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WHAT SHOULD BE DONE TO IMPROVE ROAD AND TRAFFIC
CONDITIONS IN AL-MEDINA AL-MUNAWARA

ما يجب عمله لتحسين حالة النقل والمرور في المدينة المنورة

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خلاصة - مما لا شك فيه أن المدينة المنورة (ثاني المدن المقدسة عند كافة المسلمين) تشهد في الأونة الأخيرة تطورا هائلا في جميع أوجه وأنشطة الحياة . ولقد كان تأثير هذا التطور عظيمًا ومباشرًا على النمو الحضري وتوزيعاته مما أثر في شكل شبكة الطرق داخل المدينة المنورة وعند مداخنها وكذلك على شكل حركة المرور وانظمته . ولقد بذلت السلطات المسئولة في المدينة المنورة جهودا كبيرة في دراسة وإعادة تخطيط حركة النقل والمرور تمثلت في ثلاثة دراسات حيث تمت الدراسة الأولى بمعرفة الاستشاري " روبرت ماثيو وجونسون " في عام ١٩٧١ وكان نصيب دراسة المرور فيها لسكيرا نظرا لعدم وجود مشكلة حقيقية في ذلك الوقت بينما كانت الدراسة الثانية بمعرفة (المجموعة الاستشارية العربية للإنشاء والتعمير) في عام ١٩٧٨ حيث كانت لدراسات النقل والمرور النصيب الأكبر من حيث تجميع البيانات والتخطيط لمستقبل التنقل والسرور بالمدينة المنورة ولقد كانت الدراسة الثالثة هي دراسة موقعية سريعة بمعرفة البنك الدولي عام ١٩٨٤ م . وعلى الرغم من أن الدراسات السابقة قد احتوت على مجموعة من البيانات والتخطيطات الهامة ولكن نلاحظ أن جميع التوقعات المستقبلية في جميع الدراسات لم تطابق الواقع بالأضالة التي تعدلات هامة قد حدثت في شبكة الطرق مما استدعى اجراء دراسة جديدة للحصول على بيانات جديدة واقعية يتم على اساسها التخطيط المستقبلي لحركة المرور . ويهدف هذا البحث الى مراجعة الدراسات السابقة وتحليلها وعمل مسح كامل للوضع الحالي للمرور داخل المدينة ثم اقتراح الخطوات اللازمة لتصميم خطتين لتخطيط النقل والمرور في المدينة المنورة على الأجلين القصير والطويل للوفاء بمتطلبات المدينة المنورة في مواسم العمرة والحج .

ABSTRACT- Medina, the second Holy City for all Moslems, has recently experienced remarkable growth in all fields of activities. Major changes have resulted in its urban development pattern which influenced the shape of road network and traffic patterns and characteristics.

Three comprehensive traffic studies have been performed to evaluate and forecast traffic volumes in Al-Medina Al-Munawara. The first was by Robert Mathew and Johnson Co. in 1971. The second was by the Group of Arab Consultants for Development and Reconstruction in 1978 while the third was a review study by the World Bank in 1984.

Although these studies have collected a valuable amount of data about road and traffic, each study has some deficiencies where traffic forecasts by all studies are not valid at the present time. Moreover, some links have been added to the road network like Manakhah tunnel and the two way bridge in the first ring road which makes quite urgent, the need for further study and analysis in both the short and long terms.

The paper reviews the previous studies, analyses the data, surveys the existing situation of the network and intersections, evaluates the traffic and road conditions and suggests appropriate steps towards developing two appropriate transportation planning strategies, short and long term, to achieve improved traffic operation in the Holy City of AL-MEDINA AL-MUNAWARA.

1. INTRODUCTION

Medina, the second Holy City after Makkah for all Moslems has recently experienced

remarkable growth in many fields. City population becomes more than half million while another half million visit the city during Omra and hidji seasons. No doubt that roads, which contribute to the growing population, visitors and all faces of development provide direct safety, convenience, and other benefits to the economic and social life of the city; and brings indirect benefits through enhancing general prosperity. For these reasons Saudi Arabian authorities commit huge investments in studying, designing and constructing road networks in the kingdom, inside big and important cities, and attempt to manage each network so as to keep it in top performance and improve levels of service.

Two major studies were performed to evaluate transportation and traffic conditions as parts of comprehensive planning studies for Medina. The first study was by Robert Mathew and Johnson Co. (London) in 1971 while the second is due to the Group of Arab Consultants for Development and Reconstruction in 1978. Moreover, a review study was performed by the World Bank in 1984.

