

# Parking Problem of Arafat

by

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A Thesis Presented to the

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DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the  
Requirements for the Degree of

**MASTER OF SCIENCE**

In

**CIVIL ENGINEERING**

June, 1988

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BY

**AL-ABDUL-GADER, ABDULLA HAMAD**

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**PARKING PROBLEM OF ARAFAT**

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## ABSTRACT

Parking is one of the extremely important issues for all automobile users. It is even more important for special events such as the Hajj. Arafat area is one of the most significant parts of the Hajj, where huge number of pilgrims arrive at the morning of the 9th of Thul-Hijja in their different types of vehicles, park, remain till sunset and depart to Muzdalifah.

This study examines the existing parking problem of Arafat in detail, suggests some alternative parking solutions for present and the future up to year 1425 H, evaluates the different parking proposals and selects the best system to be implemented at Arafat.

Finally, this study gives some recommendations and an operational plan for Arafat.



## الخلاصة

ان موضوع مواقف السيارات يعتبر من أهم المواضيع التي تهم جميع سائقي السيارات . وخاصة في المناسبات الخاصة كالحج .

ان عرفات هي احدى المشاعر المقدسة التي لها أهمية كبرى في الحج حيث يصل اعداد هائلة من الحجاج الى عرفات صباحا في اليوم التاسع من ذى الحجة ، ثم يوقفون سياراتهم ويمكنون الى مغيب الشمس حيث يغادرون الى مزدلفه .

ان هذا البحث يتناول مشكلة مواقف عرفات الحالية بالتفصيل ويقترح بعض الحلول لمعالجة مشكلة المواقف في الحاضر والمستقبل الى عام ١٤٢٥هـ ويشتمل أيضا على تقييم للحلول المقدمه واختيار أفضلها .  
وختاما يحتوى هذا البحث على بعض التوصيات لتسهيل حركة السائرين في عرفات .

## Chapter 1

### INTRODUCTION

#### 1.1 Problem Statement

The Hajj is the annual Islamic pilgrimage to the holy city of Makka. It has existed since long before Islam from the days of the prophet Ibrahim. Since the ninth year of the Islamic Lunar Year (Sabiq 1985) the Hajj became an obligation at least once in a life time for those who can afford it.

There are many ways to perform Hajj. Following is a brief description of the method many pilgrims follow:

By the eighth day of Dhul-Hijjah, the last month of the lunar Islamic calendar, almost all the pilgrims are already in Makka (see Figure 1.1) or its environs (shown in Figure 1.2). On the morning of the eighth day, some pilgrims go from Makka to Mina (see Figure 1.3), (a distance of about 8 km) to camp there for that day, and the rest either proceed directly to Arafat or stay in Makka. On the ninth day, all the pilgrims must be in the plain of Arafat (see Figures 1.4 and 1.5), (20 km from Makka). Being in Arafat on this day is the most important rite of the Hajj. Pilgrims spend their day in Arafat in prayer and supplication and prefer to visit the Mountain of Mercy which is located as shown in Figure 1.6, while there are no required activities within Arafat.

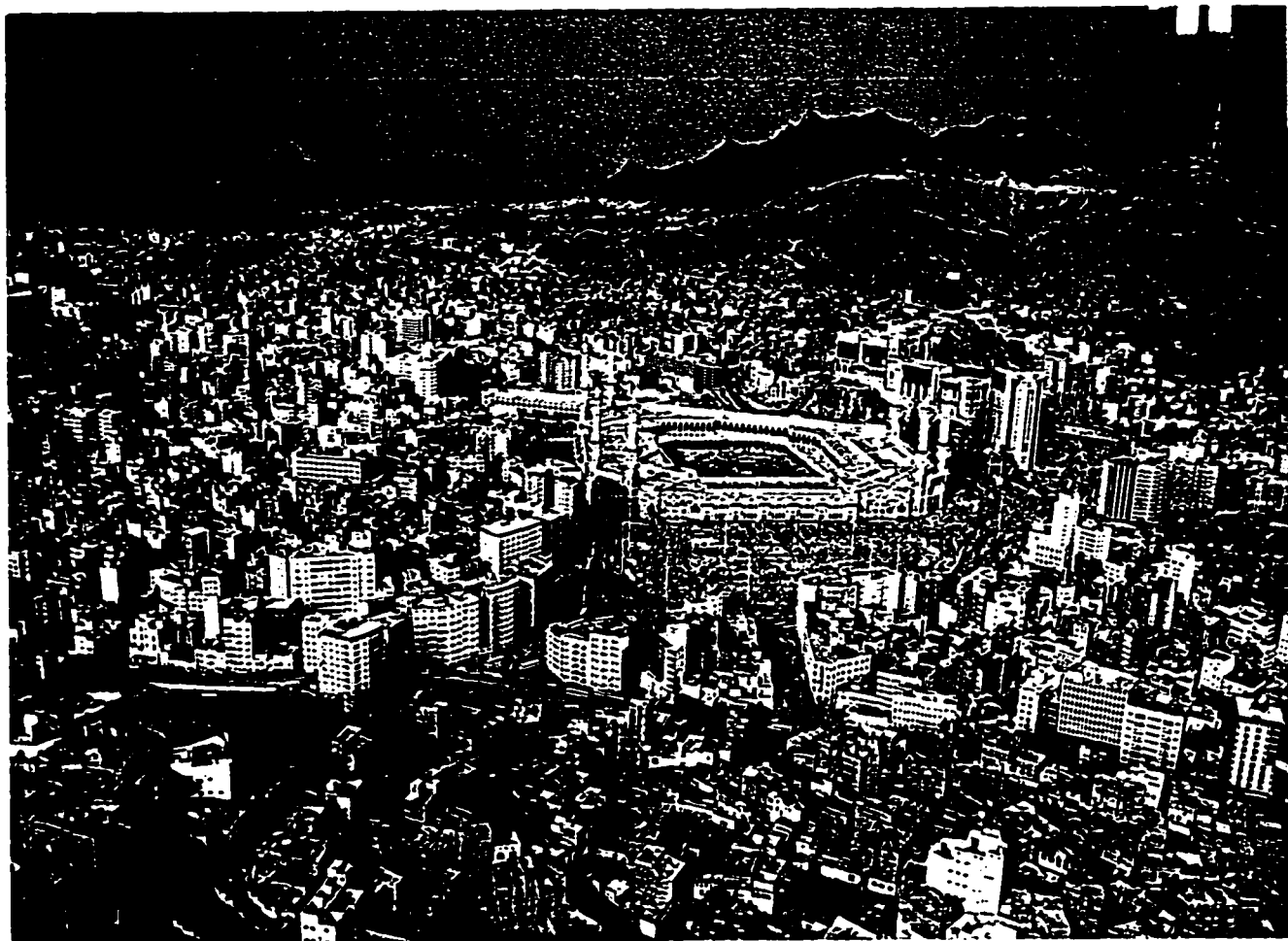


Fig. 1.1: The Holy Mosque in Makka.

مكة المكرمة  
المنطقة الحرة  
عاصمة المملكة العربية السعودية

MINA

MECCA

ARAFAT

MUZDALIFA

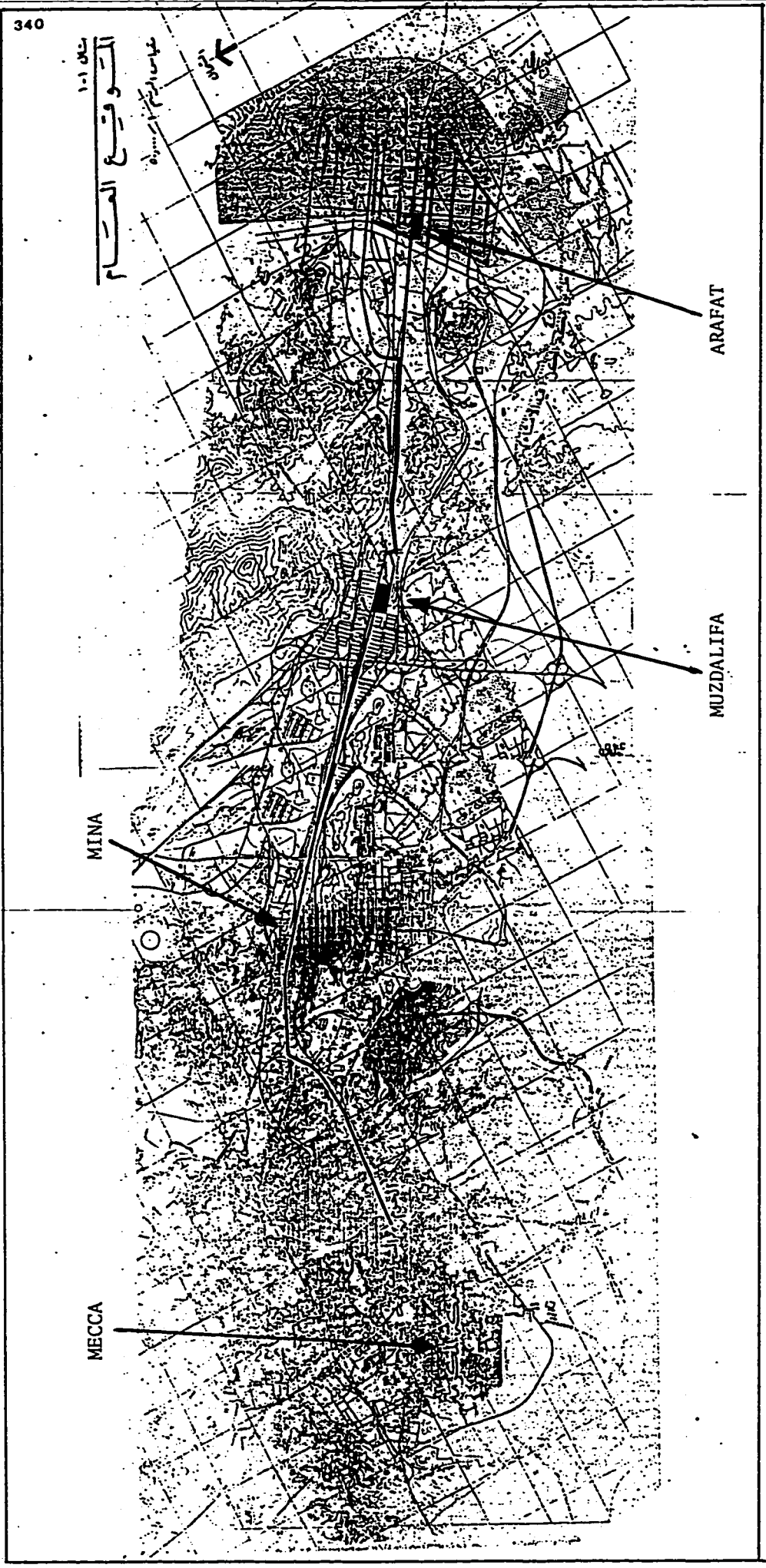


Fig. 1.2: Makka and Its Environs

Source: Ministry of Communications (1979)

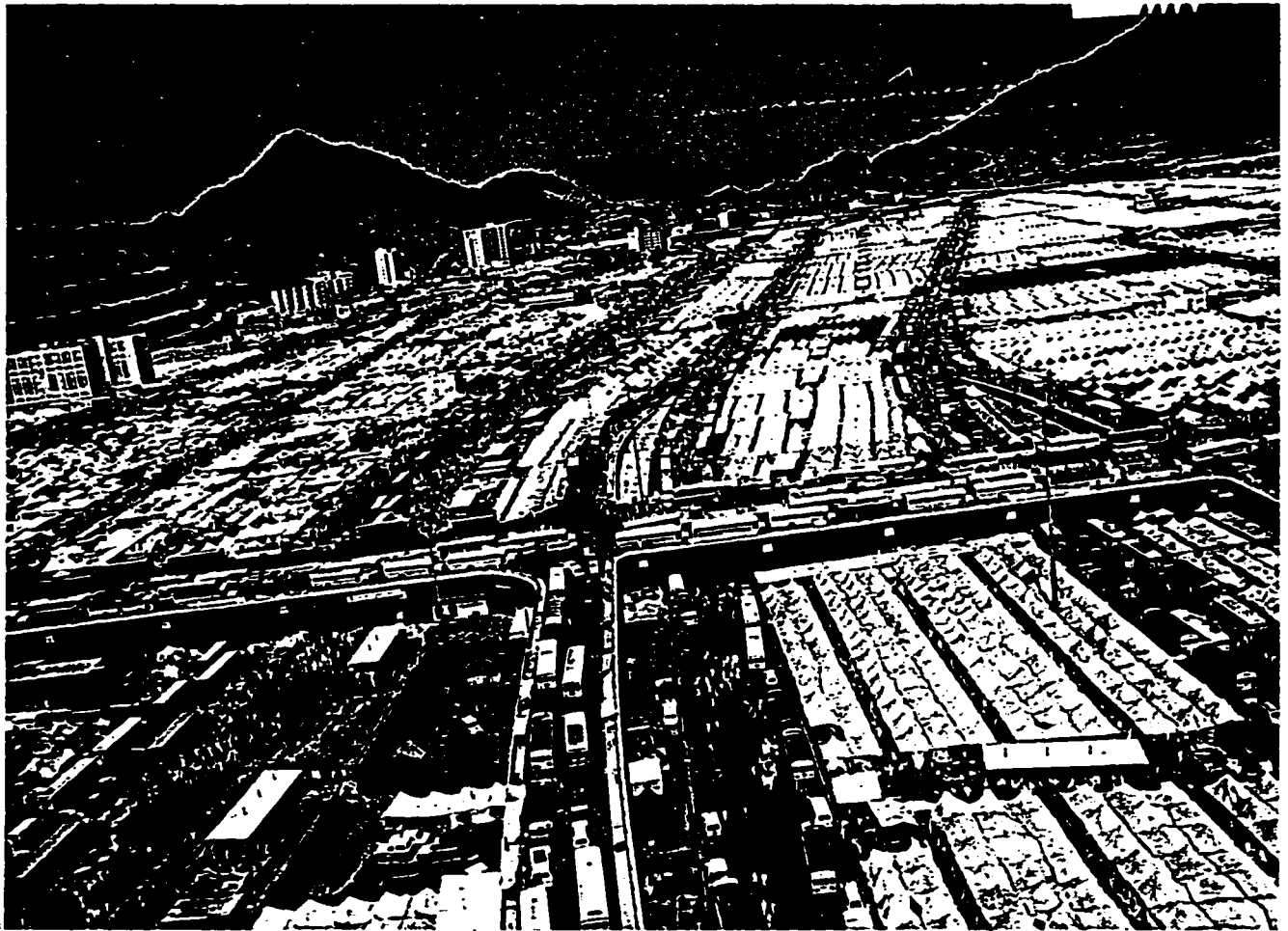


Fig. 1.3: Mina crowded with traffic jams and pedestrian movement.

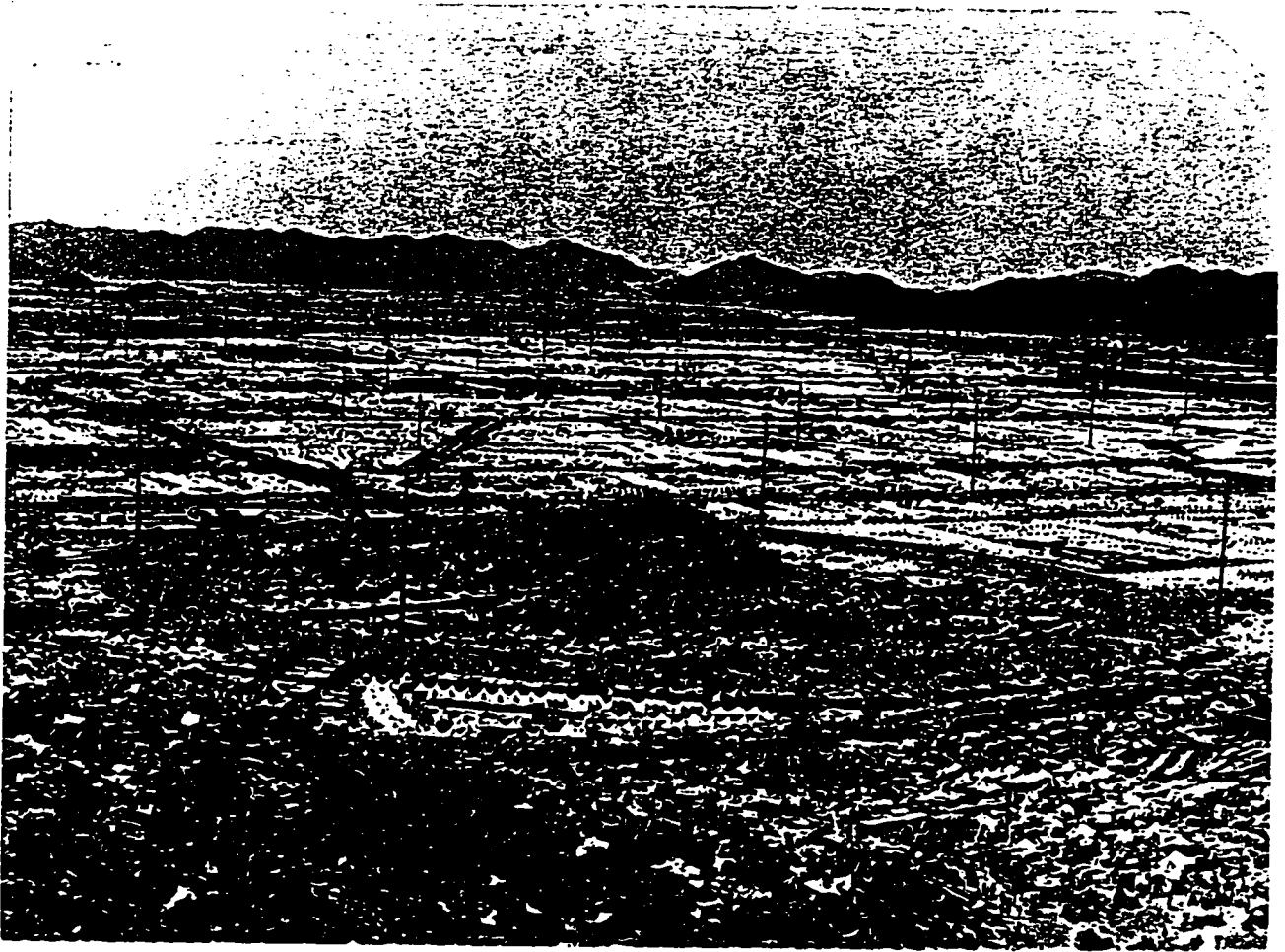


Fig. 1.4: A close view towards Arafat

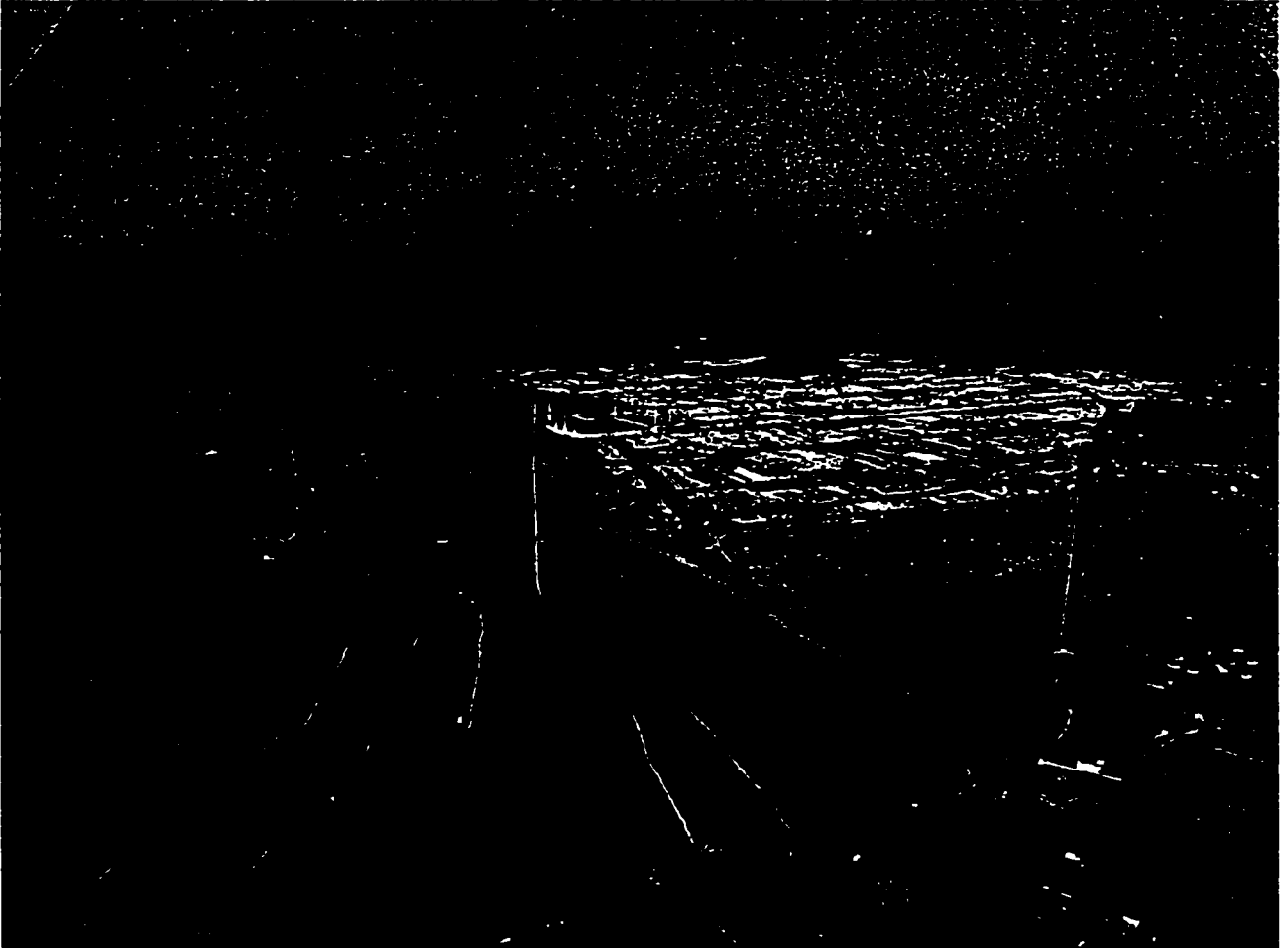


Fig. 1.5: An aerial view of Arafat

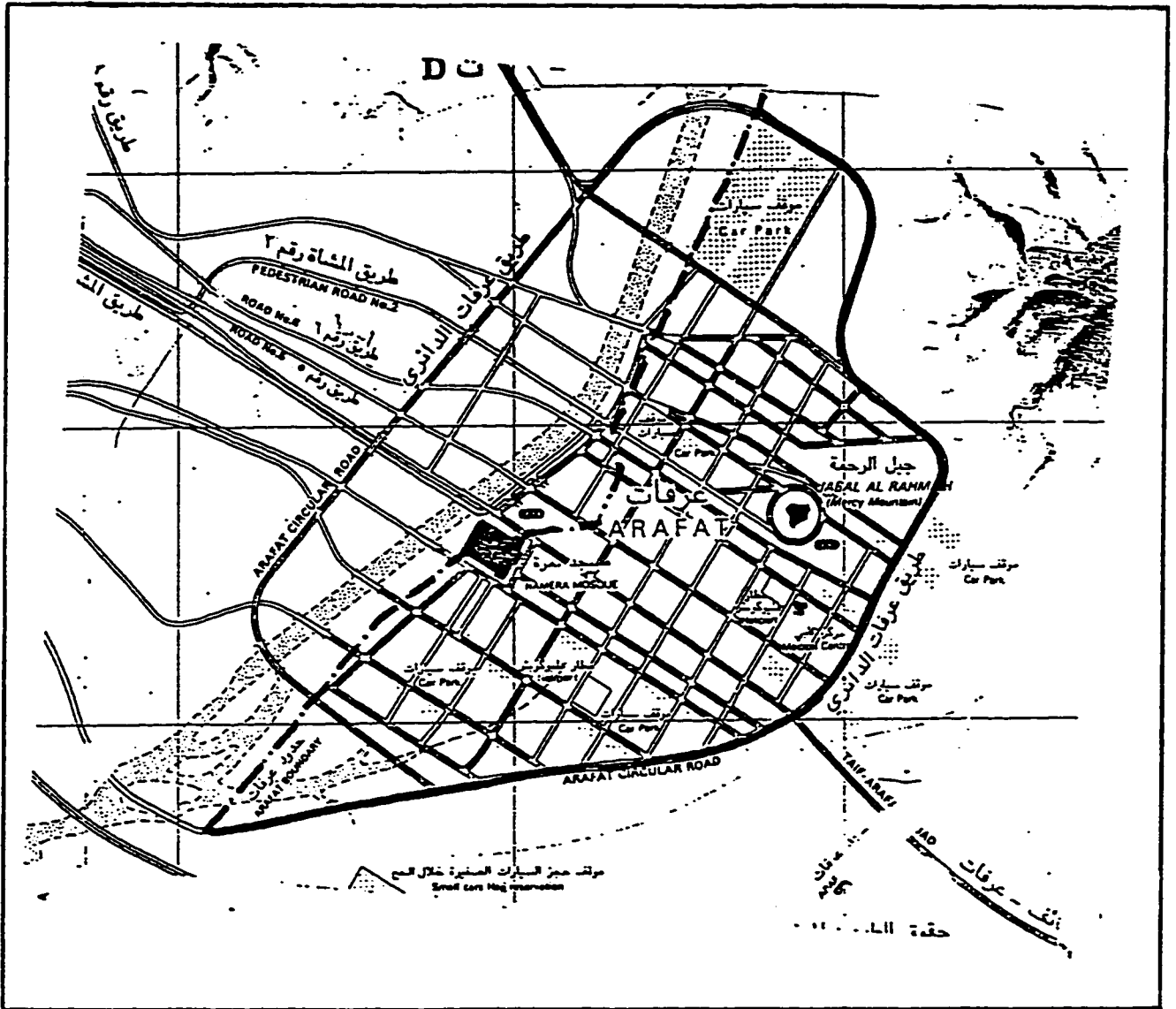


Fig. 1.6: General Layout of Arafat



Immediately after sunset of the ninth, all the pilgrims desire to leave Arafat. They move to Muzdalifah (6km), where some spend the night. Most pilgrims stop in Muzdalifah for a short time to pray, then continue to Mina.

