 |
| 46 | 226 | 751 | 183 | 61 | 215 | 735 | 182 |
| 47 | 229 | 761 | 187 | 62 | 218 | 742 | 185 |
| 48 | 213 | 725 | 175 | 63 | 221 | 750 | 187 |
| 49 | 218 | 734 | 179 | 64 | 224 | 758 | 190 |
| 50 | 208 | 708 | 171 | 65 | 211 | 727 | 180 |
| 51 | 212 | 720 | 174 | 66 | 214 | 733 | 182 |
| 52 | 214 | 727 | 177 | 67 | 217 | 742 | 185 |
| 53 | 221 | 744 | 182 | 68 | 220 | 748 | 188 |
| 54 | 224 | 751 | 185 | 69 | 223 | 757 | 190 |
| 55 | 228 | 762 | 189 | 70 | 222 | 756 | 191 |

7 ECONOMIC DESIGN VOLUME

Based on the above results, it is clear that the dominant cycle length equals 50 sec. and lasts as optimum value for eight hours (7-9 am, 12-3 pm, 6-8 pm). The average of these volumes is 5055 veh/hr. which represents 93% of the peak volume and 102% of the average off peak volume. The second optimum cycle length is 43 sec.. This cycle length is dominated for five hours. These hours are distributed throughout the day as 10-11 am, 3-6 pm, and 8-9 pm. The average volume of these hours is 5224 veh/hr. This presents 96% of the peak volume or 106% of the average off peak volumes. It is worth mentioning that the average volume 5224 veh/hr includes the effect of the peak volume that equals 5428 veh/hr.

It is shown that differences in all the evaluation measures due to the application of the signal design of the peak volume as the design volume or the application of the traffic actuated signal design is minimal. This is due to practicing uniform volume during different hours of the day that varies from 85% to 100% of the peak volume. However, a procedure is set out in this research to investigate the economic design volume. This procedure starts with the calculation of the average volume that has the same value of the optimum cycle length. Only 3 values of cycle length are determined (43, 50 and 65 sec) as mentioned earlier. These values are applied over the whole day and the corresponding total values of the evaluation measures are calculated. The results of this application are obtained from Tables 2, 3, and 4 and summarized in Table 5. The table shows that the differences in evaluation measures between the actuated condition and the group of the peak volume are 4 hrs saving in delay (from 2366 to 2362 hrs) and about 22 liter saving in fuel consumption (from 9885 to 9863 liters).

Table 5. Example Average Volume with Corresponding Evaluation Measures Observed

| Average Volume | Cycle Lengths | Total Delay | Total FC | PI |
|----------------|---------------|-------------|----------|-----|
| 5224 | 43 | 2362 | 9863 | 208 |
| 5055 | 50 | 2388 | 9913 | 211 |
| 4648 | 65 | 2514 | 10178 | 207 |
| 5086 | actuated | 2366 | 9885 | 208 |
| 5428 | peak | 2362 | 9863 | 208 |

Regression relationships between the average volume and each evaluation measure are calibrated to study the sensitivity of each measure due to volume changes. The parameters of these models depend on the local operation features. Justification of these relations to fit different locations is out of the scope of this research. The importance of these regression models is in their capabilities to reflect the

variability between the involved variables. The application of the fitted relations resulted the estimated values of the measures that provided in Table 6.

Table 6. Example Average Volume with Corresponding Evaluation Measures (estimated)

| Average Volume | Cycle Lengths | Total Delay | Total FC | PI |
|----------------|---------------|-------------|----------|-----|
| 5224 | 43 | 2348 | 9823 | 207 |
| 5055 | 50 | 2394 | 9919 | 208 |
| 4648 | 65 | 2505 | 10152 | 210 |
| 5086 | actuated | 2385 | 9902 | 208 |
| 5428 | 43 | 2292 | 9707 | 206 |

For evaluation purposes, the average values of each traffic volumes group and the associated evaluation measures using the calibrated models are used. When the peak volume is used, the estimated delay associated with the peak volume group is 2292 hrs, fuel consumption is 9707 liters and the PI is 206. On the other hand, when the group that includes the actual traffic volumes is used, the estimated delay equals 2385 hrs, the fuel consumption equals 9902 liters, and the average PI equals 208. Consequently, the application of the peak volume signal design (43sec.) uniformly over different hours saves around 195 liters of fuel (from 9902 to 9707 liters) and reduces delay by 93 hours (from 2385 to 2292 hrs). As a result, a volume of from 96% to 100% of the peak volume can be defined as the “economic design volume” since it is associated with best performance over all hours of the day. These results show that the application of "pre timed " signal design using signal design associated with the peak volume is more efficient than using "traffic actuated" signal design technique.

8 MONETARY VALUATION OF THE IMPACT OF ECONOMIC DESIGN VOLUME APPLICATION FOR SIGNAL DESIGN

This research shows that the selection of the signal design associated with the peak volume as pre-timed signal design is the best. This selection gives the minimum values of the evaluation measures such as delay and fuel consumption. The differences if the evaluation measures between the case of the traffic actuated signal performance and the application of the signal design of the peak volume are calculated. These differences are considered as savings when calculated in money.