3. HISTORICAL BACKGROUND

Medina city lies at 600 m above mean sea level at about 150 Km inland east of the Red sea. Climate is hot, dry desert. Rainfall averages 90 mm per year. Recent modernization has destroyed most of the green areas of the city.

The Haram, where pilgrims and visitors travel to visit the prophet's mosque and sanctuary is the core and heart of the city. Medina population increased from 30,000 in 1950 to 310,000 in 1978. Saudi residents represent 82.7% and the "productive people" represent 19.3% of the total population. Car ownership increased from 4304 cars in 1971 to 24624 in 1978.

Land use values was about 3.75 hectares per 1000 persons for public use (mosques, schools, hospitals, etc.) and 1.6 hectares for 1000 persons for roads (0.5 hectares for major roads, and 1.1 hectares for municipal and collector roads) in 1971.

Increasing car ownership and population have resulted in some traffic problems specially around the Haram. Delay times, low speeds, conflicts with pedestrians and lack of parking places are some problems which need to be studied.

Robert Mathew and Johnson Co. had carried out in 1971 a comprehensive social and economic survey. Transportation and traffic had received little attention in this study due to the low car ownership at that time, when no real traffic problem existed. The important findings of this study can be summarized as:

- population was 138,000. With 6.5% rate of growth population expected to increase to 250,000 as minimum by 1991.

- land use values for 1000 persons were:
 - 3.75 hectares for public use
 - 1.1 hectares for minor roads and collectors
 - 0.5 hectares for major roads.

- Employment structure was found to be:
 - 10.4% working in commodity sector
 - 28.6% working in distribution sector
 - 61% working in service sector.

- 78% of all pilgrims to Makkah, also visited Medina. This presents 100,000 residents in Medina throughout the year.

- Traffic volume would increase in Medina streets from 6 to 10 times by 1991.

- Car ownership is 1.6 vehicle for each 1000 persons.

- Number of vehicles moving at peak times was 5090.

However, within a few years, all these forecast figures had been exceeded. The under-

stination underlined the need for another comprehensive study to obtain more realistic figures for planning.

The Group of Arab Consultants for Development and Reconstruction (Mausali, Shaker, Mandili) was the responsible for the 1978 project No.202 aimed to give a Master Plan for Medina. Transportation and traffic formed a reasonable part in this study. The survey included traffic counts, road-side interviews, home interviews, analysis of data and computer analysis. The main findings of this study are:

- Total area of major, minor and collector roads are:
 - 13.68% in south area
 - 36.43% in central area
 - 16% in west area.
- Car ownership was 24624 vehicles with a rate of 79 vehicles for each 1000 persons.
- Population was 310,000 with 575000 employees.
- Trip characteristics were:
 - 46% by private cars
 - 11% by taxis
 - 43% on foot.
- The existing road network which was based on a radial pattern was totally inadequate even for the current population and vehicle ownership level.
- Drivers prefer to go by major roads rather than local streets even with increased distance or travel time.
- Medina needed 11340 parking places by 1991 of which only 3000 existed.
- 70% of the parked vehicles park for only one hour or less while 30% park more than one hour and less than six hours.
- All intersections need to be redesigned.
- All intersections need to be operated efficiently.
- All roads and streets need road marks and roadway signs.
- No shoulders were existing in most of the streets.
- Pedestrians presented many problems to traffic. Subways or overhead bridges may be constructed at strategic positions.
- There were 479 accidents in 1978 resulted in 893 injured + 153 killed. These figures increased to 530 accidents in 1979 with 1016 injured + 208 killed.

This problem was subjected to a further evaluation and assessment by the World Bank in 1984. The findings of that evaluation were:

- Volume of traffic entering the central area had increased by almost 50% inter-survey period.
- A major increase in the proportion of private cars in traffic flow had happened accompanied by a steep decline in the proportion of taxis and pickups.
- Considerable congestion was experienced within the inner ring roads.
- There was much illegal parking and other problems of congestion at the urban core around the Haram.
- The central area remains the key problem area and Master Plan proposals have been largely unrealized.
- Demand for parking spaces is exceedingly high. Medina needed 7500 spaces in 1985 while the plan estimated 8340 by 1991.
- The level of public transport operations and use are considerably lower than forecast.

- Further detailed studies are needed for future planning.