Early in the morning of the tenth day, all the pilgrims are in Mina where each individual first throws seven pebbles at the third pillar of the "jamarat", sacrifices a cattle, and then takes off his or her "ihram" (special cloth for the Hajj). Sometimes during this day or the following two days, the pilgrims go to Makka, usually in the evening when it is cool, to perform the "tawaf" (circumambulating the holy Kaba 7 times) and "sae" (walking briskly 7 times between 2 hills spaced about 400 m apart) in the sacred mosque, then return to Mina to spend the night there.

On the 11th, 12th, and 13th of the month, the only required activity is throwing 7 pebbles at each of the 3 jamarat pillars early in the afternoon. Pilgrims are allowed to leave Mina on the 12th and most of them do so. The only rite left at this stage is a farewell tawaf which is to be performed before departing from Makka.

The Ministry of Finance showed that at year 1405 H approximately 1.6 million pilgrims came to Makkah with 198,000 vehicles of different types. This concentrated activity creates serious transportation problems at various stages of the Hajj activities.

Arafat is an open valley with some mountains of medium height at its north eastern section. The recognized holy area of Arafat

(13,680,000 sq. m.) focuses on Jabal-el-Rahma, the Mountain of Mercy, around which pilgrims camp during the 9th of Thul-Hijja. The area currently used for camping is about 10,000,000 sq. m. About 25 percent of the total camping area is reserved for roads and car parking. Incoming traffic is brought to Arafat through nine roads which have abundant capacity.

However after arriving in Arafat the problem of finding a suitable parking space begins, (Yafi, 1983). Parking in Arafat is currently a problem area because of the following reasons:

- 1) Demand is very large compared to the limited supply.
- 2) Operational problems : searching for parking creates delay, accidents, pollution, etc.
- 3) Parking is of a special nature in Arafat. This is because most people want to be close to their vehicles as a temporary residence. Some of the Hajjis build make-shift tents attached to their vehicles for protection from the sun. Therefore these Hajjis do not want to be far away from their vehicles.
- 4) Due to double and illegal parking on both sides of most streets, access of emergency vehicles becomes very difficult in medical emergencies and other emergencies (such as fire).

## 1.2 Goals and Objectives

The main goal of the study is to examine the parking problem in Arafat, and find an optimal design to solve the future parking problem.

Under this general goal an attempt will be made to achieve the following objectives :

- 1) Determine the existing parking supply and demand through other studies and further data collection.
- 2) Forecast future demand for the years 1410 - 1425 H.
- 3) Suggest some engineering parking design alternatives suitable to solve the existing and future parking problem.
- 4) Evaluate the different suggested parking designs, and select one for further detailing.
- 5) Give recommendations for the physical arrangements and the operational aspects of the selected design.

## Chapter 2

### LITERATURE REVIEW

#### 2.1 General Introduction

The terminal, the roadway, and the vehicle are the basic elements of the highway transportation system. The arrangement and design of each element influences the performance of the total system (Pignataro, 1973).

There are five basic elements essential to any parking study:

- 1) Preparation, planning and organizing the study.
- 2) Data collection for surveying existing parking condition.
- 3) Data analysis for the determination of the needs and developments of alternatives.
- 4) Evaluation of the feasible alternatives.
- 5) Implementation of the recommendations by selecting a program of improvements (Parking Principle, 1971).

The problem of parking is very important in today's automobile-oriented cities. Much of the congestion in many cities is caused by inadequate parking facilities.

## **2.2 Relationship Between Design and Operation**

The operation of a parking facility is greatly influenced by its design. The design elements and their associated operational features may be identified in successive steps as follows:

- 1) Vehicular access from the street system (entry driveway).
- 2) Search for a parking stall (circulation and/or access aisles).
- 3) Maneuver space to enter the stall (access aisle).
- 4) Sufficient stall size to accommodate the vehicle's length and width plus space to open car doors wide enough to enter and leave the vehicle.
- 5) Pedestrian access to and from the facility boundary (usually via the aisle).
- 6) Maneuver space to exit from the parking stall (access aisle).
- 7) Routing to leave the facility (access and circulation aisles),  
and
- 8) Vehicular egress to the street system (exit driveway),  
(Parking Principle, 1971).

## **2.3 Special Event Parking Problem**

The available literature about special event parking is mainly at stadiums, convention centers, auditoriums, and exhibition halls

(Whitlock, 1982) which are somehow similar to the Hajj in some of the characteristics but, still, the Hajj is a unique special event as mentioned before.

Special events occur once in a time on an occasional basis, where a special facility is non-existent or grossly inadequate, require temporary arrangements to handle traffic and parking demands. Special arrangements should be based on the following:

- 1) The anticipated parking.
- 2) Traffic characteristics likely to result for the type of event.
- 3) Expected crowd
- 4) Location or area that will host the event (Whitlock, 1982).

To prevent or minimize special event traffic and parking problems, the key is advance planning. Parking demand characteristics for special events are reflected by:

- 1) Mode of arrival used
- 2) Vehicular occupancy

which are largely dependent on the type of event and its location, (Whitlock, 1982). Since Hajj is a special event that has similar characteristics as other special events such as sport meetings, it is useful to include Tables 2.1 and 2.2 which show mode of arrival used an vehicle occupancy rate for various special events.

Table 2.1: Example of Mode of Arrival to Some Special Events.

Location	Type of Event	% of People Arrived By Private Vehicle
Oakland, california	Pro-football	88
Anaheim Stadium, California	Football	100
Edmonton, Canada	Soccer	80
Hagley Museum, DE	Museum	49

Source: Whitlock, (1982), p. 34.

Table 2.2: Example of Private Vehicle Occupancy Rate

Type of Event	Average Number of Persons per Vehicle
Museum	3.0
Horse racing	2.5
College football	3.0

Source: Whitlock (1982), p. 34.

## 2.4 Studies About Hajj Problem

A study of the Arafat area and the parking problem was conducted by Ministry of Communication (1979). Their study is possibly the closest to this thesis. But because their study is old, they have not taken into account the conditions and regulations prevailing now, such as that a minimum of 9 persons must be present in any vehicle entering the Holy area, and that non-Saudi resident in the Kingdom can only perform Hajj once in every five years. They explained the existing case of Arafat and the importance of study for the future parking problem. In their study they have assumed three different scenarios:

Scenario 1: Pilgrims are free to use any type of vehicle, even sedan cars.

Scenario 2: To discourage pilgrims using small vehicles without any law enforcement.

Scenario 3: Only buses with occupancy rate of 40 pilgrims/bus are allowed to enter the Holy area. In their study they have forecasted for the future using a simple linear regression analysis for foreign pilgrims. For internal pilgrims they assumed that the rate of increase in the number of pilgrims would be 3 percent every year which is the growth rate of the Saudi population. They predicted 2.4 million pilgrims in the year 1405 H, but the actual figure was only 1.59 million, therefore there was an overprediction. They showed the traffic volumes on each of the nine major roads for year 1412H for incoming traffic to Arafat in the morning of the 9th of



Thul-Hijjah and for departing traffic out of Arafat to Muzdalifah after sunset, (see Figure 2.1). without giving any idea about the level of service on these roads. They proposed some designs for parking lots such as a parking lot to accomodate 660 small and 230 buses see Figure 2.2 another design to accomodate 1760 small and 306 buses see Figure 2.3 .

Many researchers have discussed the Hajj, and talked about different Hajj problems in the past and at present.

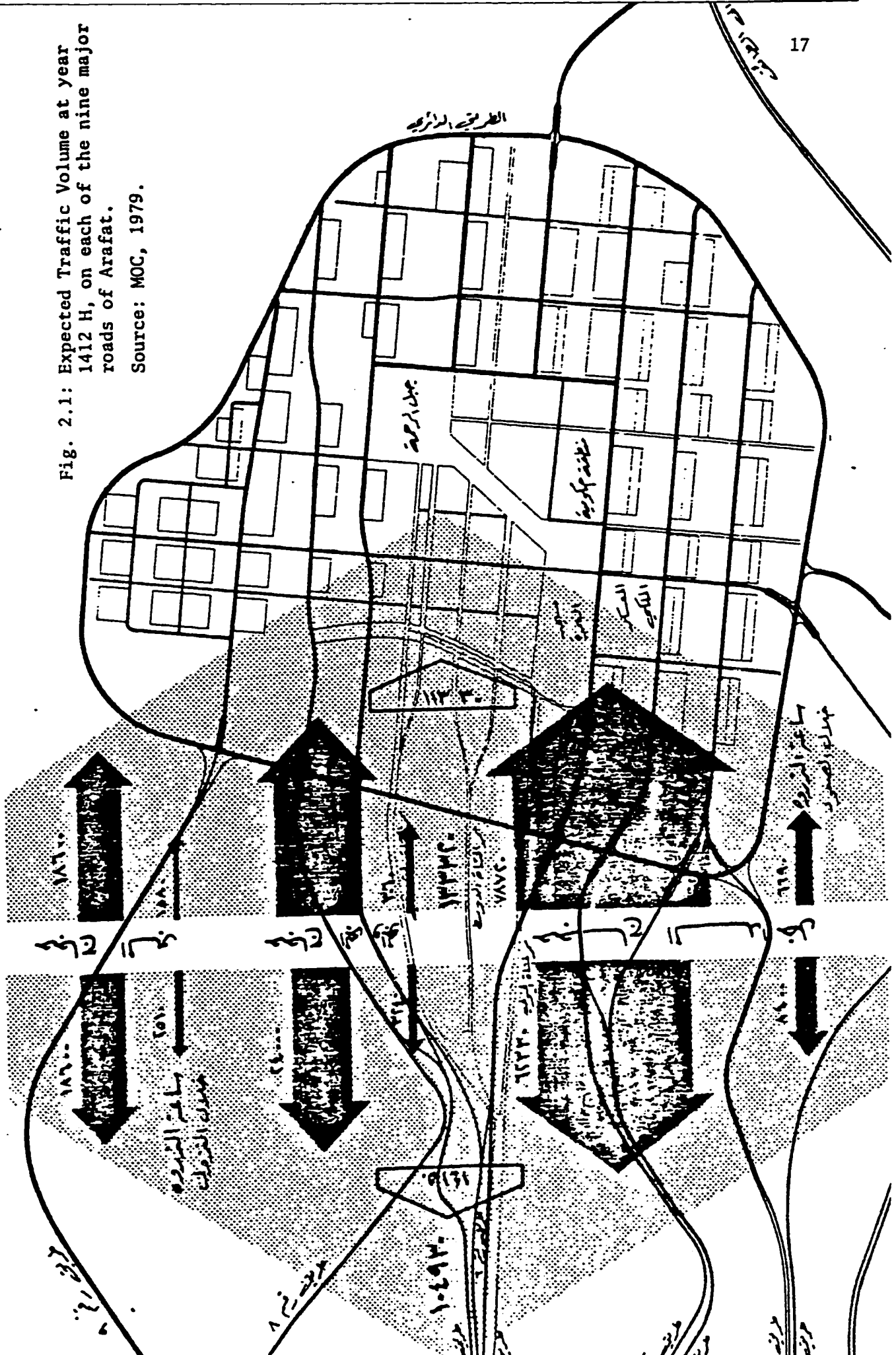
*El-Hamadan (1976)* talked about many different topics of the Hajj in the past and the existing case including housing in Makka, traffic volume between Jeddah, Makka, and Medina, the economic impact of the Hajj on the Kingdom. He explained the major reasons affecting the number of pilgrims coming to Hajj and their mode of arrival since year 1380H and he concluded that the improvements of transportation facilities within Saudi Arabia and worldwide development in transportation technology have been the major factors influencing the numbers of pilgrims. He made several trials to obtain a forecasting model for the future number of pilgrims, to fit a multiple regression equation, the following is an example of his trials:

$$P_{ij} = \alpha + B_1 Y_i + B_2 D_i + B_3 C_{ij} + B_4 T_{ij}$$

where

$P_{ij}$  = number of pilgrims from country  $i$  by mode  $j$ .

Fig. 2.1: Expected Traffic Volume at year 1412 H, on each of the nine major roads of Arafat.  
Source: MOC, 1979.



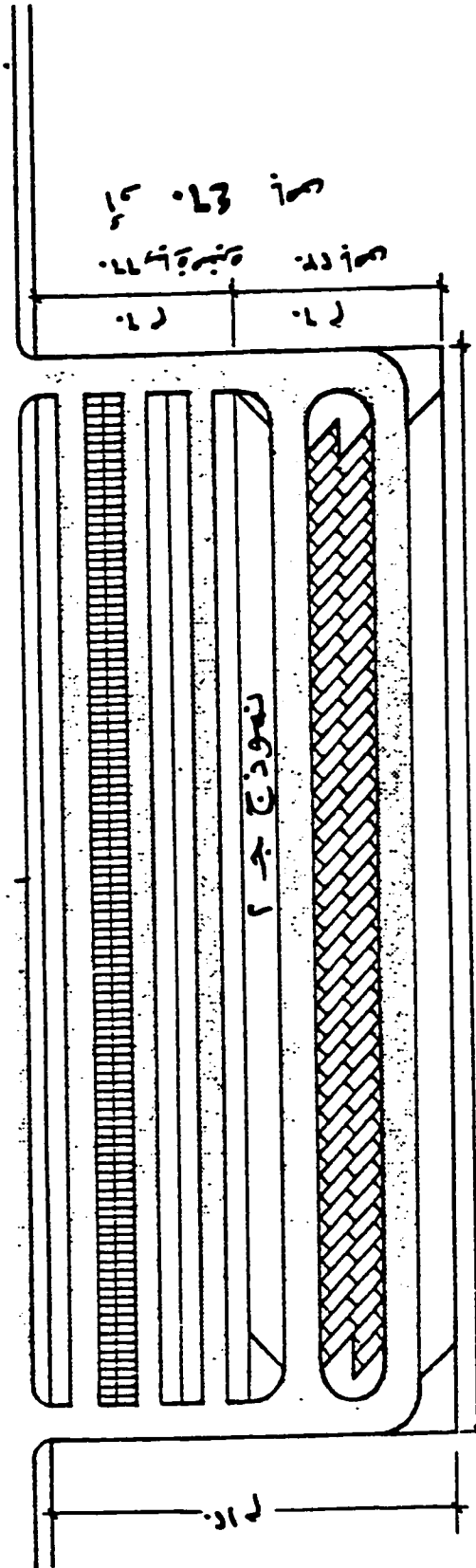


Fig. 2.2: A Proposed Parking Lot to accommodate 660 small vehicles and 230 buses.

Source: MOC, 1979.

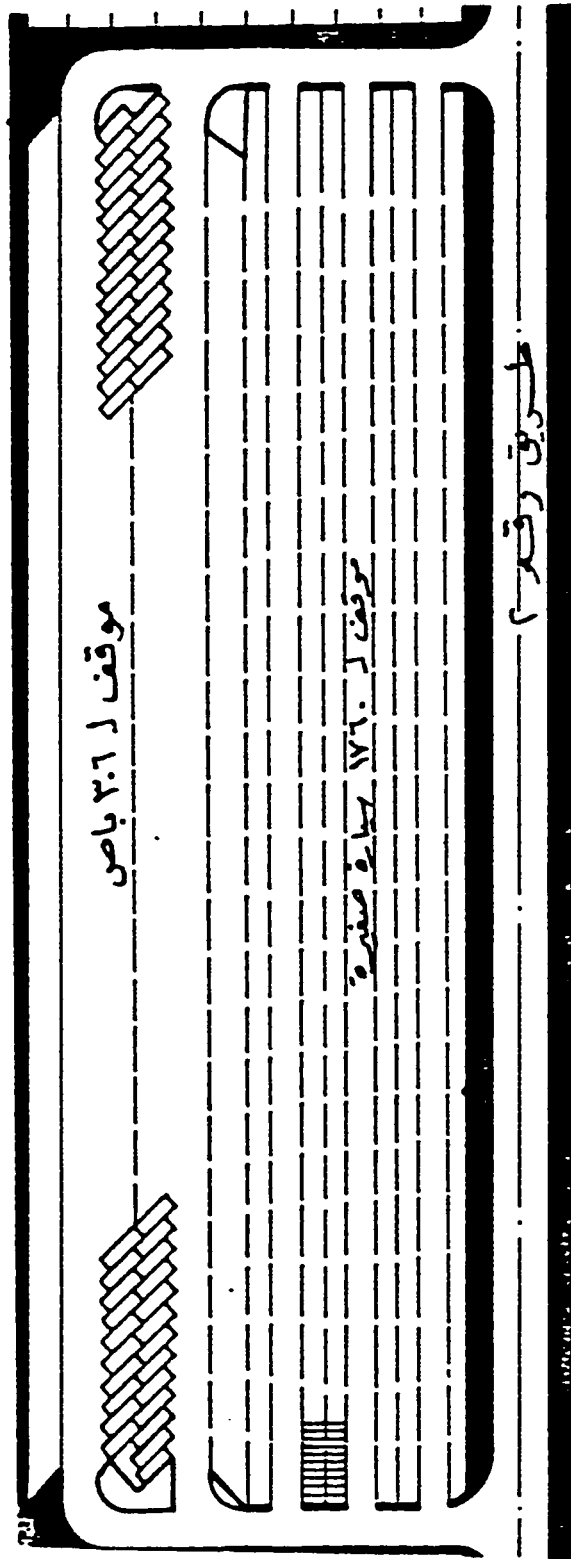


Fig. 2.3: A Proposed Parking Lot to accommodate 1760 small vehicles and 306 buses.

Source: MOC, 1979.

$Y_i$  = per capita income of country i.

$D_i$  = distance of country i from Makka.

$C_{ij}$  = cost of travel from country i to Makka by mode j.

$T_{ij}$  = time of travel from country i to Makka by mode j.

$\alpha, B_1, \dots, B_4$  are parameters to be estimated by the model.

At the end of his forecasting work he predicted the number of pilgrims at year 1983 to be 1,025,000 while the actual number was 2,501,706. He suggested some proposals for solving future traffic problems in the Hajj, including two types of camping in Arafat: Type A is for pilgrims arriving by air or sea. The size of this type is 200 x 300 m to accommodate 2000 pilgrims and parking spaces for 72 buses and 24 small cars, see Figure 2.4. The Type B camping is for pilgrim arriving in their own vehicles. It has a parking capacity of 124 buses and 572 small cars, see Figure 2.5. Moreover, he expressed that the 9 major roads leading to Arafat do not exceed the level of service C (see Figure 2.6) even in the peak hours, as shown in Table 2.3 .

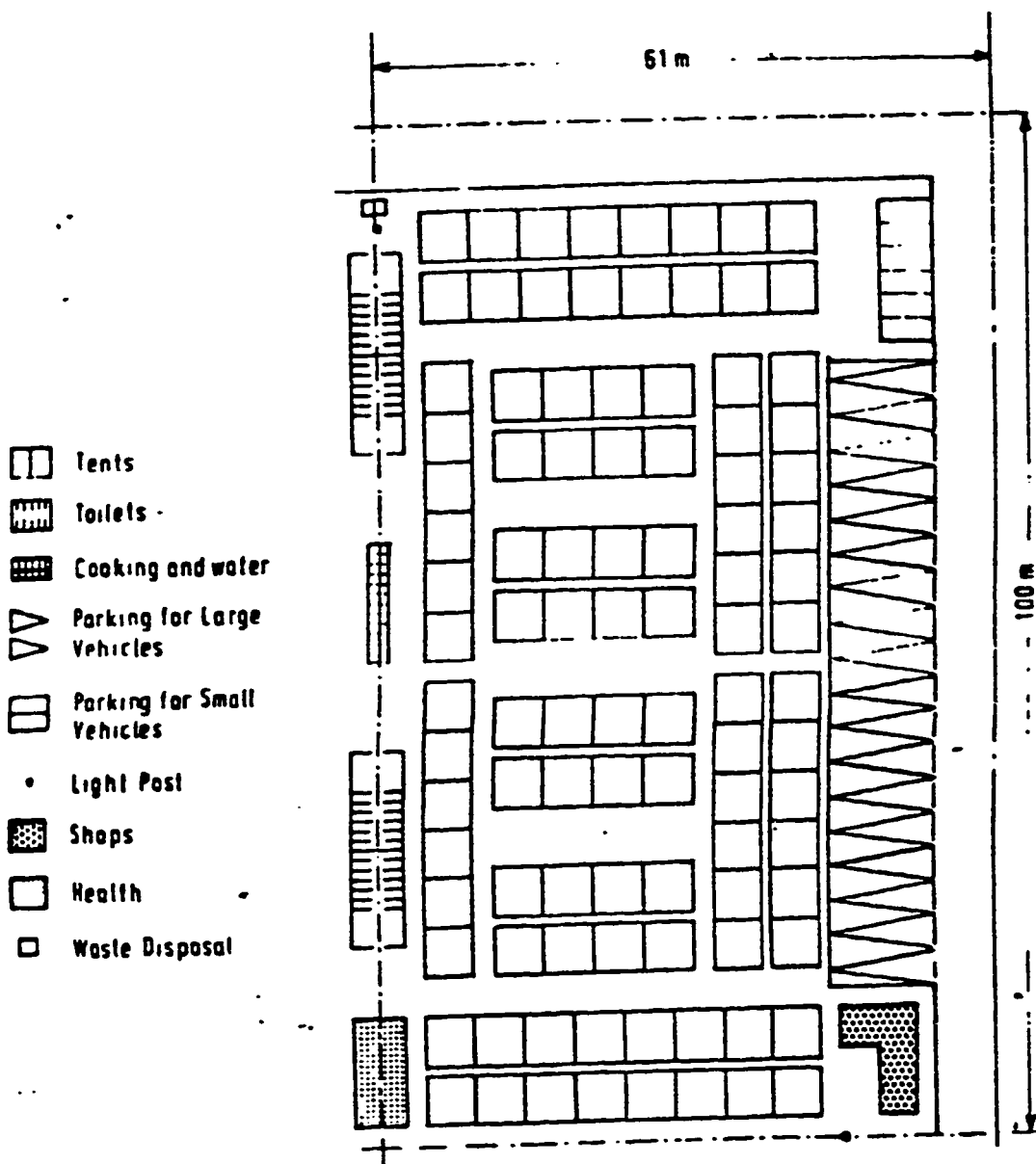


Figure 2.4: Details of a subunit of camping layout type (A).

Source: El-Hamadan, 1976,

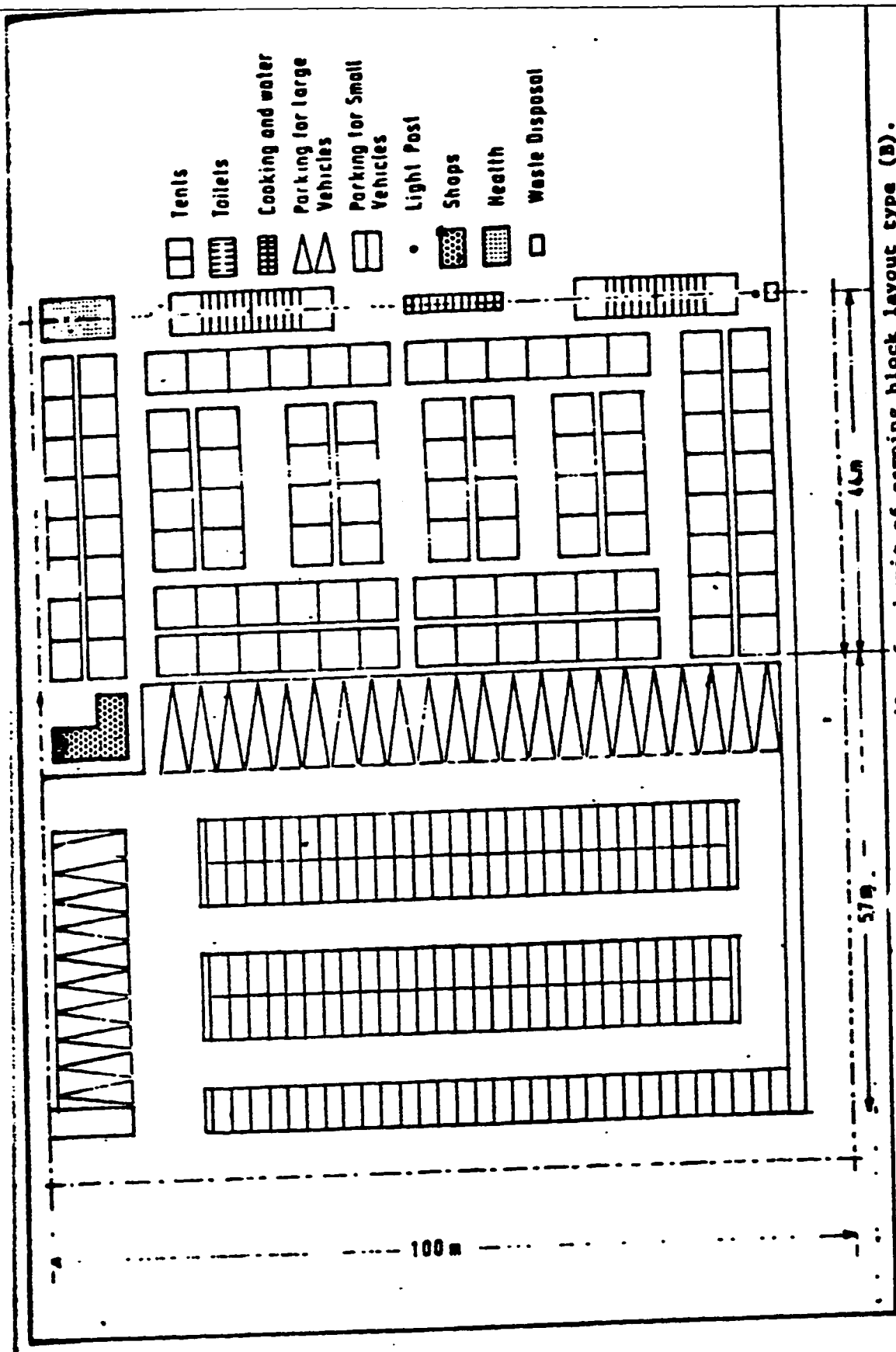


Figure 2.5: Details of subunit of camping block layout type (B).  
 Source: El-Hamadan, 1976.