The estimation of these savings' money values are necessary to enable the analyst to assess the benefits due to the optimum choice for signal design volume. The evaluation measures used for this analysis are the delay and the fuel consumption. The evaluation takes into consideration a hypothetical operation period of 10 years with 340 days of annual

normal performance. The necessary information for this evaluation includes the fuel price per liter, the value of persons travel time in Egyptian urban areas and the price consumer index for 2003. The literature and the information available about the existing situation help in identifying these requirements. Consequently, the value of persons' travel time in Egyptian urban transport studies is reviewed and found as 2.617 LE/vehicle.hr of volume in 1987 prices (Abdel_Nasser,1987) . Estimation of this value in 2003 price needs the price consumer indices for years 1987 and 2003. Available references give the price consumer index for 1998 (= 389.9) referred to 1987 index(= 100). Complementary references give the price consumer index for 2003 (= 132.2) referred to that for 1996 (=100). Based on this information and additional calculations concluded that the price consumer index for 2003 is 445.7. ((Census Report, 1997 & (Central Agency for Public Mobilization and Statistics ,2003)).

The calculations indicate that the total savings due fuel equals 662,796 LE per intersection and the savings due to time savings equal 3,698,589LE per intersection. Consequently, the total savings approaches 4,361,384.8 LE for one intersection based on the estimated data from the models. According the urban road network size and geometric features similarities between intersections, the economic value of these savings of the network can be assessed.

9 SUMMARY

In this research, the choice procedures of the economic design traffic volume for isolated signal design in saturated flow conditions are investigated. Typical intersection is selected to establish the field work and consequently the analysis. This intersection is selected as four-leg intersection in Cairo CBD area. A traffic count survey was carried out for continuous 14 hours in under normal operation conditions. Volumes were measured by approach and direction and consequently, the traffic fluctuation was obtained and the peak volume and the average off peak volumes were determined. It was investigated that the minimum traffic volume presents 85% of the peak volume. This observation with other features of the locations (i.e. road width, saturation flow) emphasized the continuous over saturation of the intersection over the measuring period. The intersection signal was designed by different pre defined and experimental volumes to enable the choice of the economic volume over the different hours of the day. The computer software “Synchro” was used in this research for signal design. First, each hour volume , including the peak volume, was applied to the intersection as the signal design volume and the associated evaluation measures were estimated. These

evaluation measures are total delay, fuel consumption and PI. The PI takes into consideration, in addition to the delay, the queue penalty and vehicle stops. The range of the best cycle length in seconds during the day was identified (40 to 70 sec.). Each value of the cycle length in this range with one sec. increment including the dominated values of optimum cycle lengths (43, 50 and 65 sec) were tested and applied one at a time over the 14 hours of the counting period and the corresponding evaluation measures were assessed. Simple regression relations between traffic volume and the corresponding evaluation measures are drawn to help in testing this approach versus any traffic volume. This analysis showed that the application of the signal timing resulted from using the peak volume as pre timed signal is more beneficial than application of each hour volume as traffic actuated technique. The assessment of the evaluation measures helps in this conclusion. The economic values of the savings in delay and fuel consumption in monetary values were assessed for a hypothetical period of 10 years. If only one intersection were considered, savings in fuel reaches about 662,796 LE and in delay savings reaches 3,698,589 LE with total amount of approximately 4.36 million LE. The size of the urban road network and number of intersections should be considered in the total economic evaluation.

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RESUME

La conception des signaux routiers isolés en espace urbain dépend des flux de trafic mesurés à distance amont sur chacune des rues en direction du carrefour. Puisque les flux sont variables selon les heures de la journée, l'expert doit choisir un contexte économique d'étude pour des signaux isolés. Quand il n'y a que 2 pointes caractéristiques de trafic (le matin et le soir), on retient habituellement l'heure de référence, qui est le résultat de la moyenne des autres heures de la journée. Bien qu'une telle étude n'optimise pas les délais d'attente pendant les deux heures de pointes, cependant elle est bien appropriée pour les autres plages horaires de la journée. Les problèmes essentiels pour les réseaux congestionnés de nombreuses villes dans les pays en voie de développement sont cependant différents. Il y a plus de 2 pointes et Cette réalité soulève la question d'avoir à utiliser les flux maximums pour la conception, mais est-ce encore économiquement raisonnable d'appliquer la conception des situations saturées ?

Ce document traite ce problème de conception et tente de trouver la réponse adéquate à la question posée. A partir de flux mesurés par heure à certains carrefours congestionnés du Caire, des comparaisons seront faites entre la conception du signal dans heures de pointes et la moyenne des autres heures de la journée et chaque heure de reference Les conséquences de ces conceptions seront économiquement évaluées en se basant sur le résultat calculé sur les retards globaux et pertes d'heures/véhicules estimés et la consommation d'essence des véhicules retardés. Des recommandations seront présentées.