4. MEDINA HIGHWAY NETWORK

Medina is fed by four main roads, figure 1. They are:

- Medina - Jedda - Makkah (Al Hijra Road) which is a six lane divided well designed road. Road marks and roadway signs are provided everywhere. There are many exits from this road. Jedda is 389 Km, and Makkah is 412 Km from Medina. The road is a first class road, and provides the highest level of service. Service lanes and parkings are provided. Average daily traffic volume reaches 100,000 vehicles/day.
- Medina - Yanbou - Jedda road (old road) which is a two lane highway. It is longer and has a lower level of service than the Al Hijra Road. Yanbou is at 234 Km and Jedda is at 413 Km from Medina. The road has many curves and has neither enough road marks nor roadway signs. Average daily traffic is about 3000 vehicles/day.
- Medina - Qassiem - Riyadh road. The road is four lane divided highway fulfilling all geometric principles. Qassiem is at 530km from Medina while Riyadh is at 918km. Average daily traffic approaches 13,000 vehicles/day.
- Medina - Tabouk road of 676 Km long is a four lane divided highway. It is well designed. Average daily traffic approaches 11,500 vehicles/day.

All these roads are operated safely and traffic volume does not exceed capacity except during Hadj time when traffic increases and approaches capacity especially the Medina and Makkah roads.

Medina local streets can be summarized as in figure 2:

- * Medina north and east are fed by:
 - Al Malek Fahd Ibn Abdel Aziz (Al Matar) Street which is the extension of Qassiem road into the city.
 - Sayyed Al Shuhadaa Street and Osman Ibn Affan (Al Ayoun) Street which are intersected with Al Jameaat road.
 - Abou Bakr Al Seddeeq (Sultana) Street which is led by Tabouk road and leading to Islamic University and Al Jameat road.
- * Medina west and south are fed by:
 - Al Seeh street and Bab Al Salam street which are intersecting with Al Jameat road and leading to Madiant Al Hijaj and King Abdel Aziz University and stadium.
 - Al Hijra road leading to Qubaa street, Al Amir Abdel Muhsen Ibn Abdel Aziz (Qurban) street and Aly Ibn Abou Taleb (Al Awali) street.
 - Omer Ibn Al Khattab (Al Anbaryia) street which is fed by o'rwah street and old Medina-Yanbou road.
- Moreover, Medina has a complete ring road around the Haram area under the name of Al Malek Faisal Ibn Abdel Aziz (Al Steen) street. The ring is four lane divided highway with eleven intersections as shown in Fig. 3. Most of these intersections are at grade with traffic light signals. All intersections are controlled by four phase system.

All these streets have varied widths at different sections. Some of the streets has

a central median while others are without. Some parts of the street has two directions while other parts are one way. Most of the streets are narrow and in some cases only one car could hardly move through them, especially on collector roads. Most of the streets have an asphalt surface and some are in good condition while others need upgrading. Side walks are very narrow and in some cases they are even less than one meter wide. Local streets have no side walks. Street medians are about two meters with very few exceptions. Most streets are well lighted and equipped with mercury or sodium lamps. Traffic signs are quite adequate. Automatic traffic light signals are provided. A brief description of Medina streets condition is provided in table 1.

Traffic volume is increasing in many of Medina streets. Two way traffic volumes for 1978 in some streets are available from the "Medina Action Master Plans" while the corresponding values are obtained from the review study of the World Bank. These values are presented in Table 2 and illustrated in figure 5 from which one can see that traffic volume in Qurban street has doubled while it is increased in Al Awali, King Abdel Aziz, Airport and Sultana streets. Traffic is almost the same in Anbaria and Quba streets.

5. DISCUSSION ON CURRENT ROADS AND TRAFFIC CONDITIONS

Road and traffic conditions in Medina can be summarized as:

1. The first ring road has recently been completed and forms a key link in the road network. The main function of the ring is to keep main stream traffic out of the centre, provide access to local traffic, maintain the traffic stream, and to direct drivers to the best route to their destination avoiding all unnecessary circulation. The ring road was found to be of little help to achieve its function due to:
 - The inadequate intersections of the ring with other roads. The ring has seven four leg surface intersections, three separated grade interchanges and three T-at grade intersections. Some intersections have been recently redesigned by the consultant Dr. Ahmed Farid and implemented under the Ammana (City Council) supervision provide smooth turns, separate traffic stream and achieving higher degree of safety to the drivers and pedestrians while the rest are now under design by the consultant. Most of the undesigned intersections contain many geometrical faults in the form of improper curves, medians and paved widths.
 - All intersections need to be designed to handle the traffic volumes and provide efficient operation. A study performed by the consultant at Bab El Shamy intersection (Figure 4) showed that although the intersection is controlled with automatic traffic lights, queues of vehicles form all day at all directions. For example a queue of length 200 vehicles was formed in the mornings of Sunday 15th of July 1987 while a queue of length 183 vehicles was formed in another direction at the intersection on the 17th of the same month. Green times, red times and cycle time must be recalculated at all intersections according to expected traffic in each direction, width of each approach, and saturated flow.
 - Many vehicles were observed to park on ring road lanes which reduces its capacity and efficiency and lowers its level of service.
 - There are no clear and good exits nor entrances to and from the ring road to the central area.
 - The conflict between vehicles and pedestrians need to be solved along the surface part of the ring road especially around the Haram area.
2. Public transport in Medina is of no real use at this time. It does not operate efficiently either due to:
 - improper plan and unsuitable routes; or/and
 - inconvenient buses; or/and

- high bus fares; or/and
- high car ownership.

Public transport must be studied thoroughly because it represents the magic key to solve many traffic problems in many cities; in the world. To attract trips to public transport especially those ending or starting in the central area, bus priority systems should be encouraged.

3. Parking demand in Medina is either short term parking due to shopping and praying or long term parking due to workers in the city. Studies showed that urgent demand of car parks in Medina is about 8450 spaces which needs area more than 25 hectares around the Haram. There are now plans to construct some underground car parks and some other multistorey car parks. In all cases these parks should be assessed in the context of the whole network. Exits, entrances and method of storing and delivery must be designed in a way not to disturb the traffic stream. Car parking demand in other places in Medina should be studied carefully.
4. Studies showed that 68% of internal trips in Medina were made on foot in 1971 while this figure became 43% in 1978. This means that pedestrian movement is quite important and need to be studied and handled in a such a way not to conflict with traffic movement. [3].
5. Although a second ring road is not yet completed, it so far appears to have no effect on relieving congestion on the first ring road. Studies are needed to determine how traffic should to be redistributed between the first and second ring roads. The area around the second ring road and between the rings should be considered.
6. Driver's behaviour and traffic characteristics in Medina should be considered in the context that drivers prefer to go by the major roads even if this means an increased travel distance.
7. The main purpose of the Manakhah tunnel (Figure 4) is to establish pedestrian links on surface with residential quarters and the Haram. The extension of the tunnel under the first ring road must be studied carefully. The consultant has prepared a three stage design of this intersection which appears to be quite adequate (5) but should be reviewed as a part of the whole study.

Permitting only pedestrian on Qubaa road should be considered since it is the most important business and commercial area in Medina. Additionally its limited width and impossibility of widening, makes this an attractive alternative.

Finally, the growth of the city has not been matched by the development of an appropriate road network. The present road network should be assessed in relation to present and future traffic and urban growth conditions especially the need for vehicular accessibility to unserved areas.

RECOMMENDATIONS

Two transportation planning strategies should be formed in Medina. The first is short term plan for a period ranging from five to ten years while the second is a long term plan.

The goal of the short term transportation plan is master to adjust, complement and correlate the given elements within an integrated planning framework which should consider national, regional, local and transportation planners in such a way to combine economic, social and modernization factors to achieve safe and convenient movement of people and vehicles. It should aim mainly to :

- increasing the efficiency of the first ring road by stopping radial through traffic, reducing the number of junctions, and simplifying the operation of intersections.
- developing as many parking spaces as possible.
- developing bus priority systems to encourage public transportation in the city .
- collecting data about traffic accidents, street inventory, water pipeline networks, sewage networks, . . . etc .
- educating and preparing a team for traffic studies, analysis and operation.

The proposed long term transportation plan should aim to:

1. developing a master plan suitable for the continuous change in traffic movement, car ownership and external traffic to and from Medina.
2. developing realistic growth rates for traffic forecasting.
3. evaluating the existing highway network.
4. evaluating and redesigning intersections to reduce delay times and congestion .
5. planning public transport system especially in the crowded areas and devising a bus priority system within and around the Haram area.
6. building a highway data bank to help the decision makers.
7. performing an Area Traffic Control Systems in Medina.
3. preparing three transportation planning strategies for Medina suitable to :
 - Normal days
 - Omra season and during Ramadan month which have different characteristics
 - Hidj season.