BASIC FREEWAY SEGMENTS



Illustration 3-5. Level-of-service A.



Illustration 3-8. Level-of-service D.

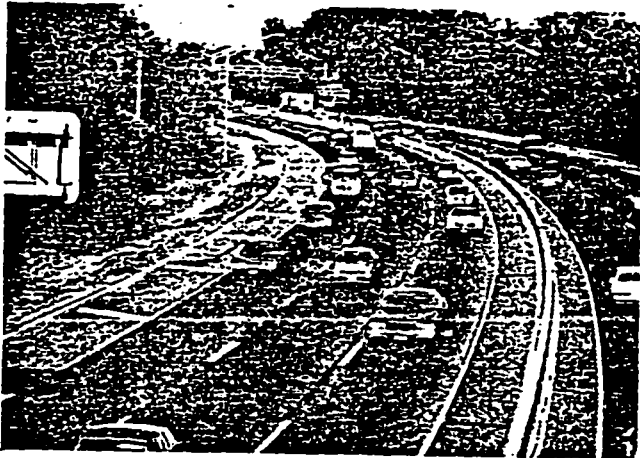


Illustration 3-6. Level-of-service B.



Illustration 3-9. Level-of-service E.



Illustration 3-7. Level-of-service C.

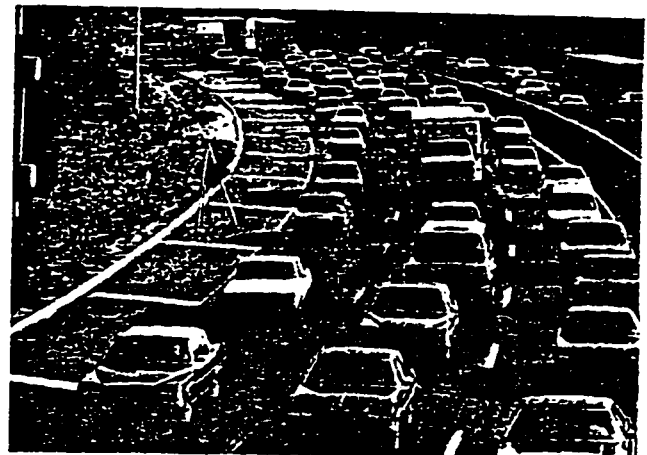


Illustration 3-10. Level-of-service F.

Fig. 2.6: Illustration of Level of Services

Source: Highway Capacity Manual, 1985.



Table 2.3: Level of service on Arafat's roads due to incoming traffic on the 8th and 9th Dhul-Hijja 1973

Time	Road 3	Road 4	Road 5	Road 6
10.00 - 11.00 am 8th.	A	A	A	A
11.00 - 12.00 am	A	A	A	A
12.00 - 01.00 pm	A	A	A	A
01.00 - 02.00 pm	A	A	A	A
02.00 - 03.00 pm	A	A	A	A
03.00 - 04.00 pm	A	A	B	A
04.00 - 05.00 pm	A	A	C	A
05.00 - 06.00 pm	A	C	B	A
06.00 - 07.00 pm	A	A	B	A
07.00 - 08.00 pm	A	A	B	A
08.00 - 09.00 pm	A	A	A	A
09.00 - 10.00 pm	A	A	A	A
10.00 - 11.00 pm	A	A	A	A
11.00 - 12.00 pm	A	A	A	A
12.00 - 01.00 am 9th.	A	A	A	A
01.00 - 02.00 am	A	A	A	A
02.00 - 03.00 am	A	A	A	A
03.00 - 04.00 am	A	B	A	A
04.00 - 05.00 am	A	A	A	-
05.00 - 06.00 am	A	A	A	-
06.00 - 07.00 am	A	A	A	-
07.00 - 08.00 am	B	E	B	-

---

(Continued Table 2.3)

08.00 - 09.00 am	C	F	D	-
09.00 - 10.00 am	B	C	C	-
10.00 - 11.00 am	A	C	B	-
11.00 - 12.00 am	A	B	A	-
12.00 - 01.00 pm	A	B	A	-
01.00 - 02.00 pm	A	B	A	-
02.00 - 03.00 pm	A	A	A	-
03.00 - 04.00 pm	A	A	A	-

---

Source: El Hamadan , (1976).

*Yafi (1983)* studied the management of some large scale logistic problems of the Hajj. He emphasized on the movement problems that pilgrims are facing between the Holy areas. He explained that today's fast jet aircrafts transport hundreds of thousands of Hajjis speedily into the Kingdom and various forms of automotive vehicles of all types are utilized to shuttle the pilgrims to and from and within the Holy areas of Makka like a giant conveyor belt. This process led to monumental problems in terms of traffic congestion, conflicts with pedestrian movement, accidents, air pollution, noise and other disadvantages. He expressed the difficulties that pilgrims are facing in Arafat where pedestrians have to force their way through bumper-to-bumper traffic which is an extremely "dangerous situation". Moreover, the special requirements to the automobile vie with those of the pilgrims. He developed a dynamic capacitated network model to schedule and minimize traffic and population congestion and thus reduce overcrowding at the Holy sites. He concluded that the smoother and more fulfilling operation of the Hajj can be achieved through the incorporation of modern modelling techniques which can readily be integrated with efforts with the mutually embraced objective of elevating to fruition the spiritual goals and deep personal meaning of the Hajj. He also talked about some old and modern topics of the Hajj such as the fire problem in Mina.

*Bodo (1980)* in his study entitled 'Tent City', explained about Arafat in general, and what pilgrims do on that day. He stated about the huge traffic problems that pilgrims face when they drive out of Arafat to Muzdalifah and the conflict between pedestrians and vehicles where people fight their way to move. He explained that in the course of the pilgrims' movements there are congestions and other disturbances which are caused by one or more of the following factors:

- 1) Congestion due to the density of the crowd.
- 2) The mixing of vehicles and pedestrians.
- 3) Insufficient infrastructure along the pilgrims' paths.
- 4) Degradation through pollution and noise.
- 5) Lack of information for pilgrims and personnel.

He explained that to understand the movement of Hajj in a better way it is presented as a "closed system" with a varying number of pilgrims flowing through it per time unit, (see Figure 2.7). This illustrates that the overall capacity of the system is dependent on the through-put capacity of the narrowest point. Tawaf admits about 30 thousand pilgrims per hour.

*Bushnaq (1977)* made a study about planning and evaluation of special event transportation systems with application to the Hajj. He explained the characteristics of SETS (Special Event Transportation System), which are as follows:

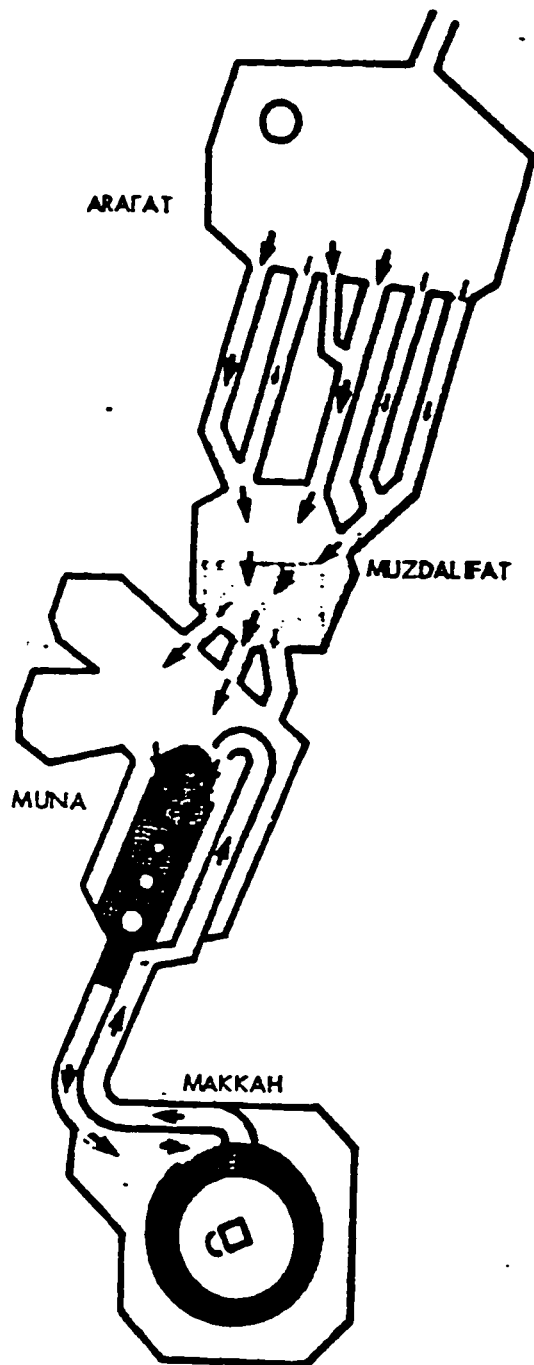


Fig. 2.7: Illustration for explaining Hajj Movement as a "Closed System".  
Source: Bodo, 1980.

- 1) has a common set of movements;
- 2) serves unfamiliar users with diverse needs;
- 3) operates at infrequent intervals and for short durations;
- 4) involves dense vehicular and pedestrian movements;
- 5) interacts strongly with other transportation and non-transportation systems;
- 6) exhibits inelastic supply and demand decision behavior;
- 7) has critical safety and security needs.

He stated that one of the Hajj goals is to commemorate the experience of Prophet Ibrahim who built the Ka'ba, threw stones at the devil which appeared to him in Muna valley, and sacrificed an animal instead of his son. For a pilgrim, to share a similar experience, he must be surrounded by a natural environment and isolated from the intrusion of the machine. This is another reason why Hajj transportation components must have minimum noise, air pollution, or destruction of natural forms. He also stated that the HTS (Hajj Transportation Systems) has the following objectives:

- 1) The satisfaction of Hajj rites' movement;
- 2) Intangible functions;
- 3) Safety-security needs.

He explained that the transportation problems of the contemporary Hajj cannot be solved merely by building more roads and providing more vehicles. Any solution must be consistent with the function of Hajj and the objectives of HTS at large. The adopted solution

for any part of HTS must be integrated with other components of the system to prevent creating new problems. Moreover, he stated that the efforts of controlling the number of pilgrims should be directed toward eliminating a sudden or an unexpected large increase or decrease to avoid overtaxing or idling the local facilities.

*The Ministry of Municipal and Rural Affairs (1405 H)* made a forecasting study about the expected future numbers of pilgrims. In their study they took into consideration the latest Hajj regulations. They conducted the long-term projection of the number of pilgrims as being a vital parameter in planning for expansion in the facilities and infrastructure for Hajj within the Kingdom of Saudi Arabia in general and the Holy environs of the Makka planning region, in particular. Moreover, it is necessary not only to project the total number of pilgrims but also to derive the composition of this number as different types of pilgrims place different demands on international and domestic transport. Figure 2.8 shows their classification of pilgrims for forecasting purposes. They developed three forecasting models for different categories of pilgrims, such as:

$$H_t = W_t (1 + f_t) m_t \sum_{i=1}^n S_{it} r_{it}$$

$$0 \leq m_t \leq 1, 0 \leq S_{it} \leq 1, 0 \leq r_{it} \leq 1, \sum_{i=1}^n S_{it} = 1.$$

where:

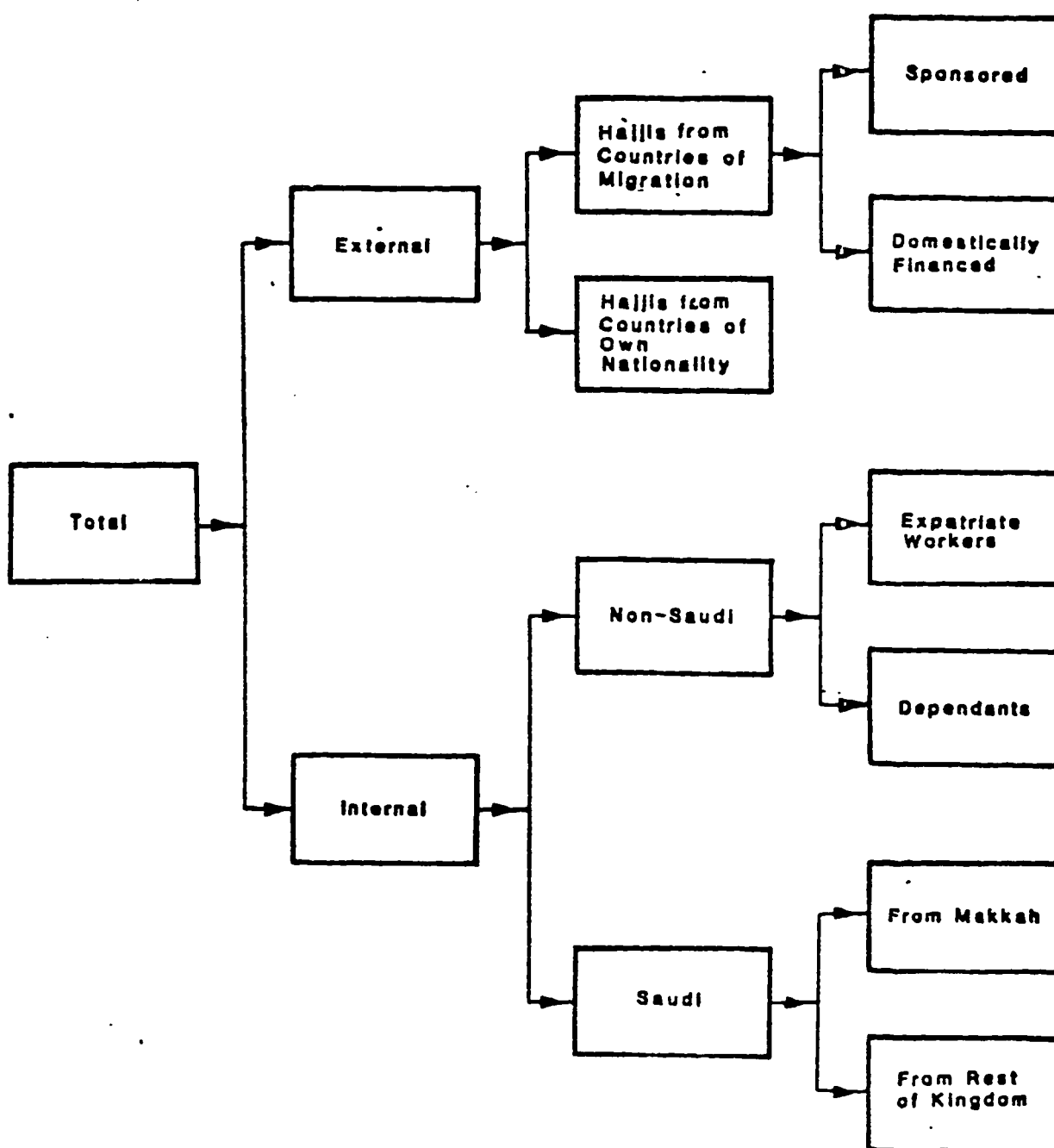


Fig. 2.8: Classification of Pilgrims for forecasting purposes.

Source: Ministry of Municipal & Rural Affairs, 1405 H.



- $H_t$  = Number of internal non-Saudi pilgrims in year  $t$ .
- $W$  = Number of non-Saudi workers in Saudi Arabia.
- $f$  = Number of dependents on average living in Saudi Arabia with each migrant worker in year  $t$ .
- $m$  = Proportion of Muslims in the total non-Saudi population.
- $S$  = Proportion of Muslim non-Saudi population that has been resident in Saudi Arabia for  $i$  years as of year  $t$ ,  $i = 1, 2, \dots, n$ .
- $r$  = Probability of Hajj being performed in year  $t$  by an individual who has been resident in Saudi Arabia for  $i$  years.

*Angawi (1975)* explained some general ideas, facts and statistics about Hajj areas such as Makka, Medina and Jeddah and also about local Holy areas such as Muna, Muzdalifah and Arafat. He expressed that there is a need to organize the existing bus system to form a continuous transportation connection between the religious sites that would alleviate traffic congestion in and between Makka, Muna, Muzdalifah and Arafat.

In his opinion, although walking may be the best way to perform the pilgrimage, not every one can walk. For the old and the infirm, walking can be too tiring. Also for those walking, the religious atmosphere should not be disturbed by the noise of automobile. A shuttle bus system is the most efficient way to move large number of people, and a good way to support the pedestrian pilgrimage.

If a shuttle bus system is introduced it will make more room for

people because if the people in buses were to travel by car, the cars needed would take much more room than the buses. A bus system will greatly decrease the number of private cars necessary. This will in turn reduce traffic jams and help the pilgrims to walk in peace.

*The Ministry of Finance* carries out a statistical study every Hajj season about the numbers of pilgrims of all categories (Saudis, non Saudis) and also the numbers of vehicles those pilgrims used for transportation. The number of Muslims coming to Makka for performing the Hajj is given in Table 2.4.

Table 2.4: Pilgrim Total

Year	Total	Foreign	Resident of Saudi Arabias	Non-Saudis
1970	1 079 760	431 270	404 186	244 304
1971	1 042 027	479 339	353 480	209 208
1972	1 216 951	645 182	352 955	218 814
1973	1 122 545	607 755	309 853	204 937
1974	1 484 975	918 777	322 761	243 437
1975	1 557 867	894 573	306 154	357 135
1976	1 456 432	719 040	302 303	435 089
1977	1 627 589	739 319	392 129	496 141
1978	1 899 420	830 236	400 179	669 005
1979	2 079 689	862 520	344 757	872 412
1980	1 949 634	812 892	292 276	844 466
1981	1 943 180	879 368	224 299	839 513
1982	2 011 555	852 555	238 985	919 015
1983	2 501 706	1 003 911	292 962	1 204 833
1984	1 664 478	1 919 671	218 589	526 218
1985	1 589 776	851 761	252 185	485 830
1986	1 600 475	856 718	239 207	504 550
1987	1 619 324	960 386	270 581	388 357

Source: General Statistics, Ministry of Finance, (1407).

## **Chapter 3**

### **METHODOLOGY**

#### **3.1 Introduction**

The work plan of this thesis can be summarized briefly in the flowchart illustrated in Figure 3.1. A brief description of each part will be given below.

#### **3.2 Studying the Existing Parking Demand and Supply**

It is important to consider the existing parking demand and supply, because it is the starting point and any study for the future will have no meaning without the study of the present situation.

As explained in Chapter 2, the Ministry of Finance carries out a general statistic every Hajj season in the Holy area (Makka, Muna, Arafat) for their own purposes, and it was found that their statistics are quite useful, reliable and contains detailed information. Therefore it was decided to use these statistics in this study.

Obviously, the existing supply is the road network and the surface parking lots. This can be found out by means of available maps of Arafat. A questionnaire was also carried out during the day of Arafat to analyze in detail the existing situation and take the opinions of some pilgrims about the existing situation of Arafat. This

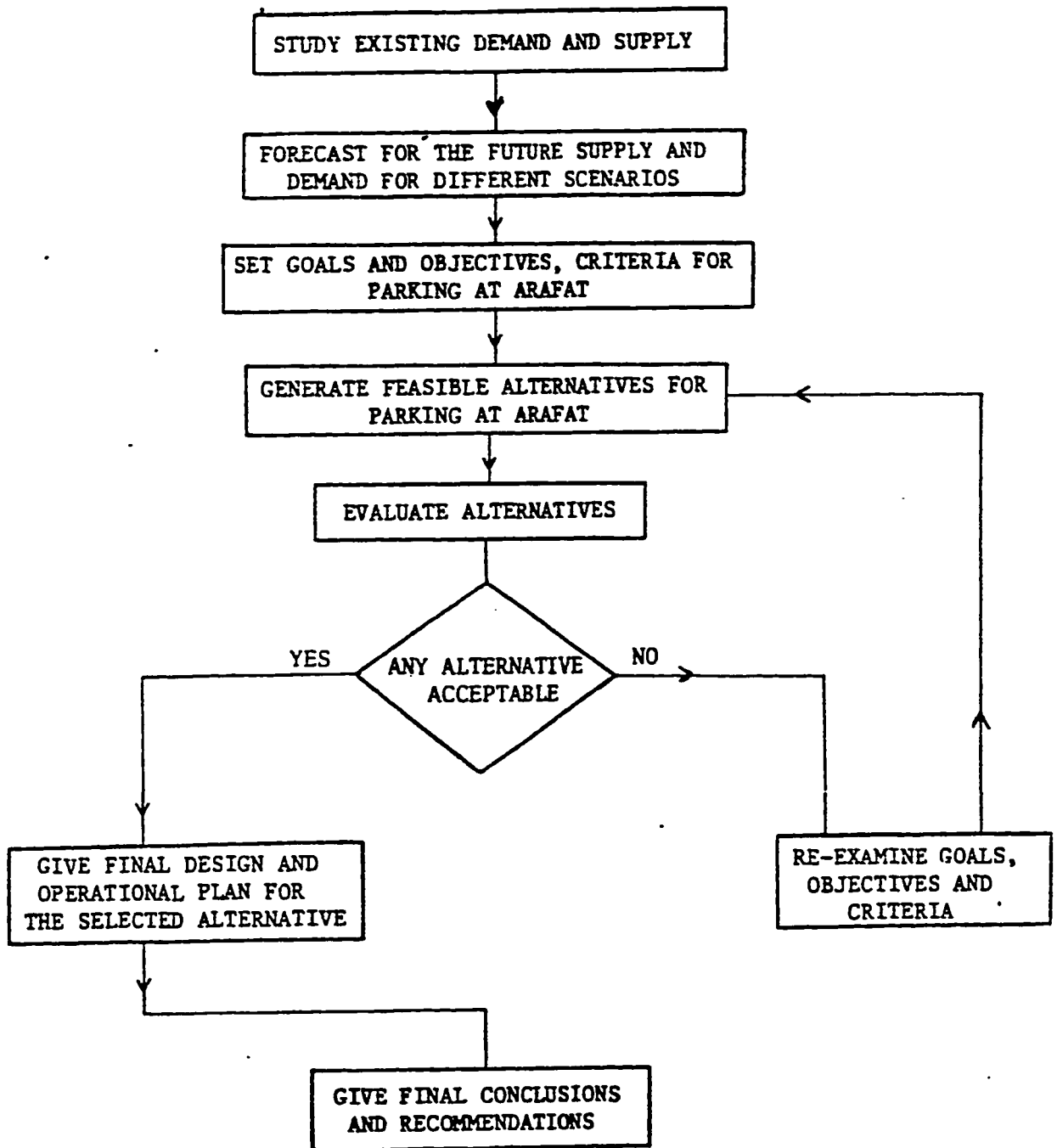


Fig. 3.1: Flow Chart for the Work Plan

questionnaire is explained in the following chapter.

### 3.3 Forecast for the Future Parking Demand and Supply

This study aims to solve the parking problem for the future, therefore future forecasts of demand and supply will be needed. Naturally, the future parking demand depends on the expected future number of pilgrims, categorized by the mode of arrival to Arafat.

A recent study done for the Ministry of Municipal and Rural Affairs (1985) included the forecasts of the number of pilgrims. After obtaining the future number of pilgrims, next step will be to predict the parking demand generated by that number of pilgrims. That will be done by using the parking demand for year 1405H as base year, it will be assumed that future parking demand will increase by the same rate of the increase of the number of pilgrims.

Classifying pilgrims according to their mode of arrival and according to their origin has a direct impact on the parking problem. Figure 3.2 shows the different categories of mode of arrival. Pilgrims coming by air or sea will either use their muttawiff's vehicle (Muttawiff is the pilgrim's leader) to Arafat or hire one and go to Arafat. Pilgrims coming in their own buses and vans have no difficulty in entering the holy area to Arafat and parking. But pilgrims coming in small vehicles (less than 9 passengers) must park in peripheral lots and either use the muttawiff's vehicle or hire one to

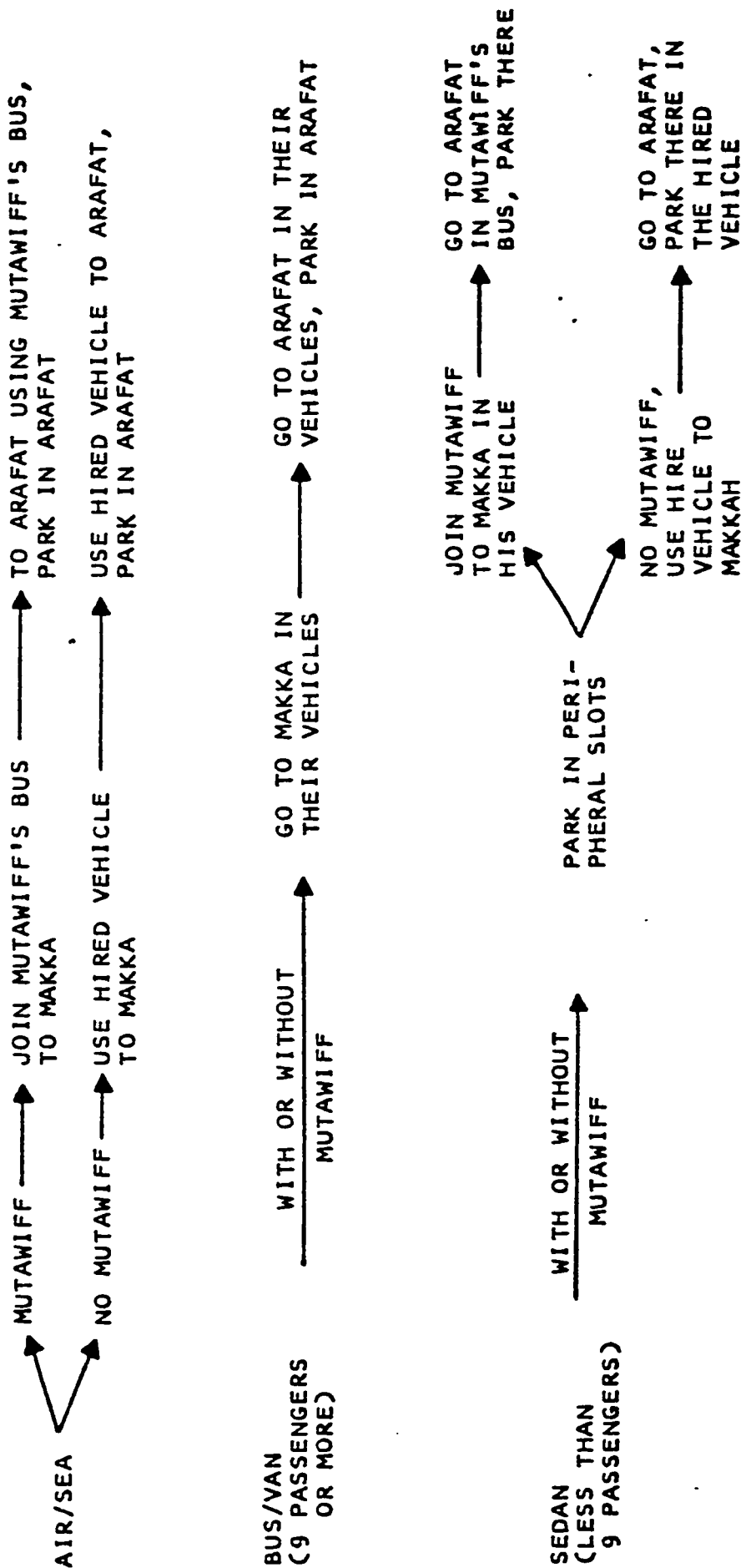


FIG. 3.2: CLASSIFYING PILGRIMS ACCORDING TO THEIR MODE OF ARRIVAL.

go to Arafat.

Figure 3.3 shows the different categories of pilgrims according to their origin. Pilgrims from the Kingdom or other GCC (Gulf Cooperation Council) countries might be split into three categories according to their mode of arrival and will follow the same pattern explained above. Pilgrims coming from all other countries are of two types: using air or sea, or their own vehicles. Each will follow the pattern explained in Figure 3.2 above. Accordingly pilgrims will be split in the following categories:

- 1) External pilgrims arriving with own buses
- 2) External pilgrims arriving with own small vehicles (mini buses, vans, etc.).
- 3) External pilgrims coming with muttawiff's bus.
- 4) Internal pilgrims using buses.
- 5) Internal pilgrims using small vehicles.
- 6) Pedestrians

Each of these different categories will have different parking requirements.

### 3.4 The Future Scenarios

This study will examine the future demand under the following scenarios:



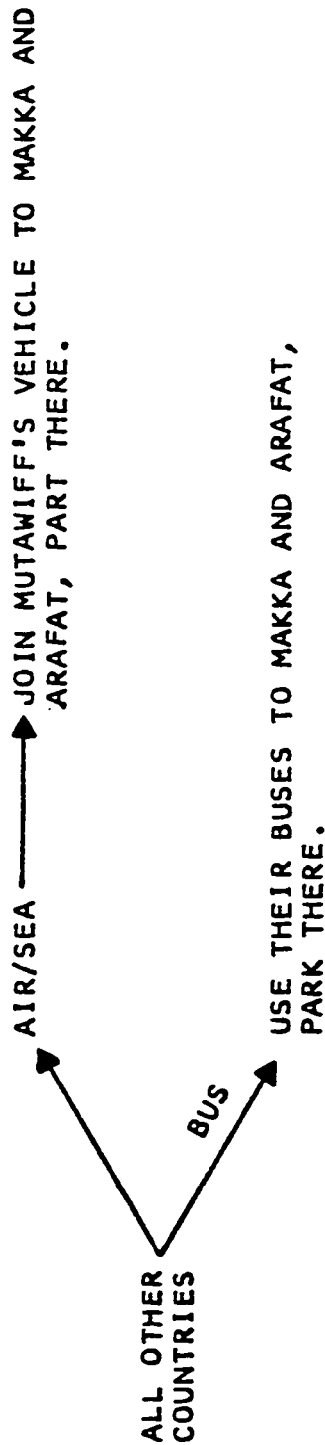
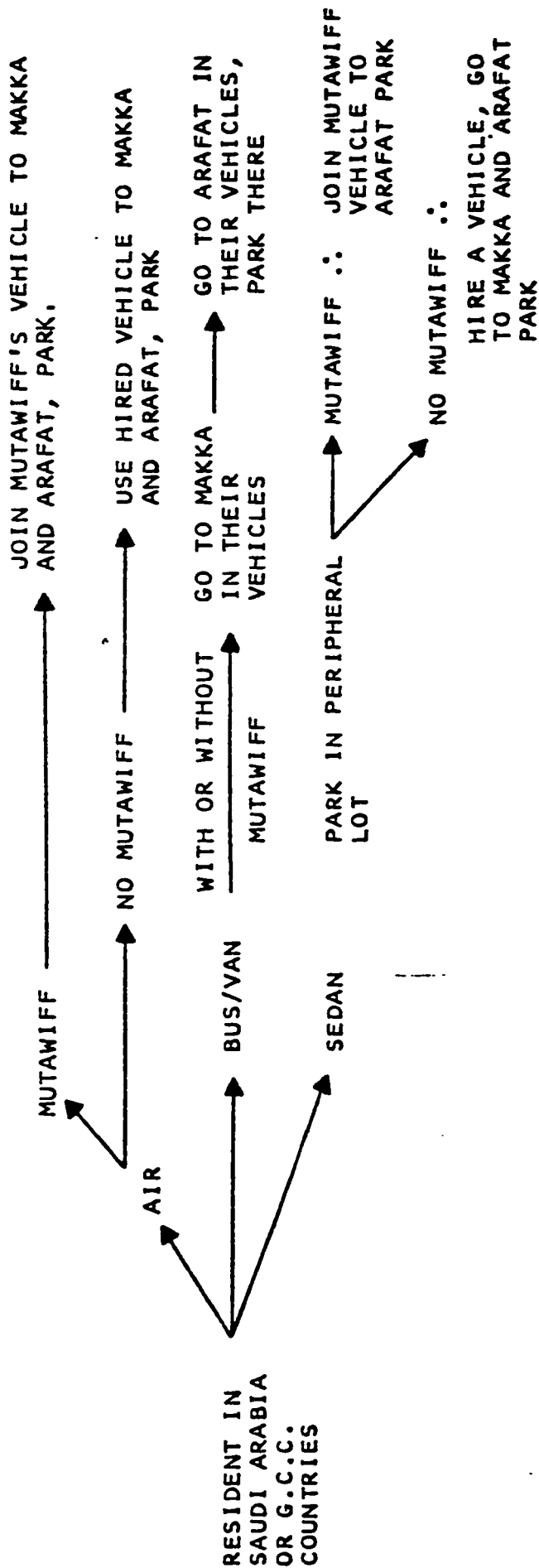


FIG. 3.3: CLASSIFYING PILGRIMS ACCORDING TO THEIR ORIGIN.

**scenario 1:** The existing case is still prevailing, i.e. no sedan vehicle is allowed to enter the holy area, unless there is a minimum of 9 passengers in each passenger vehicle.

**scenario 2:** No sedan, vans and suburbans are allowed. A minimum of 18 passengers per vehicle will be imposed, i.e. mini-buses or larger vehicles will be allowed for transporting pilgrims inside the holy area. All sedans, vans, suburbans must be parked outside the Holy area.

**scenario 3:** No sedans, vans and mini buses are allowed: a minimum of 36 passengers vehicle is allowed i.e. only large buses or double deckers are allowed.

### 3.5 Criteria and Objectives for Future Parking Systems

Since Arafat parking is a very special case, there are specific objectives that should be fulfilled. These objectives are listed below:

- 1) The system should reduce delay in searching for a parking space, because wasting time in searching for a parking space is undesirable for the pilgrims and causes air pollution and traffic problems.
- 2) The system must be convenient for the driver to get in and out, because in the case of complicated system, drivers may get irritated which might cause traffic hazards and violations, specially by unfamiliar drivers.

- 3) The system should minimize walking distance between the parking lots and the camping area to reduce pilgrims' fatigue, specially those who are old and carry their luggage (food, clothes, etc.) themselves.
- 4) The system should provide the minimum conflict between vehicles and pedestrians because of the safety of the pilgrims.
- 5) The system should cause minimum air pollution by providing enough distance between parking lots and camping area.
- 6) The system should be aesthetic (to give nice view to Arafat).
- 7) The system must be consistent with the Islamic feeling and the spiritual side of pilgrims, because their goal is to commemorate the experience of Prophet Ibrahim and to share a similar experience pilgrims must be surrounded by a natural environment and be isolated from the intrusion of the machine.
- 8) The system should minimize fire hazard by avoiding parking vehicles inside camping areas where pilgrims may prepare their meals.
- 9) The system must be economic.

From the available literature (El-Hamadan, 1976), it was found that the area needed for one pilgrim is about 3 sq.m. for living. Moreover one meter sq. is assumed for temporary toilets, shops. etc.

Therefore, a total area of 4 meter sq. will be allocated for each pilgrim.

### **3.6 Generate Future Alternatives**

In this part some parking systems will be proposed keeping the parking system objectives in mind. Obviously, the amount of satisfaction of the objectives may not be equal in all systems, therefore, an evaluation is needed.

### **3.7 Evaluate Alternatives**

The next step is to evaluate the different systems based on the objectives mentioned above. It was decided to conduct a survey for the evaluation of the future suggested parking systems. A questionnaire was prepared including all important information about the parking alternatives, was sent to specific people who were experts in traffic engineering and/or have good experience about Hajj traffic problems. Their response was used in selecting the best system.

### **3.8 Final Design and Operational Plan**

After selecting the best alternative for Arafat the next step was to prepare detailed design of the selected system and to propose an operational plan. The detailed design will show the land distribu-

tion of Arafat, where each category will be located, the exact dimensions of the parking and camping lots of each category.

In the operational plan the following will be decided:

- 1) The traffic assignment of each of the major roads leading to Arafat.
- 2) The direction of flow and traffic assignment of the local streets of Arafat.
- 3) The numbering of all blocks, and organization of the blocks in a systematical way to make it easy for all pilgrims to reach their camp in short time.
- 4) The circulation of traffic during the morning period (when pilgrims are entering Arafat), and during the evening period (when pilgrims are departing out of Arafat towards Muzdalifah).

## **Chapter 4**

### **STUDY OF PARKING DEMAND AND SUPPLY AT ARAFAT**

#### **4.1 Existing Demand**

The existing demand was obtained from the general statistics of the Ministry of Finance (it is carried out every hajj season) Year 1405 H was used as the base year. The detailed demand during this year is shown in Table 4.1

Since there are only two types of parking, one large space parking for buses and one small for all other types of vehicles such as vans, mini bus, jeep, etc., total parking demand can be summarized as shown in Table 4.2.

#### **4.2 Existing Supply**

The available maps were used to find the available parking area in Arafat. Currently the used land in Arafat is approximately 10 000 000 sq.m. Of this, 942,500 sq.m. is used by the government officials, such as traffic police, administration. etc. Within the religious boundaries of the Arafat area, 3,680,000 sq.m. more can be developed. So the future total available land will be 13,680,000 sq.m. (Ministry of Communication 1979).

To study some characteristics of the existing situation, it was

Table 4.1: Detailed Parking Demand at Year 1405 H.

Small	Jeep	Mini Bus	Bus	Lorry	Others	Total
4,803	3,417	23,795	10,647	4,883	788	48,333

Source: General Statistics, Ministry of Finance, (1407).

Table 4.2: Total Parking Demand at Year 1405H

Bus	Small	Total
10,647	37686	48333

Source: Table 4.1, above.

decided to carry out a survey during Arafat's day. For this a questionnaire was designed.

In this survey all the pilgrims present in Arafat at that day are included as units of the population. Interviewers randomly selected some pilgrims and had interviews with them.

The questionnaire included questions about the pilgrims (his country, whether or not he is with a muttawiff, his mode of arrival to Arafat, vehicle occupancy in his vehicle and time of arrival), his opinion about the parking situation and traffic and finally questions related to distance from the parking and type of parking. A copy of the questionnaire is shown in Appendix A. Students were employed to carry out the interviews. The questionnaire form, the method of selecting pilgrims and some general rules of interviewing were explained to them before they started the interviews. The following findings are deduced from the questionnaire:

- 1) It was found that 78% of the respondents are Saudis and 22% are Non-Saudis. Moreover it was found that the majority of the respondents are without muttawiff (81.2%), while only 18.2% are with muttawiff. Therefore, it can be seen that the interviewers were biased towards Saudis without muttawiffs.
- 2) Regarding the Saudis, the percentage of pilgrims from Taif and Makkah environs was the highest (23.6%), while the percentages of pilgrims from other provinces were as fol-



lows:

Eastern Province	10.4%
Riyadh and Environs	18.9%
Jeddah	17.0%
Madina	8.0%
Northern Province	12.3%
Southern Province	5.2%
Others	4.6%

---

Total 100.00

- 3) Regarding the Non-Saudis, the percentage of pilgrims from Gulf Area was the highest (33.3%), while the percentages of pilgrims from other countries were as follows:

Sudan and Somal	8.3%
Egypt	25.0%
Turkey	10.0%
Algeria	3.3%
Lebanon, Syria & Jordan	13.3%
America and Europe	1.7%
Yemen	3.3%
Pakistan	1.7%
Others	2.3%

---

Total 100.00

- 5) Regarding the type of vehicles used by the pilgrims, it was found that 31.7% used vans and suburbans which is the highest ratio. Next comes the mini-buses (31.3%), and 19.2% used buses and others 17.9%.
- 6) Although the regulations stress that no vehicle is allowed to enter the holy area with less than 9 passengers, Table 4.3 shows that about 34.4% of the vehicles did not abide by that rule. This shows that current enforcement checks are not sufficient.
- 7) Almost 90% of pilgrims enter Arafat in the morning period of the 9th Thul-Hijja, as shown in Table 4.4. This is an important fact from the point of causing traffic congestion on the major roads leading to Arafat and the local streets of Arafat.
- 8) From Tables 4.5 and 4.6, it can be seen that the existing road system leading to Arafat and the local streets inside Arafat have enough capacity to handle the existing traffic volume since only about 19% of pilgrims reported that they suffered from the traffic congestion before entering Arafat, and about 20% suffer from congestion after entering Arafat.
- 9) Table 4.7 shows that only about 20.6% of Pilgrims find it difficult or very difficult to find a parking space. This can be explained by the fact that many pilgrims join mutawiffs in Arafat and the mutawiffs know their camps in advance.

Table 4.3: Number of People in the Vehicle

No. of Pilgrims Per Vehicle	Frequency	%
Less or equal to 8	78	34.4
9-15	85	37.4
16-25	26	11.5
26-40	6	2.6
More than 40	32	14.1
Total		100%

Table 4.4: Time Entered Arafat

Arrival Time	Frequency	%
Morning 9th	247	89.2
Afternoon 9th	17	6.1
Morning 8th	1	0.4
Afternoon 8th	11	4.0
Before 8th	1	0.4
Total		100.1

Note: Due to rounding of error total does not add to 100%.

Table 4.5: Traffic Before Entering Arafat

Situation of Traffic	Frequency	%
Very Difficult	20	7.3
Difficult	32	11.2
O.K.	98	35.8
No Congestion	124	45.3
Total		100.1

Note: Due to rounding of error total does not add to 100%.

Table 4.6: Traffic After Entering Arafat

Situation of Traffic	Frequency	%
Very Difficult	22	7.9
Difficult	33	11.9
O.K.	99	35.7
No Congestion	123	44.4
Total		99.9 %

Note: Due to rounding of error total does not add to 100%.

Table 4.7: Difficulty of Parking

Situation of Parking	Frequency	%
Very Difficult	31	10.8
Difficult	26	9.4
O.K.	67.2	24.2
Very Easy	153	55.6
	Total	100%

- 10) From Table 4.8, almost 25% of pilgrims waste half an hour or more searching for a parking space, which is substantial. Presently, there are no illustrated maps or sketches or signs to lead the drivers to search for their locations easily.
- 11) Although the existing system has many disadvantages from the safety and convenience point of view, Table 4.9 shows that about 83.5% of pilgrims are satisfied. This can be explained by the fact that many pilgrims do not care about the safety point of view. For them the most important point is that their vehicle is parked very close to their camp.
- 12) Table 4.10 shows that almost 97% of pilgrims park their vehicles too close to their camp. Parking vehicles too close to the camp is recommended only if enough spacing is provided to separate the parked vehicles from the camp area, such as a 5m side walk, as will be explained later in the proposed future systems, but because the existing system does not provide that safe distance, the 97% (Table 4.10) who have parked their vehicles too close create fire hazard and air pollution.
- 13) Table 4.11 shows that about 21% of pilgrims park their vehicles illegally (such as inside the camp, or street double parking, or others). The reason may be lack of proper parking system. Although the existing parking demand is only 48,333 vehicle than for sure the problem will be more serious at future years (1410, 1415 H).

Table 4.8: Time Needed to Find Parking

Length of Time	Frequency	%
Less than 10 min	113	40.5
10-20 min	70	25.1
20-30 min	29	10.4
30-45 min	16	5.7
45 min-1 hr	21	7.5
More than 1 hr	30	10.8
	Total	100%

**Table 4.9: Satisfaction with the Existing System**

Respondent Answer	Frequency	%
Yes	233	83.8
No	45	16.2
	<b>Total</b>	<b>100%</b>

**Table 4.10: Distance from Parking**

How Close is the Vehicle Parked	Frequency	%
Very Near	205	97.6
Less than 250m	4	1.9
250-1000m	1	0.5
	<b>Total</b>	<b>100%</b>



Table 4.11: Type of Parking

Parking Case	Frequency	%
Inside Camp	7	3.2
Street Illegal	37	17.1
Street OK	172	79.3
Others	1	0.5
	Total	100.1%

Note: Due to rounding of error total does not add to 100%.

### 4.3 Future Demand

The researcher attempted to calibrate a multi-regression model to forecast the future number of pilgrims. He tried the "Abstract Mode" model which is originally developed by Baumal and Quandt (see Stopher, 1975). The hypothesized model is given below:

where:

$$H_{ki} = \alpha_0 (P_i^{\alpha_1}) (M_i^{\alpha_2}) (D_{ki}^r)^{\alpha_3} (T_{ki}^r)^{\alpha_4} (C_{ki}^r)^{\alpha_5} (D_i^b)^{\alpha_6} (T_i^b)^{\alpha_7} (C_i^b)^{\alpha_8}$$

$H_{ki}$  = number of pilgrims coming from country i by mode k.

$P_i$  = Muslim population in country i.

$M_i$  = average income in country i.

$D_{ki}^r$  = relative distance from country i to Makkah by mode k.

$T_{ki}^r$  = relative travel time by mode k with respect to travel time by the quickest mode.

$C_{ki}^r$  = relative cost by mode k with respect to the cheapest mode.

$D_i^b$  = shortest distance (air distance).

$T_i^b$  = shortest time of travel.

$C_i^b$  = cheapest cost of travel.

$\alpha_j$  = parameters that need to be calibrated using regression analysis.

But because that model requires a lot of reliable data which was not available, the model did not come up with reasonable forecast. The researcher investigated number of forecast studies but none of them was more authenticated and updated than the forecast done by Ministry of Rural Affairs (1405 H), which has been explained in Chapter 2. Their forecast of future number of pilgrims is shown in Table 4.12 for year 1405 till 1425 H. But by comparing their forecast number for year 1405 H (2,049,100) with the actual number (1,589,776), it was realized that there was some overestimation. Therefore, it was decided to deflate all their forecast before using them. The amount of deflation was calculated as the ratio between:

$$\frac{\text{The Actual \# 1405}}{\text{The Forecasted \# 1405}}$$

substituting, one gets:

$$\text{Deflation Factor} = \frac{1,589,776}{2,049,100} = 0.776$$

Using this factor the corrected forecasts shown in Table 4.13 were obtained.

The ratio of parking demand to pilgrims is assumed to be constant over the years. Using this ratio one can obtain the parking demand for any future year. Multiplying this ratio with the forecast of pilgrims at a specific future year will give the parking demand for that year.

Table 4.12: Forecasts of Pilgrims

---

Year	Overall Total	Internal	External
1405	2,049,100	765,500	1,283,600
1410	2,253,800	931,300	1,322,500
1514	2,596,300	1,094,500	1,501,800
1420	3,081,400	1,281,000	1,800,400
1425	3,734,000	1,570,600	2,163,400

---

Source: Ministry of Municipal and Rural Affairs (1405 H).

The next step is to separate pedestrians out of the number of pilgrims, mentioned in Table 4.13. Ministry of Communication (1979), showed that on the average 22% of total pilgrims go to Arafat on foot as shown in Table 4.15.

Table 4.13: Adjusted Forecasts for Pilgrims

Year	Overall Total	Internal	External
1410	1,748,949	722,689	1,026,260
1415	2,014,739	849,332	1,165,407
1420	2,391,166	994,056	1,397,110
1425	2,897,584	1,218,786	1,677,798

Table 4.14: Parking Demand

Year	Bus	Small*	Total
1410	11,713	41,459	53,162
1415	13,493	47,760	61,263
1420	16,014	56,683	72,697
1425	19,406	68,688	88,094

\* Small vehicle denotes any vehicle less than a bus such as a van, a mini bus, a jeep, etc.

Table 4.15: Forecast of Pedestrian

Year	Pedestrian	Internal Pilgrims	External Pilgrims
1410	384,769	653,697	800,483
1415	443,243	662,479	909,017
1420	526,057	775,364	1,089,745
1425	637,468	950,653	1,309,463

#### **4.3.1 Calculation of Number of Pilgrims According to Their Mode of Arrival to Arafat**

In the next step the internal and external pilgrims were split according to their mode of arrival to Arafat, which have different impacts on parking at Arafat. As explained in Chapter 3 six categories were considered:

- 1) External pilgrims coming to Arafat with own buses.
- 2) External pilgrims coming to Arafat with own small vehicles.
- 3) External pilgrims coming to Arafat with Muttawiff's buses.
- 4) Internal pilgrims coming to Arafat with buses.
- 5) Internal pilgrims coming to Arafat with small vehicles.
- 6) Pedestrians

The following calculations for the six categories are according to Scenario # 1, i.e. assuming that the existing regulation is still prevailing (no vehicle is allowed to enter with less than 9 pilgrims in it).

The number of pilgrims in each category was calculated as explained below:

##### **1) External Pilgrims coming to Arafat with their own buses:**

From the statistics obtained it was found that 18.5% of external pilgrims come with their own vehicles. Moreover, Hamadan's Study (1976), showed that 47.5% of them come with buses with an average occupancy rate of 36 passengers per bus. So using these percentages external pilgrims



coming with their own buses were calculated as shown in Table 4.16.

**2) *External Pilgrims Coming with Their Own Small Vehicles:***

This can be calculated as explained in Step 1, above: the 18.5% are coming with their own vehicles, if 47.5% of them are using buses, therefore 52.5% of them will be using small vehicles. The occupancy rate is not available, but it will be assumed to be 1/2 of a bus, i.e. 18 pilgrims per vehicle. So using these percentages external pilgrims coming to vehicles can be calculated as shown in Table 4.17.

**3) *External Pilgrims Using Muttawiff's Buses:***

This type can be calculated by subtracting the number of external pilgrims with own buses and the number of external pilgrims with own small from the total number of external pilgrims. The occupancy rate was found by Ministry of Communication (1979), 94 pilgrims per bus (assuming that two trips are made by each muttawiff's bus with an average occupancy of 47 pilgrims/bus. Accordingly, Table 4.18 shows the number of external pilgrims coming to Arafat with Muttawiff's buses.

**4) *Internal Pilgrims Coming to Arafat With Buses:***

This category of pilgrims are coming to Arafat either by their own buses or muttawiff's buses. The number of buses can be calculated by subtracting the number of buses

Table 4.16: External Pilgrims Coming to Arafat with Own Buses (Occupancy Rate = 36 pilgrims/Bus)

---

Year	Number of Pilg.	# of Buses
1410	70,342	1954
1415	79,880	2219
1420	95,761	2660
1425	115,069	3197

---

**Table 4.17: External Pilgrims Coming to Araftat  
With Own Small Vehicles  
Occupancy Rate = 18 pilgrims/Vehicle**

Year	Number of Pilg.	# of Small Vehicles
1410	77,747	4320
1415	88,288	4905
1420	105,841	5880
1425	127,182	7066

**Table 4.18: External Pilgrims Coming to  
Arafat With Muttawiff's Buses  
Occupancy Rate = 94 pilgrims/Bus**

Year	Number of Pilg.	# of Buses
1410	652,394	4,320
1415	740,849	7,882
1420	888,143	9,449
1425	1,067,212	11,354

used by external pilgrims coming with own buses (from Table 4.16) and the number of buses used by external pilgrims using muttawiff's bus (from Table 4.18) from the total number of buses (from Table 4.14). There is no exact statistics about their occupancy rate, but it was found in Ministry of Communication Study (1979) that they assumed two trips each carrying 47 pilgrims, i.e. 94 occupancy rate. Accordingly, Table 4.19 shows the number of internal pilgrims coming to Arafat with buses.