These strategies should be performed by a local qualified staff under a continuous and tight supervision of resident consultant office with the great support of city council, traffic department, electricity and water departments. The need of resident consultant is right for as long period as possible and to deal with them. Moreover the local staff can benefit from his experience in data collection, analysis and dealing with problems to be able to implement these plans and deal with them in future.

Finally it worth noted here that the Medina city authorities has recently established a pioneer new traffic section, include qualified local staff, to deal with traffic problems but it needs a lot of support and experience and need to visit some other cities with similar problems to see how they are handling such problems.

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Table 1
Road Conditions in Medina

Street	Length ms.	Average Paved Width	Average Sidewalk ms.	Median Width ms.	Notes
Airport	8340	15.6-19.0	1.3-2.5	1.0-5.4	
Aurwa	7990	12.3-19.0	0.7-2.5	0.5-5.0	
Abu Osman Ibn Affan	5910	5.0-28.5	- - - -	5.0	
Ist Ring Rd	7035	7.15-15.5	0.0-3.0	0.0-5.0	
Aly Ibn Aby TALEb	2630	20	5.0	5.0	
Qubaa	3925	7.7-32.9	2.0-5.05	1.0	
Qurban	2941	18.1-32.9	2.0-5.35	1.0-3.1	Both Direct
King Abdel Aziz	6799	7.8-15.4	0.0-4.6	0.0-1.9	
Sayed Al Shuhada	2975	10.2-16.6	0.0-7.0	- - - -	
Abu Zarr	8480	7.0-13.6	0.0-7.5	- - - -	
Anbariah	1090	14.0-14.3	4.5	2.5	
Manakhah	780	15.6-26.5	4.6-8.0	1.0-6.0	
Sieh	1230	18.6-34.8	5.0-14.0	2.3-9.8	
Islamic University	2980	9.8-22.1	0.0-1.7	0.0-1.9	
	890	10.0-11.6	0.0-2.2	- - - -	

Table 2
Comparison Between Traffic Volumes
in Medina Streets

Streets	Traffic Volume Per day		% increase	Notes
	1978	1984		
Anbaria Rd.	35235	34500	-2 %	Traffic is measured in PCU .
Qubaa	42780	45000	+5 %	
Qurban	14240	30500	+114%	
Awali	15270	22200	+45%	
King Abdel Aziz St .	4690	37800	+706%	
Airport Rd.	33730	38600	+14%	+ Ayoun St.
Sultana ,	31050	50000	+61%	
Sieh St .	17100	28900	+69%	