5) *Internal Pilgrims Using Their Own Small Vehicles:*

Table 4.14 has the total number of small vehicles, Table 4.17 has the small vehicles used by external pilgrims, therefore, the difference will be the number of vehicles for internal pilgrims. Table 4.15 gives the total internal pilgrims, Table 4.19 gives the internal pilgrims using buses, the difference would be the internal pilgrims using small vehicles. Accordingly, Table 4.20 was obtained. It was found that their average occupancy rate is 8 pilgrims/vehicle. Note that the allowable number is 9 pilgrims/vehicle but because some vehicles are used in transporting luggage, food, etc., that the average number of pilgrims was less than 9.

The above tables (4.15 - 4.20) can be summarized in Table 4.21, below.

**Table 4.19: Internal Pilgrims Using Buses**  
**Occupancy Rate = 94 pilgrims/Bus**

Year	Number of Pilg.	# of Buses
1410	264,892	2,818
1415	318,848	3,392
1420	367,070	3,905
1425	456,370	4,855

**Table 4.20: Internal Pilgrims Using Their**  
**Own Small Vehicles**  
**(Occupancy Rate = 8 Pilgrims/Veh.)**

Year	No. of Pilg.	# of Vehicles
1410	298,805	37,139
1415	343,631	42,855
1420	408,294	50,803
1425	494,283	61,622

Table 4.21: Parking Demand for Scenario 1

Year	External Pilgrims Coming With		Internal Pilgrims Coming With		Pedestrian	Total
	Own Buses	Own Small	Muttawiff's Bus	Buses		
1410	70,342	77,747	652,394	264,892	298,805	1,748,949
1415	79,880	88,288	740,849	318,848	343,631	2,014,739
1420	95,761	105,841	888,143	367,070	408,294	2,391,166
1425	115,069	127,182	1,067,212	456,370	494,283	2,897,584

#### **4.3.2 The Forecasts for Future Scenarios**

To calculate the parking demand under Scenario 2 (minimum of 18 passengers per vehicle), the following steps were followed:

- 1) The total number of pilgrims and number of pedestrians are assumed to remain the same.
- 2) The external pilgrims coming to Arafat with their own small vehicles, since there is no exact data available, it is assumed that 50% of them are above 18 pilgrims per vehicle already, 50% are less. Out of the latter 50%, 25% will join the external pilgrims using own buses, and 25% will continue using small vehicles with an occupancy rate equal to 18 pilgrims per vehicle to be consistent with this scenario. Similarly the internal pilgrims coming with small vehicles, 50% of them are already above 18 pilgrims/vehicle, and 50% are less. Out of the latter 50%, 25% will join the internal pilgrims using buses, 25% will continue using small vehicles with an occupancy rate equal to 18 pilgrims per vehicle. Accordingly, Table 4.22 is obtained.

Scenario 3 assumes a minimum vehicle occupancy of 36 passengers per vehicle, which means that only buses will be allowed to enter Arafat. To calculate the future parking demand in this scenario the following assumptions were made:

- 1) All external pilgrims using small vehicles will be assumed to

Table 4.22: Forecast Number of Pilgrims According to Scenario # 2.

Year	External Pilgrims Coming With			Internal Pilgrims Coming With		Pedestrian	Total
	Own Buses	Own Small	Muttawiff's Bus	Bus	Small Vehicle		
1410	89,779	58,310	652,394	339,593	224,104	384,769	1,748,949
1415	101,952	66,216	740,849	404,756	257,723	443,243	2,014,739
1420	122,221	79,381	888,143	469,143	306,221	526,057	2,391,166
1425	146,864	95,387	1,067,212	579,941	370,712	637,468	2,897,584



shift to external pilgrims buses with occupancy rate equal to 36.

- 2) All internal pilgrims using small vehicles will be assumed to shift to internal pilgrims using buses. Accordingly, the forecasts shown in Table 4.23 are obtained.

Table 4.23: Forecast Number of Pilgrims According To Scenario # 3.

Year	External Pilgrims Coming With		Internal Pilgrims Coming With Bus	Pedestrians	Total
	Own Buses	Muttawiff's Bus			
1410	148,089	652,394	563,697	384,769	1,748,949
1415	168,168	740,849	662,479	443,243	2,014,739
1420	201,602	888,143	775,364	526,057	2,391,166
1425	242,251	1,067,212	950,653	637,468	2,897,584

## Chapter 5

### ALTERNATIVE GENERATION

Various alternatives were generated keeping in mind the objectives listed in Section 3.5. The proposed alternatives were evaluated in terms of fulfillment of those objectives. Most of these objectives are unquantifiable. Therefore a subjective evaluation method as described below was used. Explanation of various alternatives which were included in the evaluation are given below

#### 5.1 Do Nothing Alternative

This system assumes that everything is kept as it is presently with minor adjustment in the future. Figure 5.1 shows the existing grid system, camping areas between the streets, and some surface parking lots.

In the existing case, Arafat lacks a proper parking system. The questionnaire which was carried out in Arafat as explained in Section 4.2.2, showed that in this system many vehicles are parked illegally. Presently, a large portion of Arafat is not efficiently and safely utilized. Many vehicles are parked inside camping area causing air pollution and a hindrance for emergency vehicles. More details will be provided in the subsequent chapters.

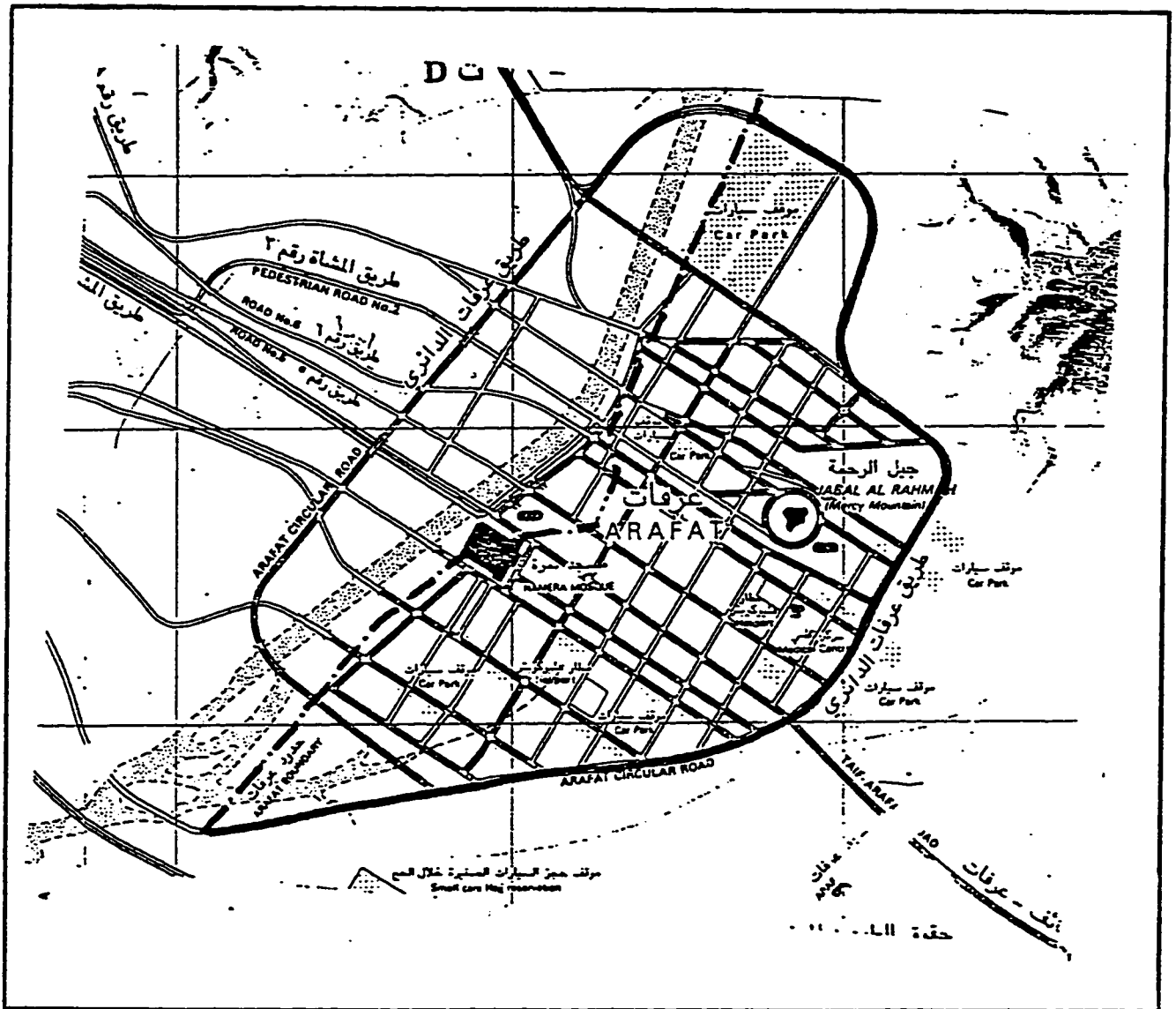


Fig. 5.1: Do nothing alternative, the existing parking system is composed of a street grid system and some open surface parking lots.

## 5.2 The Proposed Systems

Three parking systems have been formulated as described below. In developing these systems the objectives which were given above, and the land limitations were kept in mind. As mentioned in Section 4.3 there are five categories of pilgrims plus the pedestrians as a sixth category. Obviously, each category has its different needs of parking spaces and camping areas because of the differences in occupancy rate and vehicle size. Therefore, each category will be accommodated in a specially designed block to satisfy its needs of both parking spaces and camping area. Different unit sizes were examined to select the best size to avoid wastage of land so that in any design parking spaces offered and camping area must be compatible. It was concluded that the size of 235 m x 150 m is most suitable for all the proposed systems and for all pilgrim categories and for all future scenarios. Therefore, this size was chosen to be used in all designs as shown in the following sections. It is hoped that these systems which consist of different parking block arrangements will solve the parking problem for both present case and the future. These parking blocks will be employed in a network of unified dimensions.

### 5.2.1 U-System

This system consists of two parts with one maneuver area in between. Figure 5.2 shows the design for external pilgrims with own buses. Each part consists of a camping area and a parking lot separated from each other by 5m sidewalk, (the sidewalk was narrowed at some cases to increase the camping area). The advantages of this system are explained below:

Since a maneuver area is provided, parking in or out will not disturb the flow of traffic in the street. Moreover, walking distance between parking lot and camping is only few meters. Table 5.1 shows the detailed dimensions of the units for each pilgrim category. In Appendix B an example of the calculations involved in designing one unit for external pilgrims using muttawiff's bus is given.

The next step is to calculate the total area needed (for all pilgrims categories) in case of implementing the U System, at each forecast year and under each scenario. Since Table 4.21 - 4.23 give the forecast number of pilgrims at each scenario, Table 5.1 gives the number of pilgrims each block can accommodate. Table 5.2 gives the number of units required at each year under each scenario, since all units have dimensions of  $235 \times 150 \text{ m}^2$ . Moreover these blocks are separated by two lane streets the centerline between each two blocks will include the width of one lane at each side, i.e. 3.7 m, therefore, area would be  $242.4 \times 157.4 = 38,153.76 \text{ m}^2$ . Then area of all units

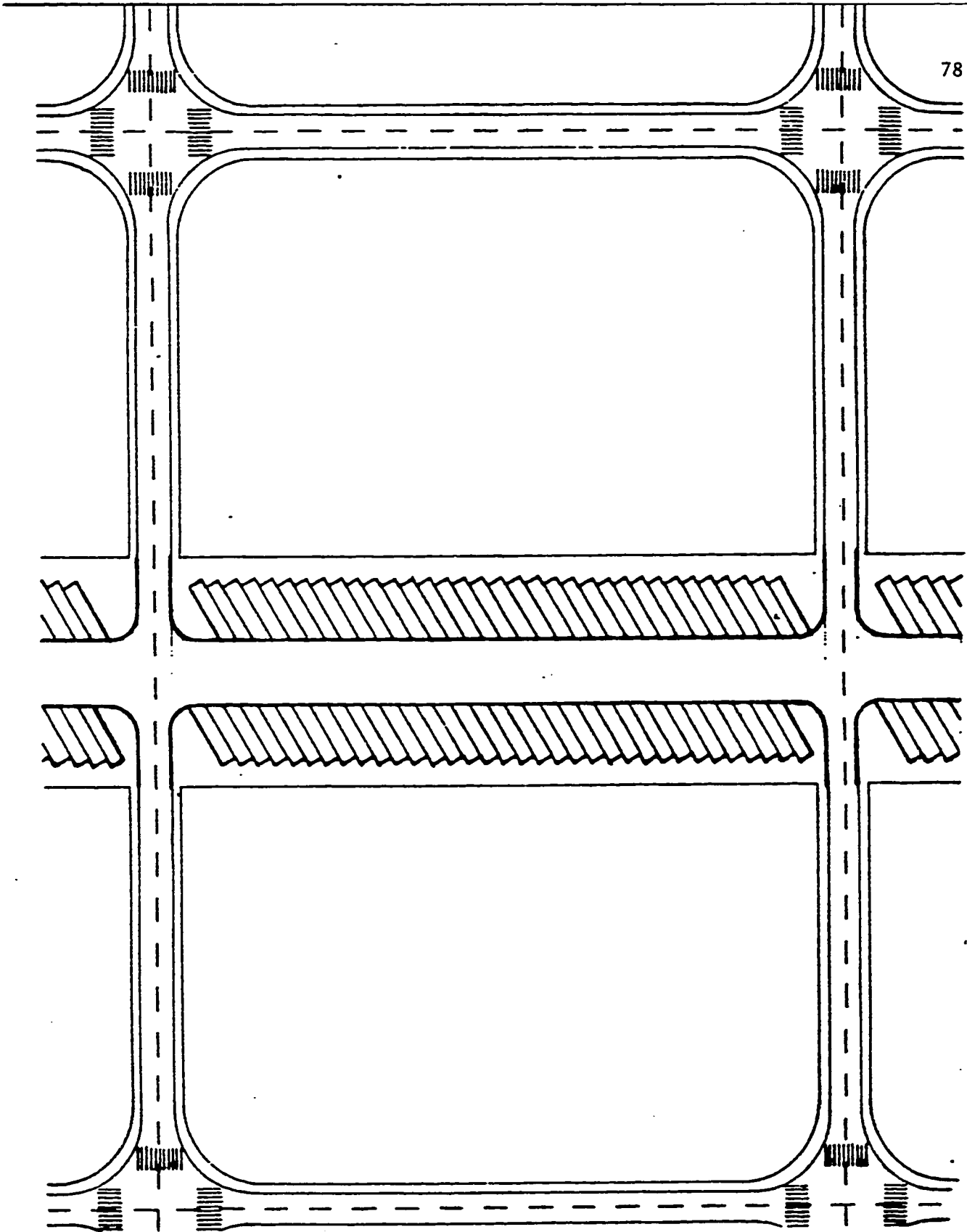


Fig. 5.2: The U-System. A Unit for external pilgrims using Muttawiff's bus. (Occupancy Rate = 94 pilgrims/bus).

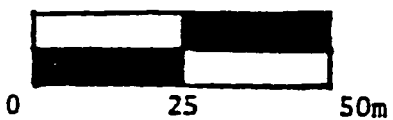


Table 5.1: U-System - Dimensions and Capacity for Accommodation of Pilgrims and their Vehicles.

Category of Pilgrims	Unit Length	Unit Width	No. of Pilgrims	Parking Needed	Parking Offered
External Own Bus	235	150	4464	124	124
External Own Small	235	150	5076	282	312
External Mutt. Bus	235	150	6392	68	68
Internal Bus	235	150	6392	68	68
Internal Small	235	150	3200	400	416



Table 5.2: Total Area Needed for U-SYSTEM

	Year	NUMBER OF UNITS										Pedest. Area m <sup>2</sup>	Area of All Units m <sup>2</sup>	Total Area m <sup>2</sup>
		EXTERNAL				INTERNAL			Total					
		Own Buses	Own Small	Mutt. Bus	Bus	Small								
SCENARIO # 1	1410	16	16	102	42	94	270	192,385	10,301,515	10,493,900				
	1415	18	18	116	50	108	310	221,622	11,827,666	12,049,288				
	1420	22	21	139	58	128	368	263,029	14,040,584	14,303,613				
	1425	26	25	167	72	155	445	318,734	16,978,423	17,297,157				
SCENARIO # 2	1410	21	12	102	54	70	259	192,385	9,881,824	10,074,209				
	1415	23	13	116	64	81	297	221,622	11,331,667	11,553,289				
	1420	28	16	139	74	96	353	263,029	13,468,277	13,731,306				
	1425	33	19	167	91	116	426	318,734	16,253,502	16,572,236				
SCENARIO # 3	1410	34	--	102	89	--	225	192,385	8,584,596	8,776,981				
	1415	38	--	116	104	--	258	221,622	9,843,670	10,065,292				
	1420	46	--	139	122	--	307	263,209	11,713,204	11,976,233				
	1425	55	--	167	149	--	371	318,734	14,155,045	14,473,779				

will be obtained by multiplying the:  $38,153.76 \text{ m}^2$  by the number of all units at any year under each scenario.

Pedestrian area is to be added. Since pedestrians do not require large area for tents or other facilities, the researcher decided to give an area of  $2\text{m}^2$  (i.e. 1/2 area for a regular pilgrim) to each pedestrian. Accordingly, Table 5.2 is obtained.

### **5.2.2 Block System**

This system consists of one camping area in the middle with parking arrangements on each side. Figure 5.3 shows the design for a unit for internal pilgrims coming with own small vehicles. A 5m sidewalk is provided to separate the parked vehicles from camp area. Because no maneuver area is provided, this design proved to be the most economic one (needing minimum area). On the other hand, when vehicles park in or out, they interrupt the flow in the street which creates a safety problem and delay. Table 5.3 shows the detailed dimensions of this alternative. Table 5.4 shows the total area required if this system is implemented.

### **5.2.3 Separated System**

This system consists of three parts; two camps, one parking lot, two maneuver areas which separates each camp from the parking lot. Figure 5.4 shows this design for external pilgrims coming with own buses. Because it has two maneuver areas it provides more

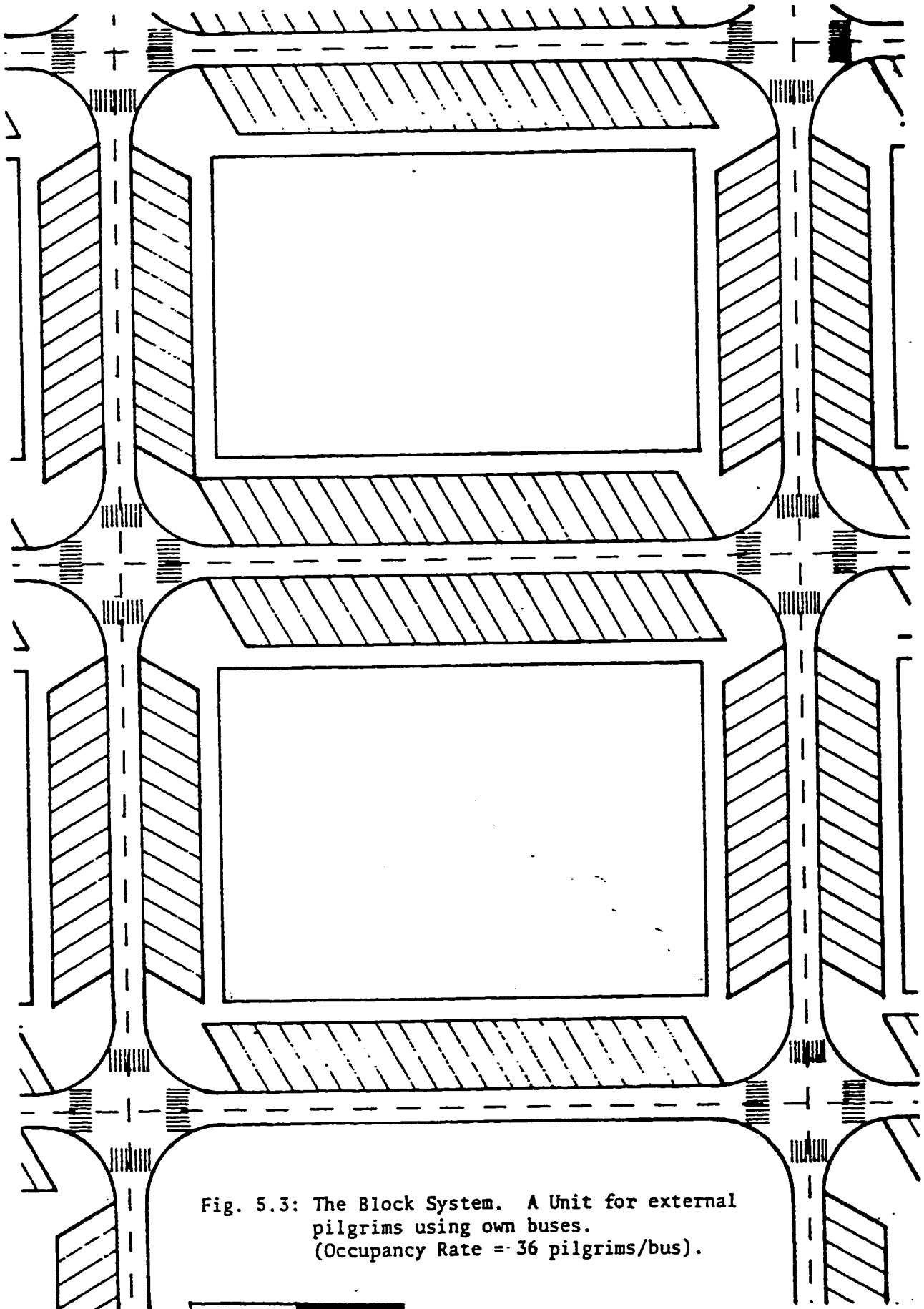


Fig. 5.3: The Block System. A Unit for external pilgrims using own buses.  
(Occupancy Rate = 36 pilgrims/bus).

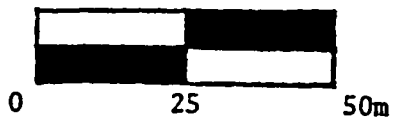


Table 5.3: Block system - Dimensions and Capacity for Accommodation of Pilgrims and their Vehicles.

Category of Pilgrims	Unit Length	Unit Width	No. of Pilgrims	Parking Needed	Parking Offered
External Own Bus	235	150	4320	120	132
External Own Small	235	150	5404	300	300
External Mutt. Bus	235	150	6580	70	76
Internal Bus	235	150	6580	70	76
Internal Small	235	150	3264	408	408

Table 5.4: Total Area Needed for Block System

	Year	EXTERNAL					INTERNAL		Total	Area of all units m <sup>2</sup>	Pedestrian Area m <sup>2</sup>	Total Area m <sup>2</sup>
		Own Buses	Own Small	Mutt. Bus	Bus	Small						
SCENARIO #1	1410	17	15	92	41	92	257	9,805,516	192,385	9,997,901		
	1415	19	17	113	49	106	304	11,598,743	221,622	11,820,365		
	1420	23	20	135	56	125	359	13,697,200	263,029	13,960,229		
	1425	27	24	163	70	152	436	16,635,039	318,734	16,953,773		
SCENARIO #2	1410	21	11	92	52	69	245	9,347,671	192,385	9,540,056		
	1415	24	13	113	62	80	292	11,140,898	221,622	11,362,611		
	1420	29	15	135	72	94	345	13,163,047	263,029	13,426,076		
	1425	34	18	163	89	114	418	15,948,272	2,318,734	16,267,006		
SCENARIO #3	1410	35	--	92	86	--	213	8,126,751	192,385	8,319,136		
	1415	39	--	113	101	--	253	9,652,901	221,622	9,874,523		
	1420	47	--	135	118	--	300	11,446,128	263,029	11,709,157		
	1425	56	--	163	145	--	364	13,887,969	318,739	14,206,703		

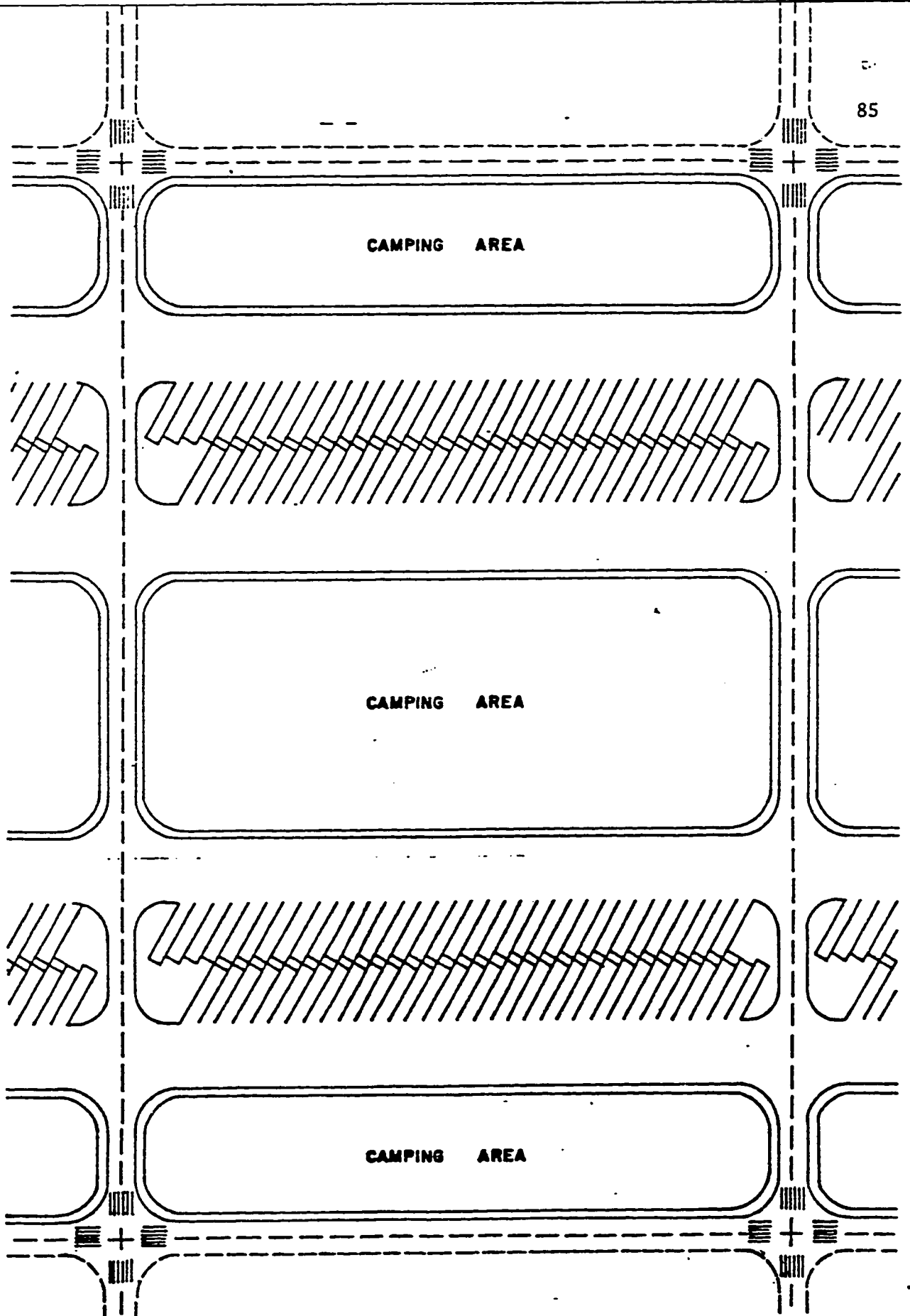
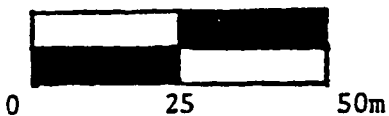


Fig. 5.4: The Separated System. A unit for external pilgrims using own buses (Occupancy Rate = 36 pilgrims/bus).



freedom, more convenience for drivers for parking in or out, which in turn increases the safety of the system. Another advantage is that the parking lot is completely separated from camping areas, yet walking distance is within an acceptable range.

Table 5.5 shows the detailed dimensions of this alternative. Table 5.6 shows the total area needed if that system was implemented.

Table 5.7 summarizes the total area requirements for all systems at each forecast year under any scenario.

#### ***5.2.4 Multi Story Building***

This solution was also considered. After consulting expert engineers in multi story parking garages, it was found out that it is about 100 times expensive as a surface lot, moreover it needs continuous maintenance, high electric power for lighting, ventilation. Multi story buildings are warranted usually in city centers where land is scarce and very costly, and parking demand is continuous throughout the year, which is not the case of Arafat. Therefore, this solution was eliminated from the beginning.

**Table 5.5: Separated System - Dimensions and Capacity for Accommodation of Pilgrims and their Vehicles.**

Category of Pilgrims	Unit Length	Unit Width	No. of Pilgrims	Parking Needed	Parking Offered
External Own Bus	235	150	4140	115	134
External Own Small	235	150	4888	272	330
External Mutt. Bus	235	150	6298	67	67
Internal Bus	235	150	6298	67	67
Internal Small	235	150	3520	440	440



Table 5.6: Total Area Required for the Separated System

	Year	NUMBER OF UNITS										Pedestrian Area m <sup>2</sup>	Area for all units m <sup>2</sup>	Total Area m <sup>2</sup>
		EXTERNAL				INTERNAL			Total					
		Own Buses	Own Small	Mutt. Bus	Bus	Small								
SCENARIO # 1	1410	17	16	104	42	85	264	192,385	10,072,593	10,264,978				
	1415	20	18	118	51	98	305	221,622	11,636,897	11,858,519				
	1420	24	22	141	59	116	362	263,029	13,811,661	14,074,690				
	1425	28	26	170	73	141	438	318,734	16,711,347	17,030,081				
SCENARIO # 2	1410	22	12	104	54	64	256	192,385	9,767,363	9,959,748				
	1415	25	14	118	65	74	296	221,622	11,293,513	11,515,135				
	1420	30	17	141	75	87	350	263,029	13,353,816	13,616,845				
	1425	36	20	170	92	106	424	318,734	16,177,194	16,495,928				
SCENARIO # 3	1410	36	--	104	90	--	230	192,385	8,775,365	8,967,750				
	1415	41	--	118	106	--	265	221,622	10,110,746	10,332,368				
	1420	49	--	141	124	--	314	263,029	11,980,281	12,243,310				
	1425	59	--	170	151	--	380	318,734	14,498,429	14,817,163				

Table 5.7: Total Area for All Systems in m<sup>2</sup>

	Year	U	Block	Separated
SCENARIO 1	1410	10,493,900	9,997,901	10,264,978
	1415	12,049,288	11,820,365	11,858,519
	1420	14,303,613	13,960,229	14,074,690
	1425	17,297,157	16,953,773	17,030,081
SCENARIO 2	1410	10,074,209	9,540,056	9,959,748
	1415	11,553,289	11,362,611	11,515,135
	1420	13,731,306	13,426,076	13,616,845
	1425	16,572,236	16,267,006	16,495,928
SCENARIO 3	1410	8,776,981	8,319,136	8,967,750
	1415	10,065,292	9,874,523	10,332,368
	1420	11,976,233	11,709,157	12,243,310
	1425	14,473,779	14,206,703	14,817,163

## Chapter 6

### EVALUATION OF ALTERNATIVE PARKING SYSTEM

#### 6.1 Introduction

To evaluate the four systems described in Chapter 5, a questionnaire was developed. The advantage of using the questionnaire technique for evaluation is that the researcher can obtain the opinion of many engineers and scientists who have long experience in the field of parking and/or Hajj traffic system. Therefore, it was important to select the people to whom the questionnaire was sent.

#### 6.2 Questionnaire Design

The questionnaire included the following parts:

1) *Cover Letter*: A letter to respondents explaining, very briefly, the intent of the study and asking their help.

2) *Explanation of Alternatives*: The proposed alternatives to be evaluated are described in this section.

3) *Evaluation of Alternatives*: The described alternatives were evaluated by the respondents by indicating their agreement for the fulfillment of an objective (such as "This system reduces the delay for searching a space") on a five-point scale (SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree).

**4) Evaluation of Importance of Factors:** To understand the importance of each of the objective, the respondents were asked to evaluate the importance using a five-point scale (NIA = Not Important at All, NI = Not Important, N = Neutral, I = Important, EI = Extremely Important).

**5) Information About The Respondent:** Some background information about the respondent such as his education, occupation and whether or not he has performed Hajj and/or has been to Hajj area were asked.

The questionnaire is given in Appendix B.

### **6.3 Explanation of Survey Procedure**

Traffic engineers, engineering faculty members and/or people involved in Hajj matters who might have good experience about Hajj traffic systems are included in the population to be sampled. The most important organizations who had the required people of the survey population are:

- 1) Hajj Research Center
- 2) Makkah Traffic Police Directorate
- 3) The General Traffic Directorate
- 4) Ministry of Communications
- 5) King Fahd University of Petroleum & Minerals, Dhahran
- 6) King Faisal University, Dammam

- 7) King Saud University, Riyadh
- 8) King Abdulaziz University, Jeddah
- 9) The Road and Traffic Departments in all municipalities.

Arabic and English copies of three hundred questionnaires were sent to some of the experts, engineers and faculty members working in the organizations listed above. Sixty five questionnaire were received back within four weeks time. Since this study is aimed to get the responses from experts in the area and because of limited number of experts, this number was considered to be sufficient. The received questionnaires were checked for their completeness and accuracy. They were coded and computer data files for analysis were created.

#### 6.4 Analysis of Evaluation Survey

The coded information from the received questionnaires were analyzed using computer package SAS (1985). Figure 6.1 shows the averages of responses on each objective for each system (called "snake-plots"). From this figure it can be observed the existing system is dominated by the other alternatives in all objectives. This can be explained by that presently Arafat is not properly designed to offer safe, legal parking spaces for all categories of pilgrims. From the first questionnaire (to study the existing situation of Arafat) it was found that 25% of pilgrims waste considerable time searching for a space, others park illegally such as double parking, inside camp,

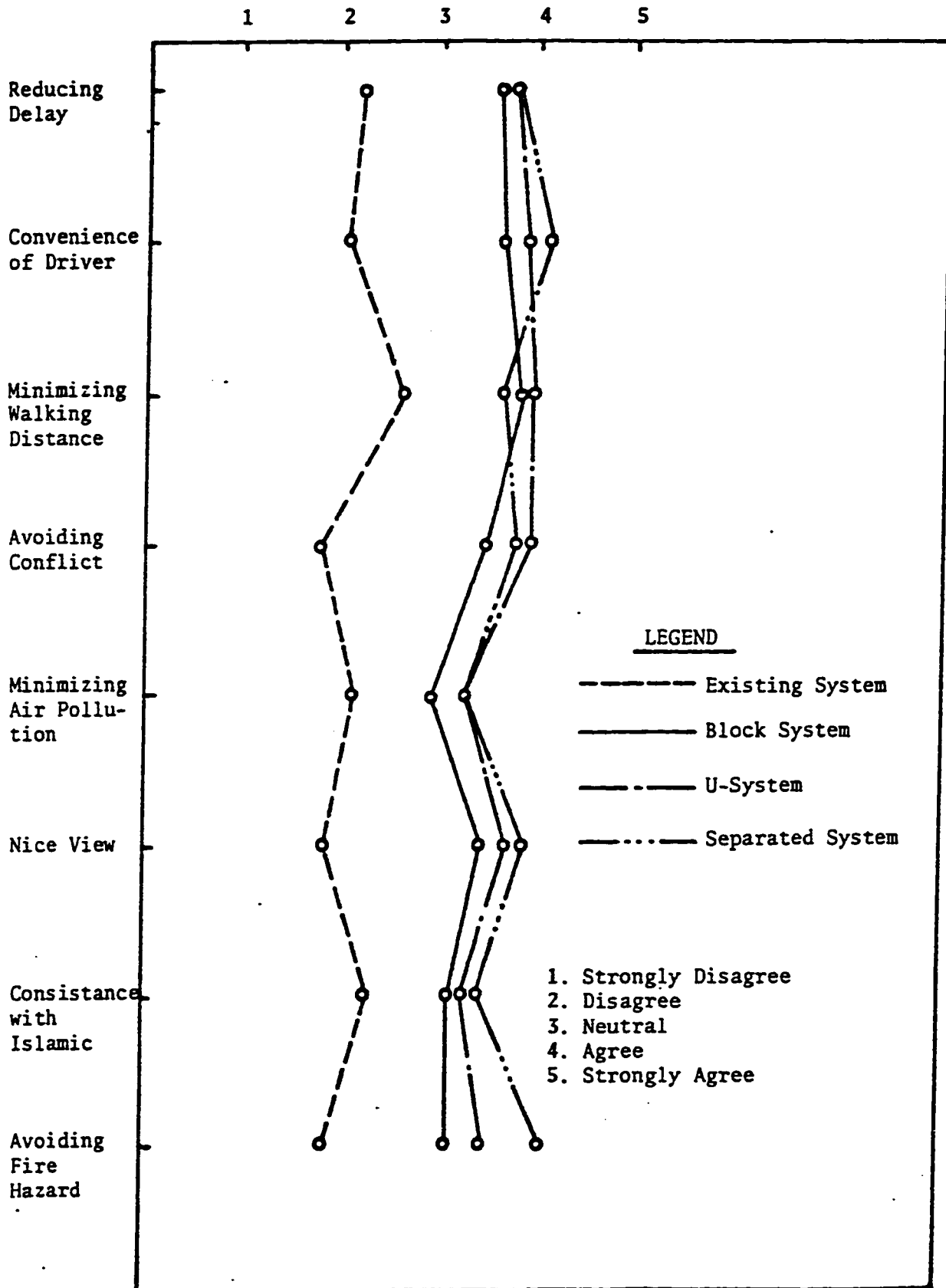


Fig. 6.1: Snake Plot for Average Score for each system in each of the eight objectives.

etc.

The U-System is inferior to the separated system in the following evaluation criteria:

- a) Driver's convenience
- b) Air pollution
- c) Giving nice view to Arafat
- d) Consistency with the Islamic feeling
- e) Reducing fire hazard

This can be explained by the fact that the Separated System has two maneuver areas while the U-System only one. Therefore, the Separated System provides more freedom to drivers, since cars are completely separated from the camp area, it reduces air pollution and fire hazard.

The Block System, generally speaking, is dominated by the U-System and Separated System at all objectives, except at minimizing walking distance. The Block System scored higher than the Separated System, possibly because vehicles are parked only 5m (being the side walk that separates the parking lot from the camping area) while in the Separated System walking distance is 10m (which is the maneuver area for small vehicles) and 15m for bus parking units.

The Separated System seems to be the best at most objectives, yet it has a lower score than the U-System at avoiding conflict between cars and pedestrians. This can be explained by that the

Separated System has two maneuver areas, while the U-System only one. Naturally, in the maneuver areas there must be little conflict between cars and pedestrians which is inevitable.

The average degree of importances scored by each of the eight objectives are reported in Table 6.1.

Table 6.1: The Average Degree of Importance

Objective	Average Score
To minimize fire hazard	4.66
Minimizing conflicts between pedestrians and vehicles	4.47
Minimizing delay in searching	4.29
To be convenient for the driver	4.08
Minimizing air pollution	3.95
Minimizing walking distance	3.94
To be consistent with Islamic feeling	3.66
Giving nice view to Arafat	3.54

From this table it can be seen that fire hazard is the most important factor scoring 4.66 out of 5.0. This can be explained by the fact that fire problem in an activity like Hajj can be a very serious problem, such as the fire that took place in Mina at year 1975 (Yafi, 1983), with a result of many deaths and large losses of properties.



The next item, receiving a score of 4.47 is "minimizing conflict between pedestrians and vehicles" is also a safety related item. This is followed by "Minimizing delay to be convenient for the driver", "minimizing air pollution", minimizing walking distance" with scores of 4.29, 4.08, 3.95 and 3.94, respectively.

The weighted score for each alternative was obtained using the following formula:

$$W_k = \sum_{j=1}^8 S_{kj} \times D_j \quad (6.1)$$

where

$W_k$  = total weighted scored by System k

$S_{kj}$  = average score for System "k" by objective j.

$D_j$  = average degree of importance scored by objective j.

The results are presented in Table 6.2.

From this table, the Separated System seems to be the best. It has the highest total weight 113.02. Next comes the U-System with a total weight of 111.59 which is very close to the Separated System. Therefore, if the Separated System cannot be implemented for any reason (such as shortage of land or budgetary problems) the U-System should be considered as an alternative. The Block System should be considered as the last alternative.

Table 6.2: The Weighted Scores of Alternatives

System	Total Weighted Score
Do Nothing	65.00
U-System	111.59
Block System	104.99
Separated System	113.02

Regarding the background of the respondents the following points can be noticed:

1) Education Level: The highest ratio (47.5%) of the respondents have completed graduate degree. Next comes college graduates (45.9%) and High School graduates (3.3%), then some college and technical school graduates, each (1.6%).

2) Occupation: The majority (70.0%) of the respondents were professionals and engineers, while professors and teachers were (16.7%), managers (8.5%) and others (4.8%).

3) Performance of Hajj: It was found that 77% of the respondents have already performed Hajj and only 23% have not.

Regarding those respondents who have not performed Hajj, it was found out that 61.5% of them have visited the Holy area of Makkah and Hajj area, while 38.5% of them have not. Therefore, it is

obvious that the majority of the respondents are very knowledgeable about the Hajj area.

## **Chapter 7**

### **FINAL DESIGN**

#### **7.1 Final Block Design For The Selected System**

In Chapter 6 the separated system was selected as the best system to solve both the present and future parking problems. Figures 7.1 through 7.5 show the unit design for all the five categories of pilgrims for this system.

#### **7.2 Land Allocation and Phasing of Design**

In this section allocation of land among the five categories of pilgrims (plus pedestrian as a sixth category) is explained. There are two basic rules to be followed in the land allocation:

- 1) Area given to any category must be enough to accommodate that category in question.
- 2) Each category will be using one or more of the major roads leading to Arafat, so that pilgrims will reach their location easily, with minimum delay, minimum congestion (as will be explained in the Capacity Analysis, below).

Accordingly Figure 7.6 shows the land allocation for year 1410 under Scenario # 1 using the Separated System. Similar figures can be drawn for other forecast years, other scenarios, and other

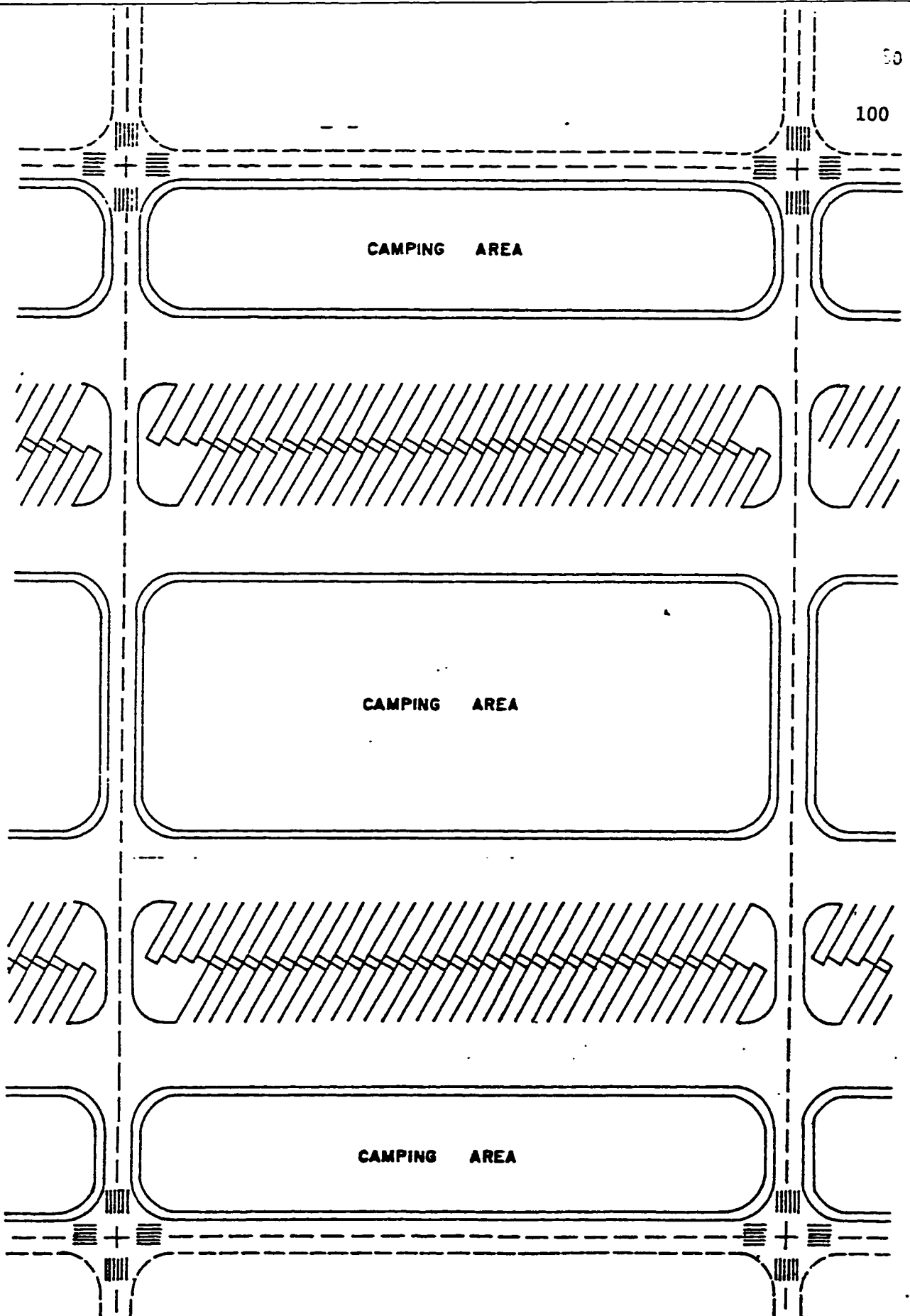
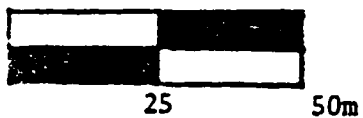


Fig. 7.1: The Separated System. A unit for external pilgrims using own buses (Occupancy Rate = 36 pilgrims/bus).



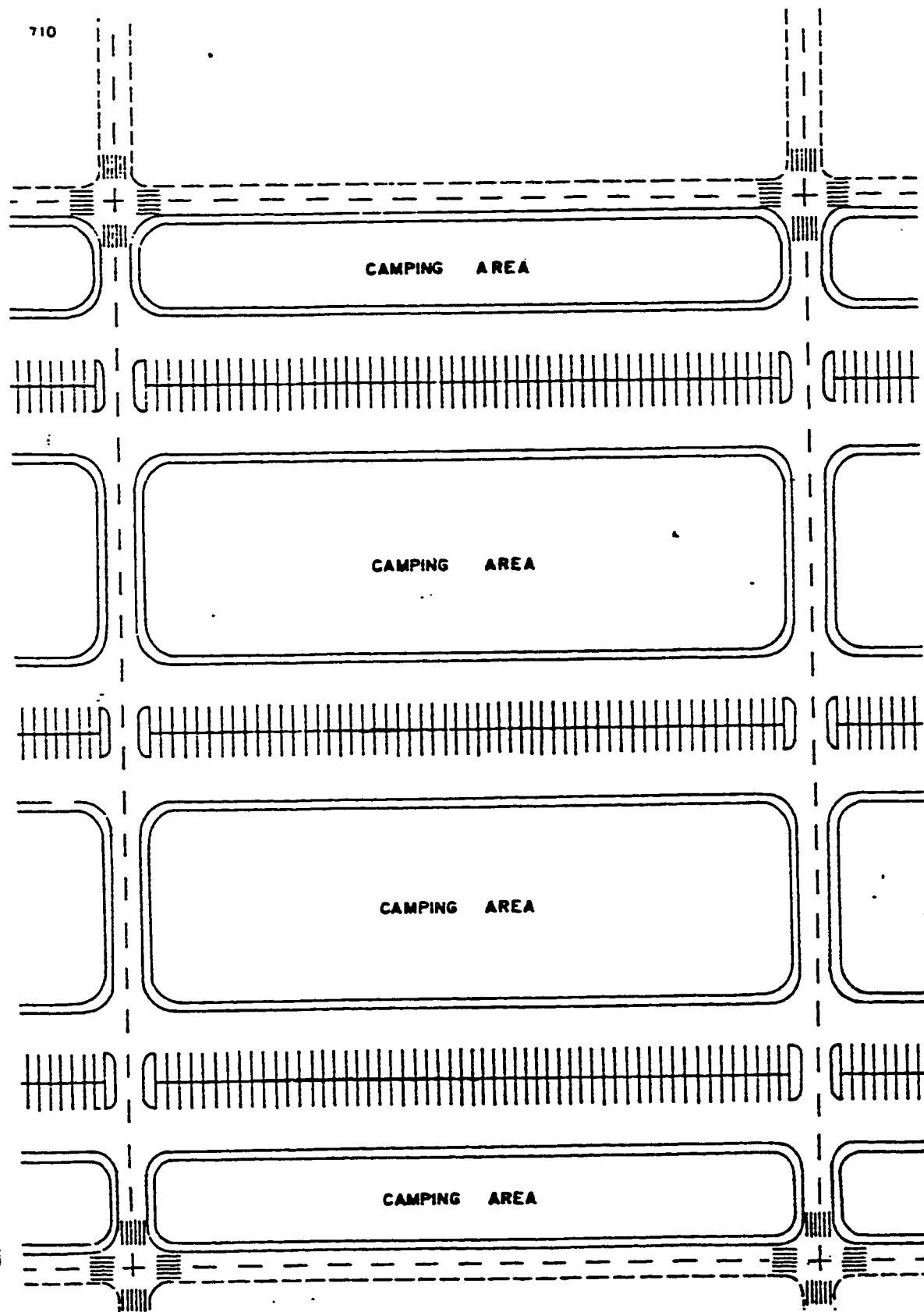
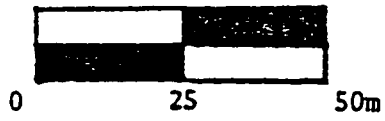


Fig. 7.2: The Separated System. A unit for external pilgrims using own small vehicles. (Occupancy Rate = 18 pilgrims/vehicle).