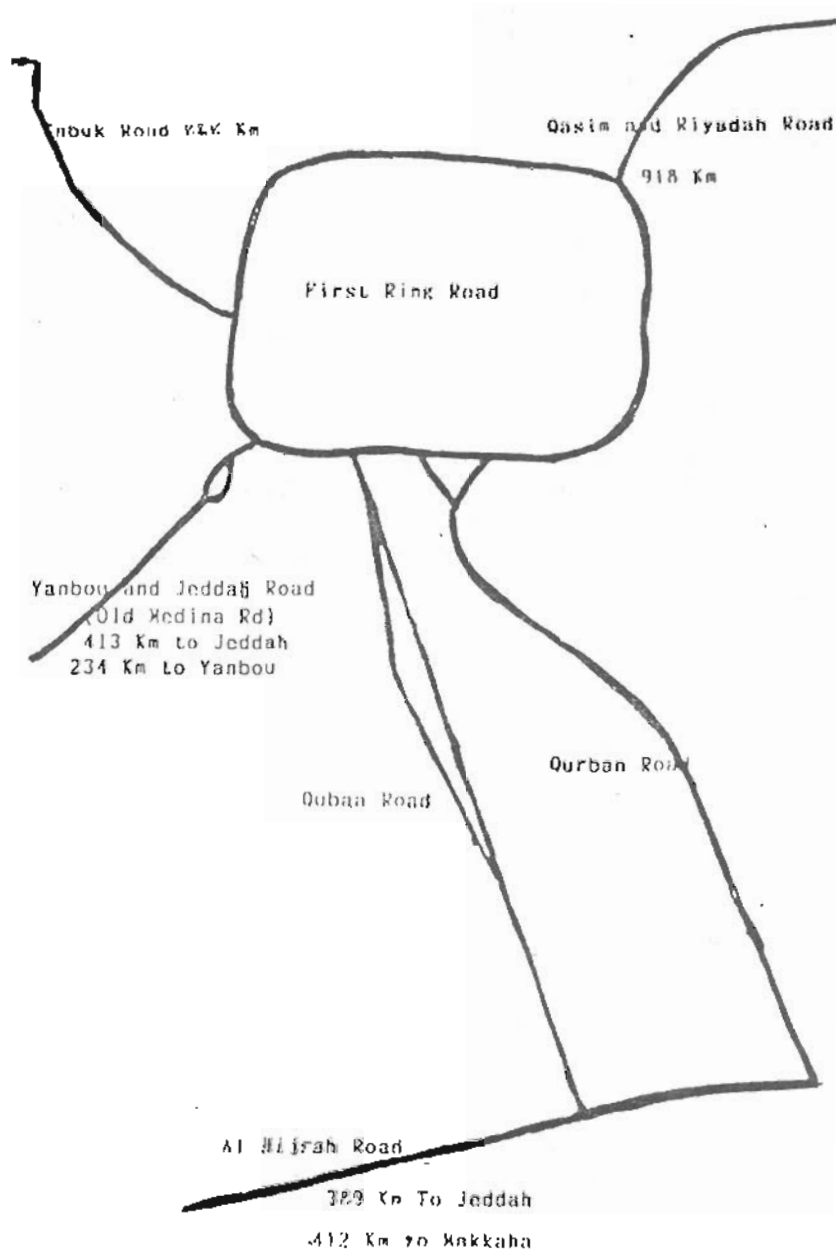


Fig (1) Main Roads To and From Medina

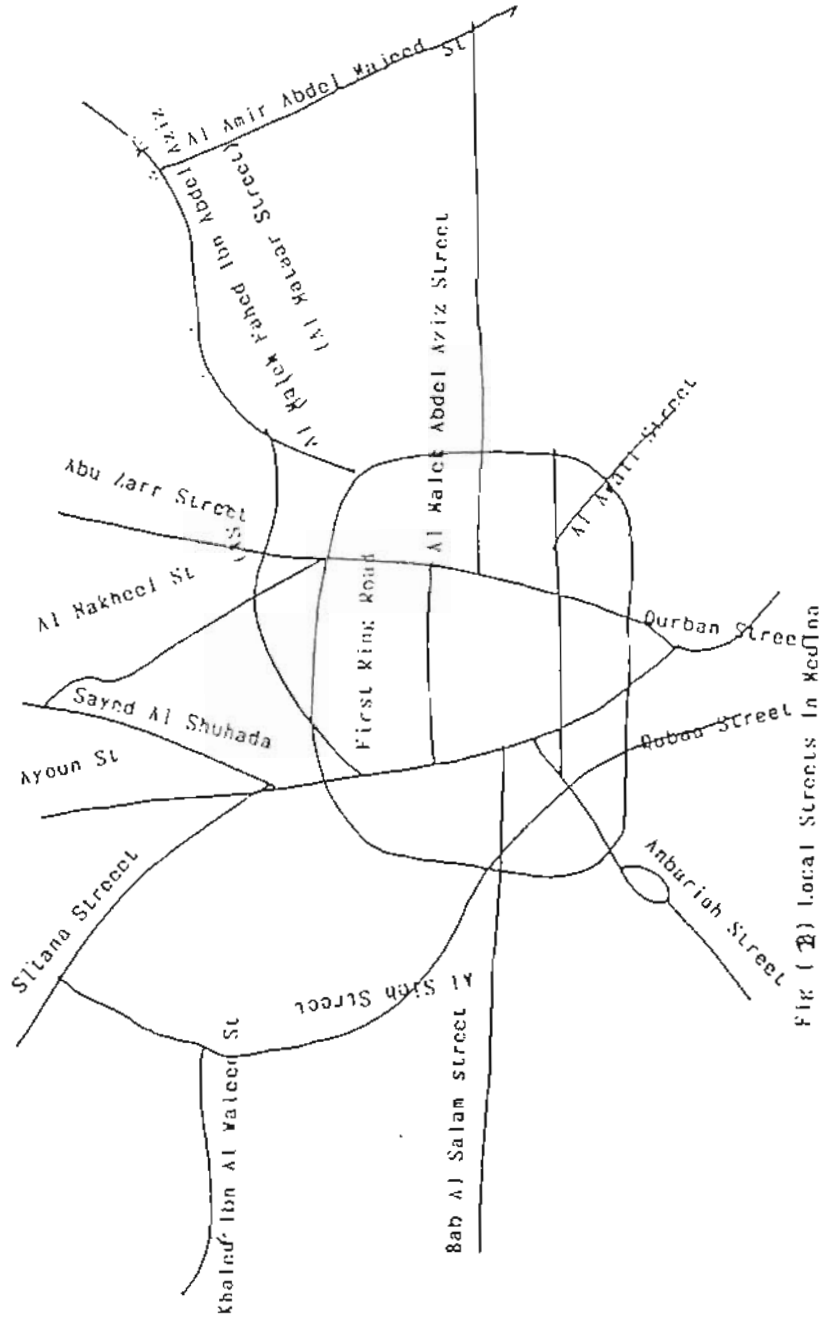