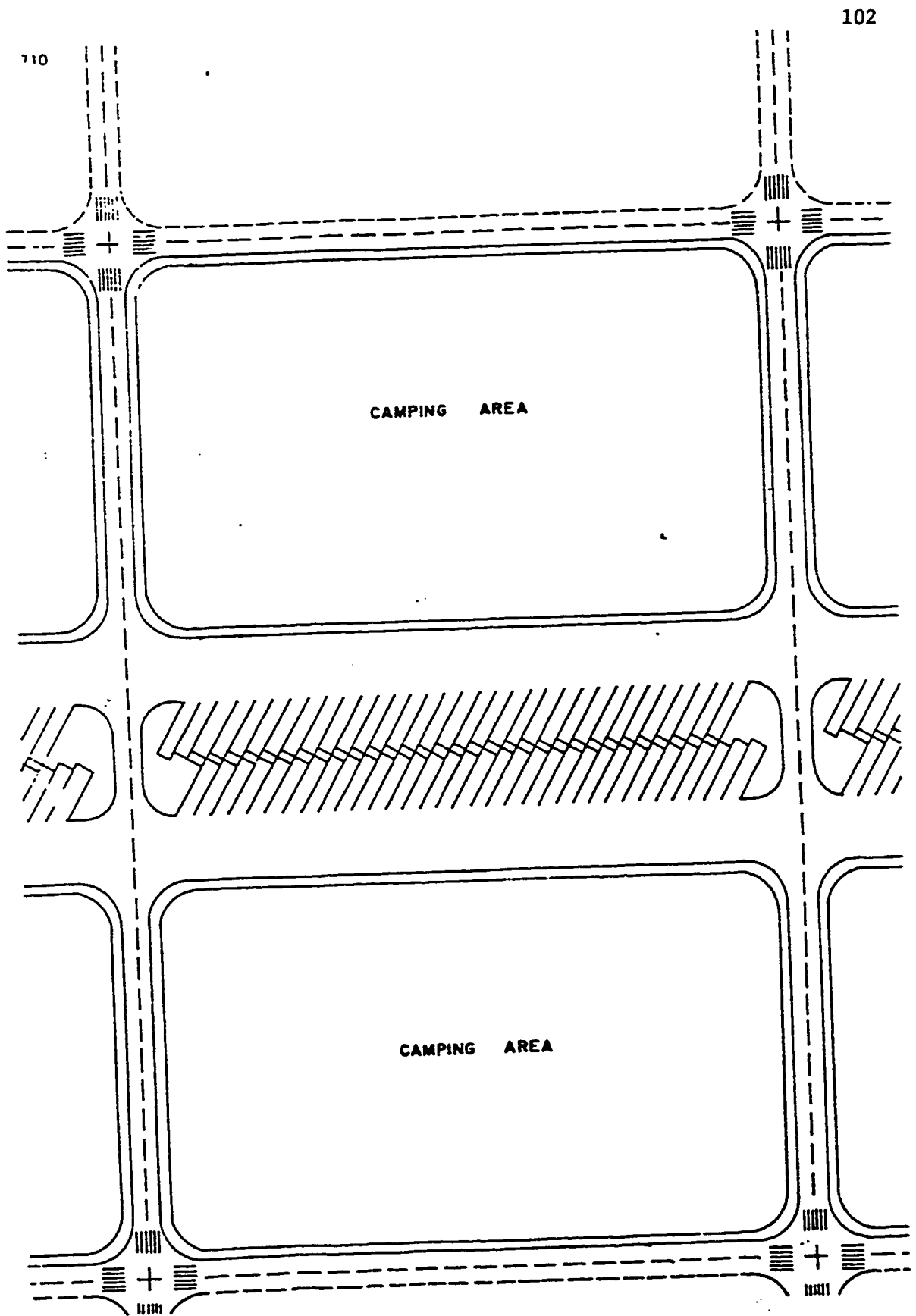


Fig. 7.3: The Separated System. A unit for external pilgrims using Muttawiff's bus. (Occupancy Rate - 94 pilgrims/bus).



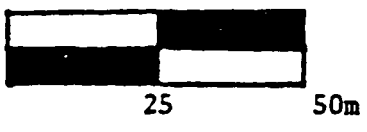
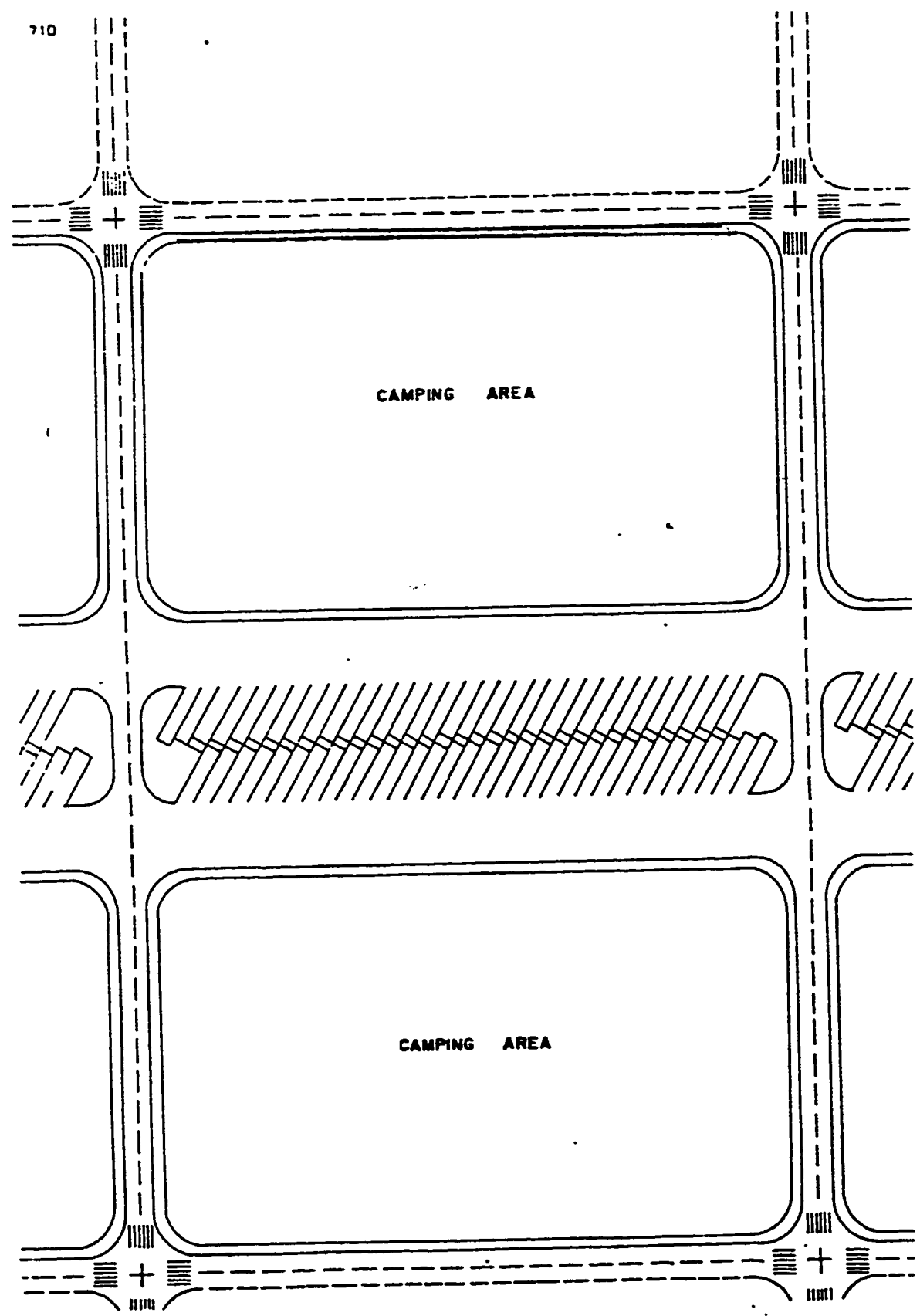


Fig. 7.4: The Separated System. A unit for internal pilgrims using buses. (Occupancy Rate = 36 pilgrims/bus).



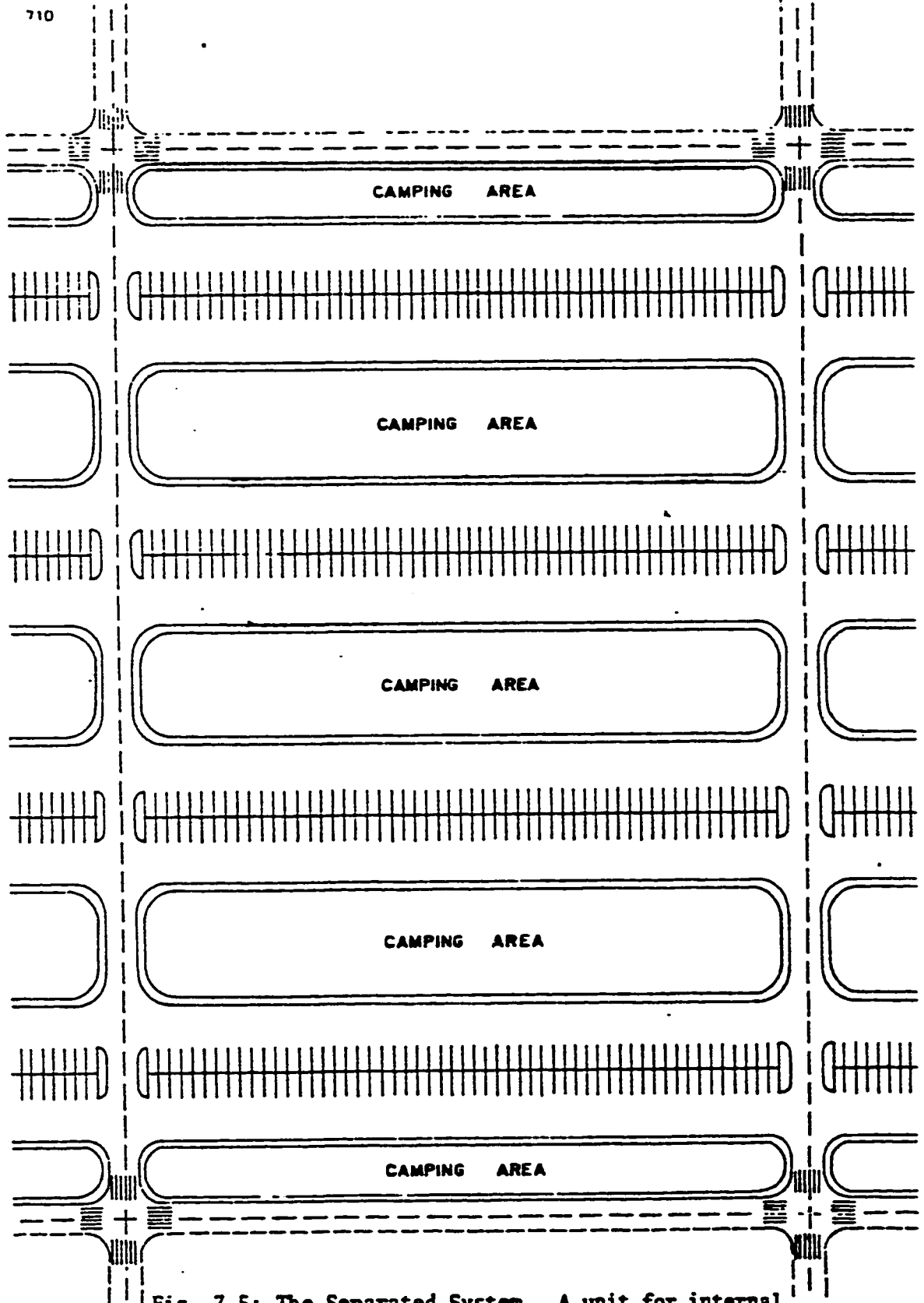
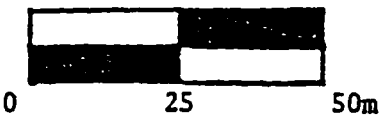
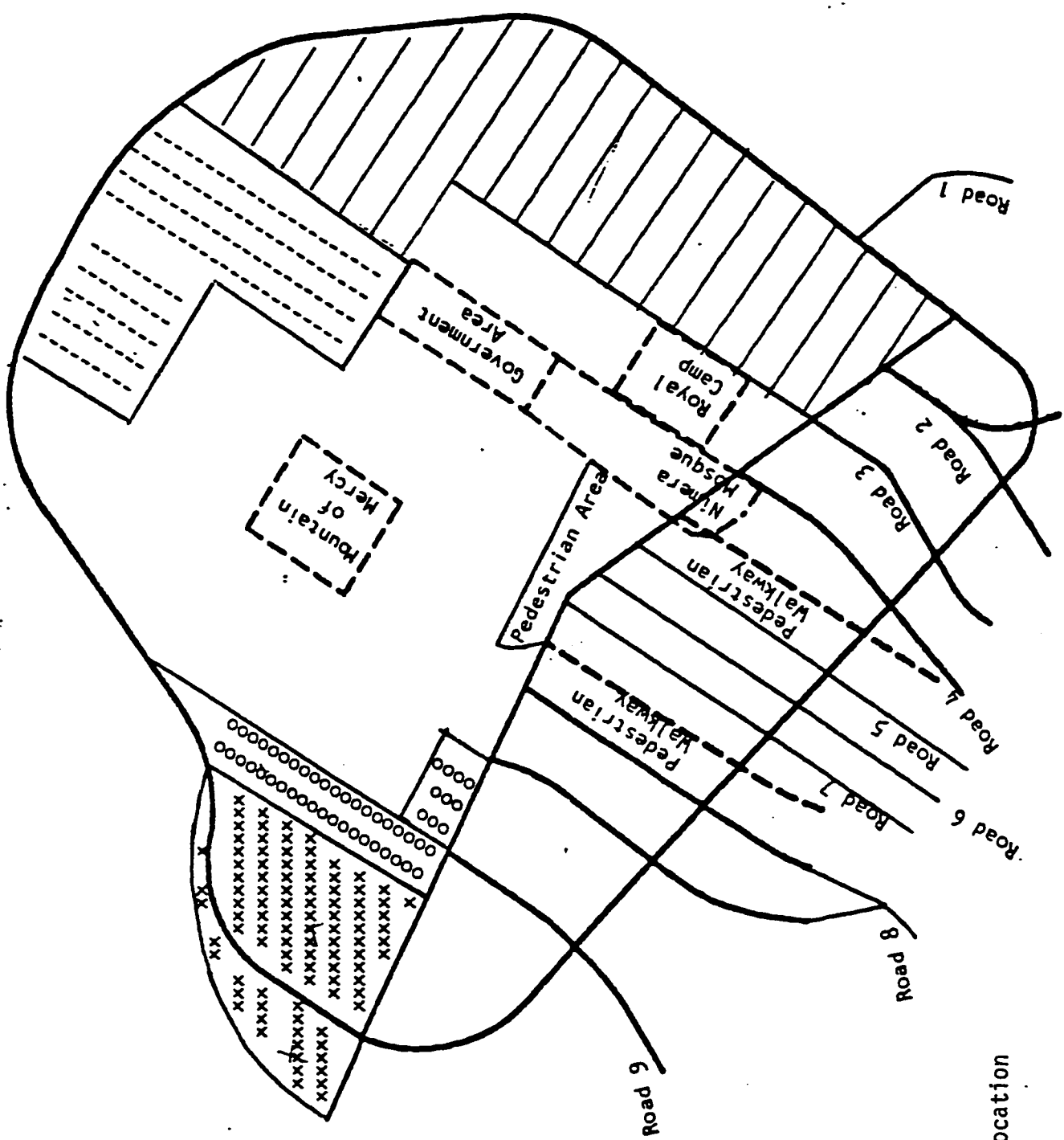


Fig. 7.5: The Separated System. A unit for internal pilgrims using own small vehicles. (Occupancy Rate = 8 pilgrims/vehicle).





External with Mutt.	XXXXXX
Internal Small Veh.	XXXXXX
Internal Buses	XXXXXX
External Small Vehicle	XXXXXX
External Buses (own)	XXXXXX

Fig. 7.6: Land Allocation

parking systems, but Figure 7.6 is enough to show an example of land allocation map.

At year 1415 there is still enough space to accommodate the same system under the same scenario. At year 1420, however, there is not enough space to accommodate the Separated System under Scenario # 1, nor under the Scenario # 2. Scenario # 3 will be suitable since it requires 12,243,310 sq. m. At year 1425 none of the three systems can be implemented at any scenario. Naturally it is difficult to forecast for that year because Hajj is one of the events that change rapidly. It seems that much more restrictive measures, such as prevention of all vehicles from entering the holy area except shuttle buses might be needed. Table 7.1 summarizes the phasing program.

### 7.3 Capacity Analysis

The purpose of this section is to ensure that the surface street system leading to Arafat can handle the traffic generated by the pilgrims at the 9th of Dhul-Hijjah.

From the questionnaire carried out to study the existing case (Section 4.2) it was found that about 90% of pilgrims arrived to Arafat in the period 6-12 A.M., i.e. 90% of the traffic volume was distributed over a 6-hour period. Accordingly, Table 7.2 shows the expected traffic volumes of the incoming vehicles to Arafat in the

Table 7.1: Phasing Program

---

Hajj Season Year	Recommendation
1410	Use Separated System under Scenario # 1
1415	Use Separated System under Scenario # 1
1420	Use Separated System under Scenario # 2 plus take some of the governmental locations to the outside boundaries of Arafat
1425	More restrictive measures for reducing vehicles will be needed.

---

Table 7.2: Traffic Calculation for Year 1410 Scenario 1

Category	Total Traffic Volume	6-12 AM (90%)	Expected Volume/Hour
External with own buses	1,954	1,759	294
External with own small	4,320	3,888	648
External with Mutt. bus	6,941	6,247	1,042
Internal using buses	2,818	2,537	423
Internal using Small	37,351	33,616	5,603

morning peirod (6-12 A.M.) of the 9th Dhul-Hijjah, assuming scenario # 1 was implemented for year 1410 H.

The next step is the traffic assignment to each of the nine major roads leading to Arafat. With reference to Fig. 7.6 for land allocation, each category of pilgrims will be assigned one (or more) of the major road(s) that leads directly to their camp location. The expected traffic volume per hour on each road is given in Table 7.3, and the total volume on each road is given in Table 7.4. Next step is to check the adequacy of the number of lanes provided at each of the nine major roads. By consulting Highway Capacity Manual (1985), considering the case similar to "Basic Freeway Segments", it was found that for level terrain and 10% truck the service flow rate per lane (SFL) is 1450 vehicle/hour at level of service C. Accordingly Table 7.5 was obtained to show the number of lanes needed for each of nine major roads to handle the expected traffic.

Next step is to check that the available number of lanes must be equal or more than needed to ensure good operational plan for the traffic. A comparison was made between the number of lanes needed and offered as shown in Table 7.6. It is obvious that for all roads the number of lanes provided is more than the number of lanes needed, ensuring good operational plan for the traffic. Regarding the local streets inside Arafat, their level of service is highly affected by the traffic police controlling Arafat, which can not be predicted at this stage and is beyond the scope of this research.

Table 7.3: Traffic Assignment To Each Road

Category	Volume Veh/Hr	Road Use
External Own Buses	294	9
External Own Small	648	9
External with Mutt. Buses	1042	8 (521) Veh/hr 7 (521) veh/hr
Internal with Buses	423	4 (212) veh/hr 7 (212)veh/hr
Internal with Small	5603	1 (1000) veh/hr 2 (2736) veh/hr 3 (1867) veh/hr

Note: Roads 5, 6 are kept for traffic in the opposite direction.

Table 7.4: Total Volume on Each Road

---

Road #	Expected Volume
1	1000
2	2736
3	1867
4	212
7	733
8	521
9	942

---



Table 7.5: Number of Lanes Required for  
for Each of the Major Roads

Road	# Lane Needed
1	0.7, say 1
2	1.9, say 2
3	1.3, say 2
4	0.1, say 1
7	0.5, say 1
8	0.4, say 1
9	0.6, say 1

Table 7.6: A Comparison between the Number of Lanes Needed and Offered at Each Road

---

Road	# Lanes Needed	# Lanes Offered
1	1	2
2	2	4
3	2	3
4	1	3
7	1	3
8	1	3
9	1	4

---

#### 7.4 Operational Plan

From last years it is known that a committee was established for distributing Arafat area between all muttawiffs. Each muttawiff is given an area relative to the size of pilgrims he is accommodating. Some blocks are left "OPEN" for non-muttawiff pilgrims. It is suggested that this committee do the land allocation according to the following procedures:

All blocks and streets should be numbered, as shown in Figure 7.7. The land committee should assign each muttawiff a part of land suitable to the size and type of pilgrims he is accommodating. "OPEN" blocks are left for non-muttawiff pilgrims. A small illustrative map should be prepared with numbering on it. A table can be prepared to show the land allocation to guide any pilgrim of any category to the suitable block for his case with minimum time loss.

Muttawiffs know their land in Arafat long before Arafat's day. They have their tents and utilities ready before the Hajj time. Their pilgrims will reach the location of the camp with minimum searching time by using the suitable roads leading to their location in Arafat, by using the illustrating map and table.

Non-muttawiff pilgrims, on the other hand, have no specific place to park and camp in the day of Arafat, they are looking for any "OPEN" space to park and remain till sunset.

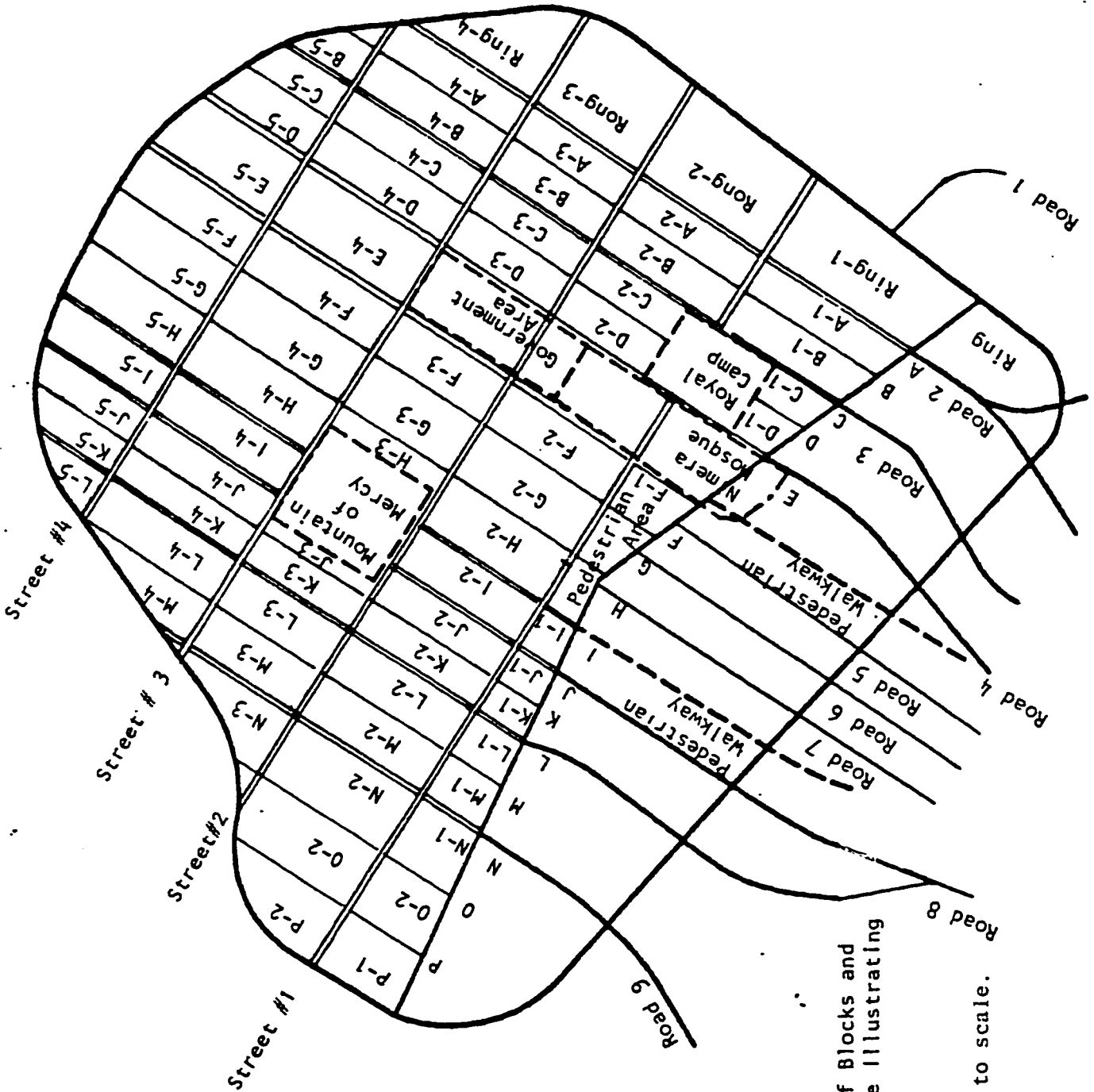


Fig. 7.7: Numbering of Blocks and Streets (The Illustrating Map).

Note: This map is not to scale.

The following steps are recommended to operate Arafat according to the suggested system:

1) In the morning the direction of the flow in road 1, 2, 3, 4, 7, 8 and 9 is east-bound, to enter Arafat. Because some vehicles make more than one trip (from Mina to Arafat), roads 5 and 6 will be operating in the opposite direction, i.e. west-bound as shown in Figure 7.8.

2) The ring road of Arafat receives the incoming traffic from all roads and distributes it to the local streets, or the other way round.

3) The local streets are one way traffic, in the morning east-bound because all pilgrims are coming to park in Arafat.

4) Non-muttawiff pilgrims should be guided by the traffic police to fill up the "OPEN" blocks starting from the east limit of Arafat onwards to the west limit. This is to reduce traffic congestion due to searching for a vacant parking lot.

5) After sunset the direction of traffic flow in the local streets will be reversed (i.e. west-bound) because pilgrims are leaving Arafat to Muzdalifah. All major roads are also operating west-bound towards Muzdalifah, but because some vehicles make more than one trip (from Arafat to Muzdalifah) roads 5 and 6 are operating east-bound as shown in Figure 7.9.