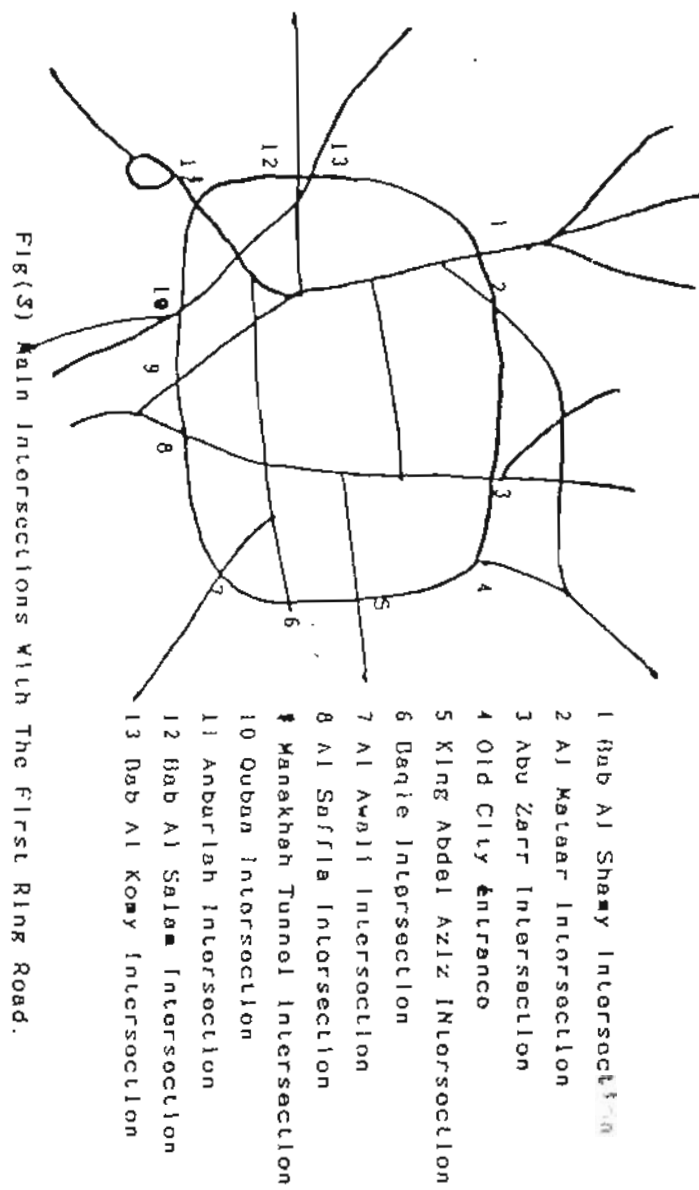


Fig (B) Local Streets In Medina



Fig(5) Main Intersections With The First Ring Road.

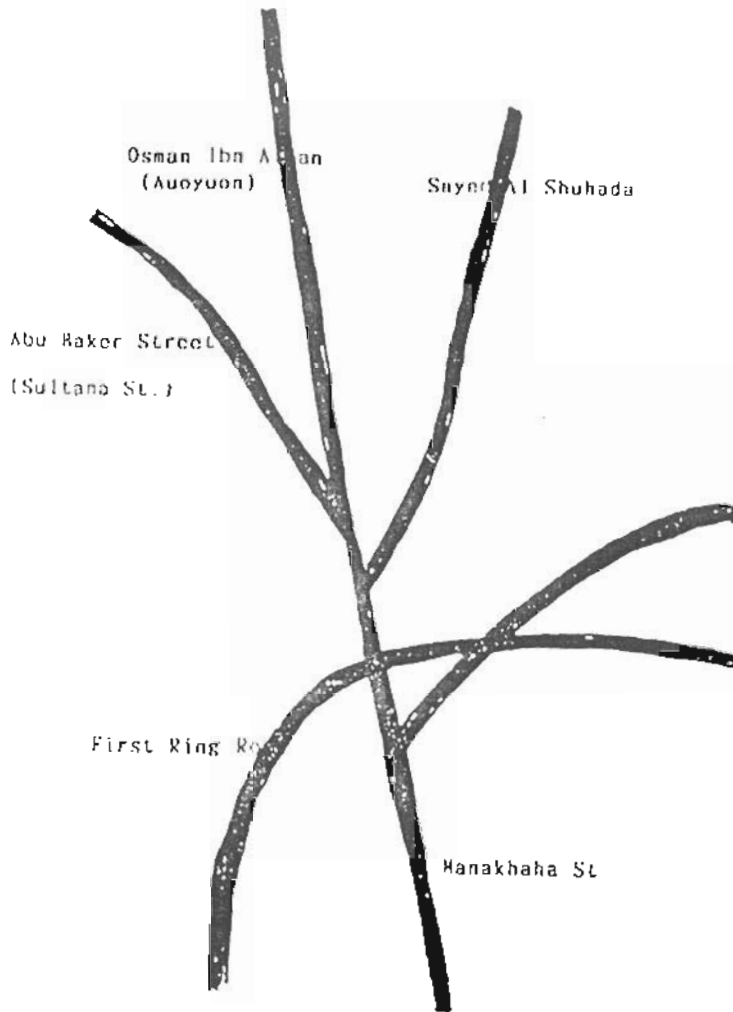


Fig (4) - Bab Al Shamy Intersection

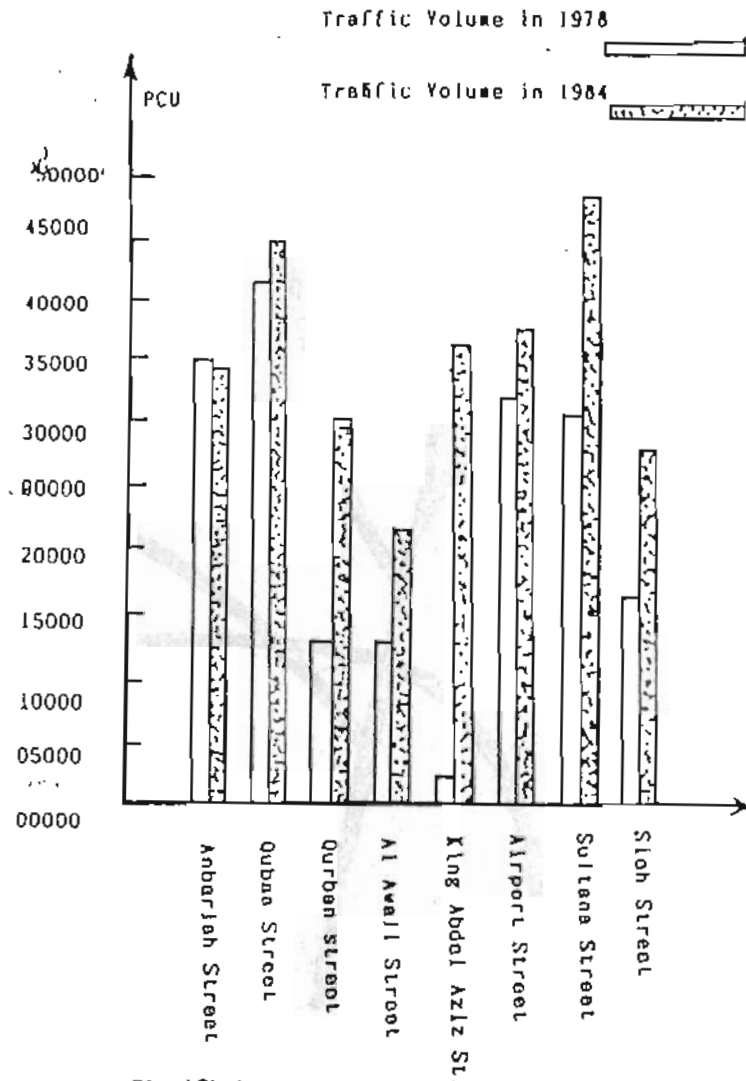


Fig.(5) Comparison Between Traffic Volumes in Medina Streets