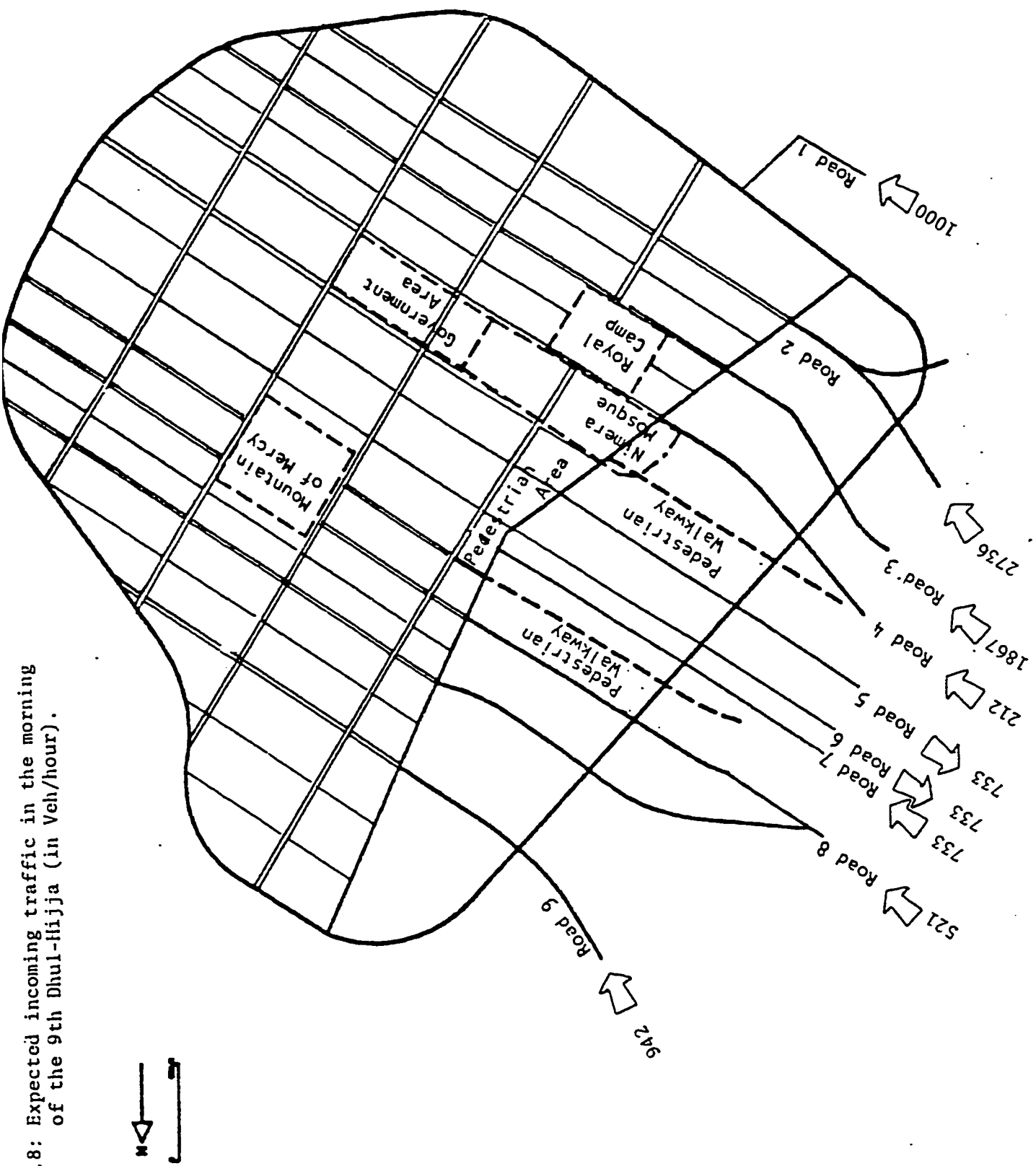
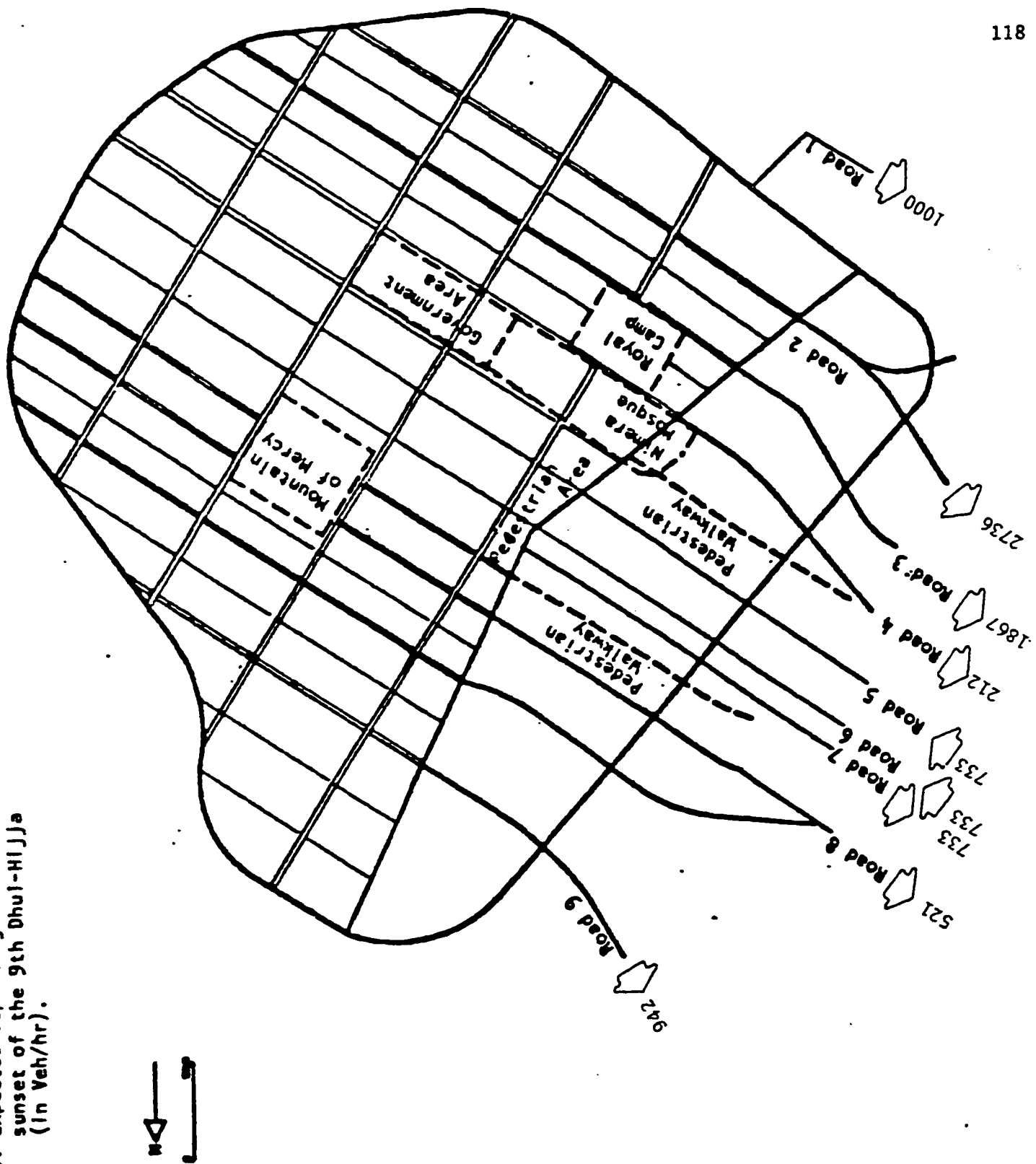


Fig. 7.8: Expected incoming traffic in the morning of the 9th Dhul-Hijja (in Veh/hour).

Fig. 7.9: Expected departing traffic after sunset of the 9th Dhul-Hijja (in Veh/hr).



## Chapter 8

### CONCLUSIONS

The major conclusions of this thesis can be summarized in the following points:

1) The Separated System should be used at years 1410H, and 1415H under Scenario # 1. The existing ring road should be replaced by the proposed ring road that includes all the holy area of Arafat except the mountain north side.

2) At year 1420H, the Separated System is still the best solution but should be operated under Scenario # 3 due to land constraints.

3) At year 1425H, none of the three proposed systems is suitable due to the high number of pilgrims arriving to Arafat. The researcher thinks that at that year either all the vehicles could be banned from entering the holy area, (only shuttle buses could be provided) or other more restrictive measures which might reduce the number of vehicles should be applied. Naturally, if vehicle are banned from entering Arafat area, the number of pedestrians will be very high. Since presently there are two roads reserved for pedestrians, more roads should be provided.



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**APPENDIX - A**

**THE QUESTIONNAIRE TO STUDY THE  
EXISTING CASE OF ARAFAT**

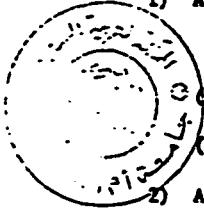


هل أنت من سكان المملكة أم الخارج ؟

- إذا كان من المملكة فأى مدينة \_\_\_\_\_
- إذا كان من الخارج فأى بلد \_\_\_\_\_
- ٢ - هل تتبع الى مطوف نعم ( ) لا ( )
- ٣ - نوع سيارتك هو: سوبر ( ) اتوبيس صغير ( ) ساس ( )  
نوع آخر ( )
- ٤ - كم عدد الافراد بسيارتك \_\_\_\_\_
- ٥ - متى وقت ومولك الى عرفنة \_\_\_\_\_
- ٦ - كيف كانت زحمة المرور قبل دخولك عرفات  
زحمة شديدة ( ) زحمة ( ) لا بأس ( ) لا يوجد زحمة ( )
- ٧ - كيف كانت زحمة المرور بعد دخولك عرفات  
زحمة شديدة ( ) زحمة ( ) لا بأس ( ) لا يوجد زحمة ( )
- ٨ - كيف كانت صعوبة ايجاد مكان للموقف  
صعب جدا ( ) صعب ( ) لا بأس ( ) سهلا جدا ( )
- ٩ - كم استغرق وقت البحث عن موقف  
اقل من عشر دقائق ( ) ١٠ - ٢٠ دقيقة ( )  
٢٠ - ٣٠ دقيقة ( ) ٣٠ - ٤٥ دقيقة ( )  
٤٥ - ساعة ( ) أكثر من ساعة ( )
- ١٠ - هل انت مرتاح من نظام المواقف الحالي بعرفنة  
نعم ( ) لا ( )
- ١١ - كم تبعد سيارتك عن مخيمك  
قريبا جدا ( )  
٢٥٠ م - كيلو متر ( ) أكثر من كيلو متر ( )
- نوع الموقف: داخل المخيم ( ) في الشارع بطريقة غير منظمة ( )  
في الشارع بطريقة سليمة ( )
- حالة اخرى \_\_\_\_\_



GENERAL QUESTIONNAIRE



1) Are you coming from S.A. or other country?

S.A. [ ] other country [ ]

(If from S.A.) which city are you from? \_\_\_\_\_

(If from other country) which country are you from? \_\_\_\_\_

2) Are you with a mutawiff?

yes [ ] no [ ]

3) Type of vehicle (check one)

van [ ] mini bus [ ] bus [ ] others [ ] \_\_\_\_\_  
(Indicate)

4) How many people were there in your vehicle approximately? \_\_\_\_\_

5) What time did you enter the Arafat area? \_\_\_\_\_

6) How was the traffic before you entered Arafat?

very congested [ ] congested [ ] OK [ ] no congestion at all [ ]

7) How was the traffic in Arafat?

very congested [ ] congested [ ] OK [ ] no congestion at all [ ]

8) How difficult was it for you to find a parking lot?

very difficult [ ] difficult [ ] OK [ ] easy [ ] very easy [ ]

9) How long did it take you to find a parking space after you entered the Arafat area?

less than 10 min. [ ] 30 - 45 min. [ ]

10 - 20 min. [ ] 45 - 1 hour [ ]

20 - 30 min. [ ] more than one hour [ ]

10) Are you satisfied with the existing parking system?

yes [ ] no [ ]

11) How far is your vehicle from your tent?

very near (parked in the same lot) [ ]

less than 250 meters [ ]

250 meters - one kilometer [ ]

more than one kilometer [ ]

12) Type of Parking

inside the camp [ ]

street illegal [ ]

street legal [ ]

others [ ]

340

155

**APPENDIX - B**

**PROCEDURE FOR DESIGNING**

**A PARKING UNIT**

**Appendix-B: Procedures for Designing Parking Unit - An Example for the U-System, the Parking Unit for Buses with Occupancy Rate = 94.**

Step 1: The whole block is divided into two pieces, each has the size of  $117.5 \times 150 \text{ m}^2$  as shown in Fig. C-1-a.

Step 2: The maneuver area is 15 m wide, therefore, 7.5m from each side of the two parts is taken for maneuver area. as shown in Fig. C-1.b.

Step 3: The parking lot has the width of 13.7m, as shown in Fig. C-1.c.

Step 4: Both the 5m sidewalk, that is separating the parking area from the camping area and the 1m sidewalk, that is surrounding the camping area, are constructed, the corners are rounded as shown in Fig. C-1.d.

Step 5: The net camping area and number of pilgrims who can be accommodated in it, can be calculated as follows:

$$(148 \times 90.3) - 2(21.5) = 13,321.4 \text{ m}^2$$

Therefore, the # of Pilgrims that this area can accommodate

$$= \frac{13,321.4}{4} = 3,330 \text{ pilgrims.}$$

Step 6: To calculate the number of parking spaces and pilgrims those buses can transport: No. of Spaces =  $= \frac{150 - 15}{4} = 33.75$  or say 34 spaces.

Therefore, the No. of pilgrims, those buses can transport =  $34 \times 94 = 3196$  pilgrims.

Step 7: To check the governing item: since camping area can take 3,330 pilgrims but parking area is enough for 3,196 pilgrims, therefore the parking area is governing. Note that the above calculations are for one side of the U-System, so the total unit can accommodate:

$$3,196 \times 2 = 6,392 \text{ pilgrims.}$$

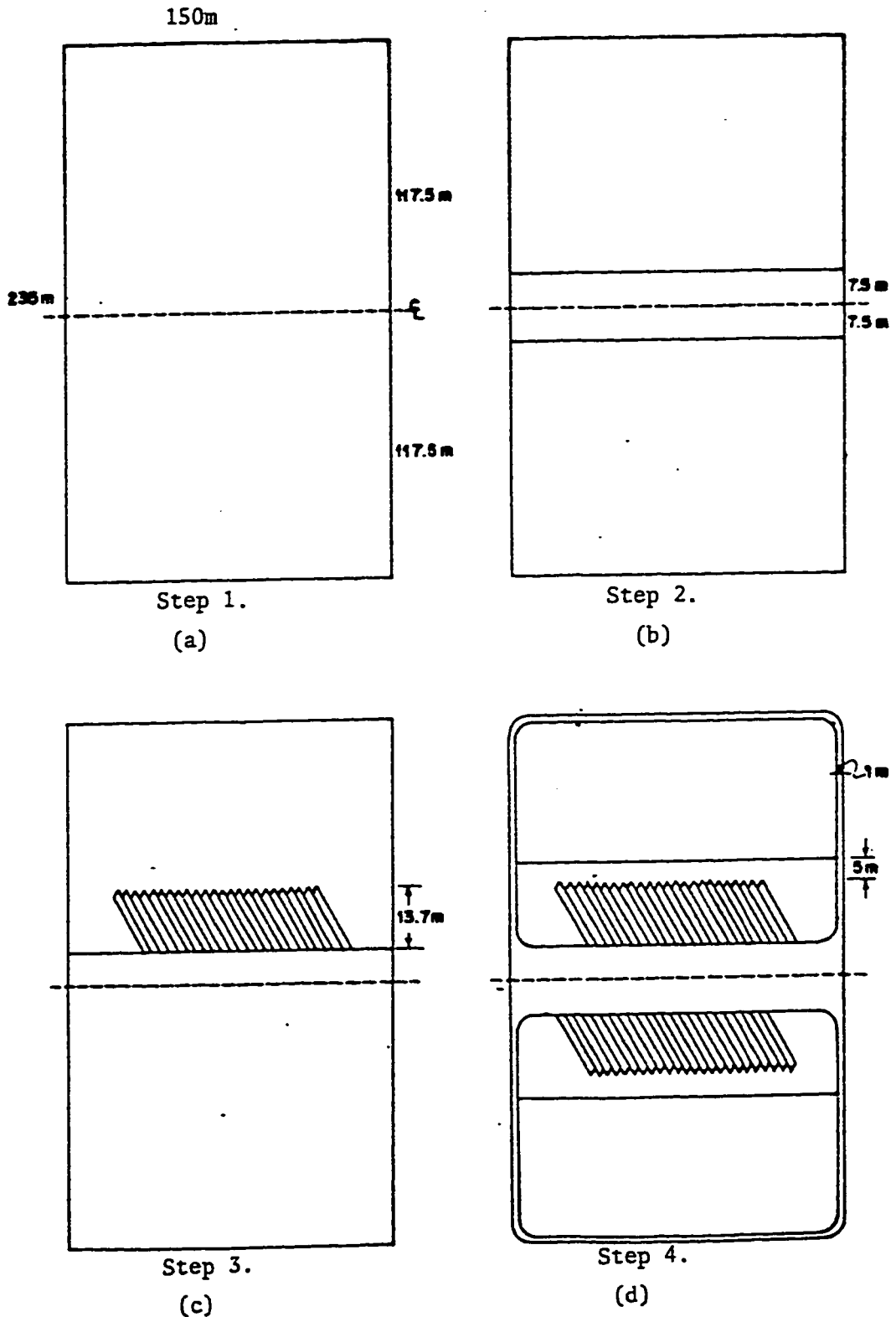


Fig. C-1: Procedures for Designing Parking Units.

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**APPENDIX - C**

**THE QUESTIONNAIRE TO EVALUATE**

**THE FUTURE SYSTEMS**

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Ministry of Higher Education  
King Fahd University of Petroleum & Minerals  
DHAHRAN 31261, SAUDI ARABIA



وزارة التعليم العالي  
جامعة الملك فهد للبترول والمعادن  
الطهران ٣١٢٦١ المملكة العربية السعودية

No. 340/87

Date : October 27, 1987

Gentleman:

Enclosed please find a design for a parking system for Arafat for future solution of parking problem. The design consists of four alternatives:

1. Do - nothing
2. U - System
3. Block System
4. Separated System

Enclosed also find questionnaires for Evaluation of Alternatives, Evaluation of Importance of Factors and Information about the Evaluator. You are kindly requested to give your response to the questionnaires as it takes about 15 to 20 minutes to complete and return them by the 14th of November, 1987. We would greatly appreciate your cooperation. Please do not enter your name and all information will be kept confidential.

Thanking you for your cooperation.



Sincerely yours,

Dr. R. I. Allayla  
Chairman,  
Civil Engineering Dept.  
KFUPM, Dhahran

Encl: As above.

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تلفون : ٨٦٠ - ٠٠٠٠ (٠٣)  
تلکس : ٨٠١١٥٠ جانهد  
برقنا : الجمنة

## I. EXPLANATION OF PRESENT SITUATION AND SUGGESTED ALTERNATIVES

### Present Situation:

Most pilgrims arrive to Arafat in the morning of the 9th of Thul-Hijja, park, stay in their camps praying and reciting holy Quran till sunset, then depart for Muzdalifah. Presently, Arafat lacks a proper parking system. Many pilgrims park their vehicles inside their camp or double parking, which causes a serious hazard to all pilgrims. The number of pilgrims at year 1405H was 1,589,776 and the number of parked vehicles was 48,333. Presently there is only one large surface parking lot reserved for foreign pilgrims coming with their own buses. Rest of Arafat is a grid system of streets with some surface parking lots.

Pilgrims are divided according to their continents, and assigned to what is called establishment of muttawiffs for that continent, and are assigned an area of Arafat. The forecast study showed that at year 1410H about 1,748,950 pilgrims are expected and their parking demand will be about 53,167 vehicles of all types.

### Suggested Alternatives:

#### Do Nothing:

This assumes keeping everything as it is presently (see Figure 1). By comparing the existing demand at year 1405H with the existing supply, it can be seen that supply is only enough for 50% of the demand if all vehicles should park legally. Therefore existing supply will never be enough for the future demand.

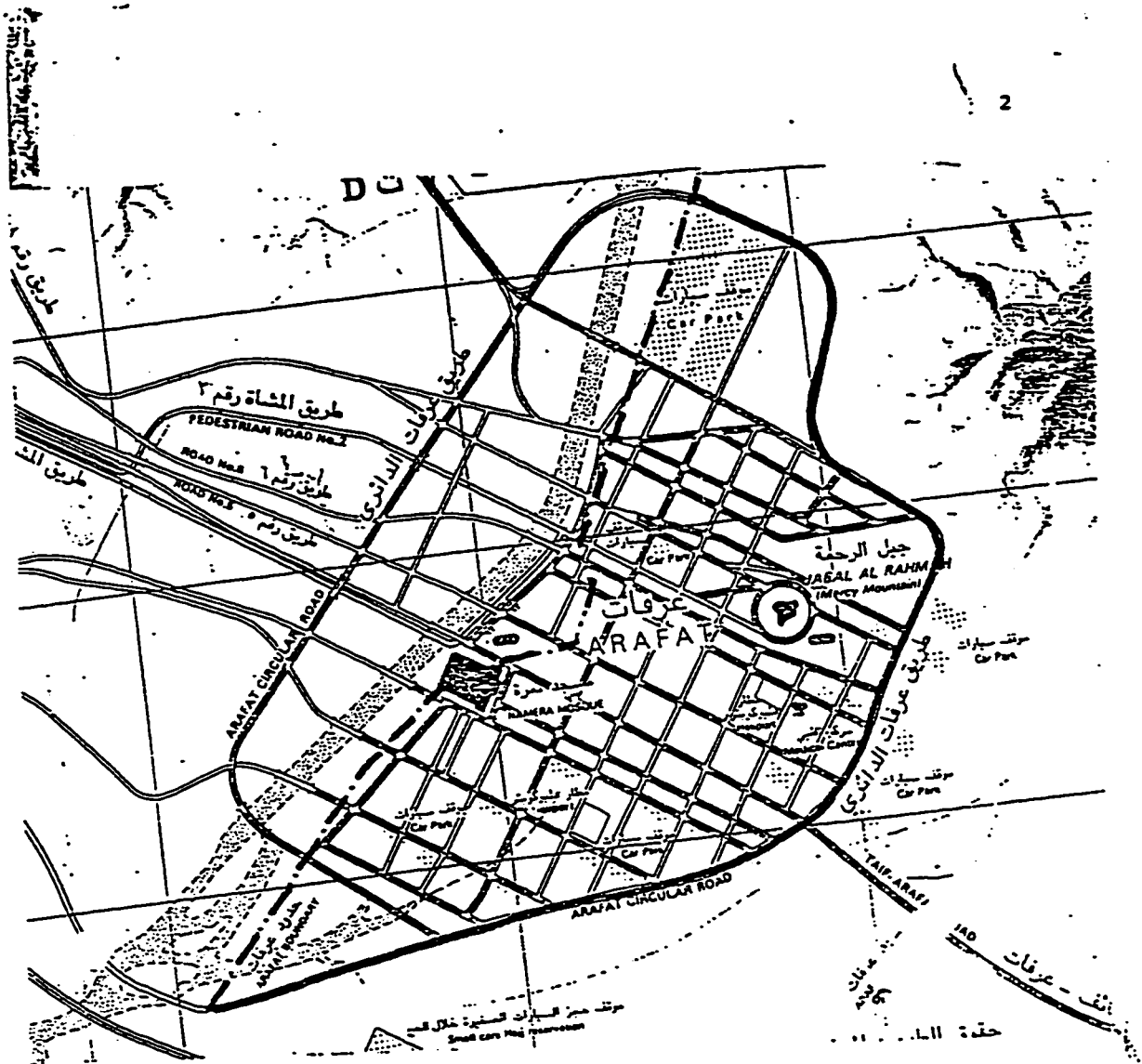
Presently many pilgrims are clustered at both sides of the paved streets. There are unpaved areas in the middle which is almost vacant. Most pilgrims do not care about the safety and the legal point of view of parking. The most important point is that their vehicle is close to their tent.

Street curb parking and surface parking lots are the only two types of parking provided, but as mentioned earlier, are not enough to meet neither future nor present demand.

#### Design Alternatives:

The three block systems (shown in Figure 2) were designed to solve the parking problem for both present case and the future up to year 1420H. These parking blocks will be employed in a network of unified dimensions. An example network for this case is shown in Figure 3. Table 1 shows a comparison between the three suggested alternatives, in terms of area needs.





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Figure 1 : Do nothing alternative, the existing parking system is composed of a street grid system and some open surface parking lots.

Table 1: Area Requirements of the Design Alternatives

System	Area Needed per pilgrim (m <sup>2</sup> /pilgrim)					Total Area Needed (m <sup>2</sup> )
	External Pilgrims			Internal Pilgrims		
	Own Buses	Own Small Vehicles	Muttawiffs Buses	Bus	Small Vehicles	
U	9.15	7.05	5.75	5.75	10.6	9,653,150
Block	7.16	6.57	5.17	5.17	9.18	8,603,428
Separated	9.90	7.60	6.00	6.00	11.6	10,295,880

(Note): Small vehicle means any vehicle smaller than a bus.

Following is a discussion of the three design alternatives.

#### U-System:

This system consists of two parts with one maneuver area in between. Each part consists of a camping area and a parking lot separated from each other by a 5m side walk. This system has the advantage that vehicles do not disturb the flow of the traffic in the local streets when parking in or out, moreover walking distance between vehicles and camp area is minimized.

#### Block System:

This system consists of one camping block with four parking lots on each side. A side walk 5m wide is separating the vehicles from the camping area.

By looking at Table 1, it can be seen that this system is economic, it takes the least area compared to other systems. One disadvantage of this system is that when any vehicle is moving in or out the parking lot it interrupts the moving traffic in the street.

#### Separated System:

This system consists of three parts: two camping areas and one parking area, there is a maneuver area provided between each camping area and the parking lot. This system has the advantage of having two maneuver areas which provides more freedom to the drivers when parking in or out without disturbing the traffic flow in the street. Another advantage is that the parking vehicles are completely separated from camping area, which is good from the safety point of view in case of fire, etc. and yet walking distance is in the acceptable range.

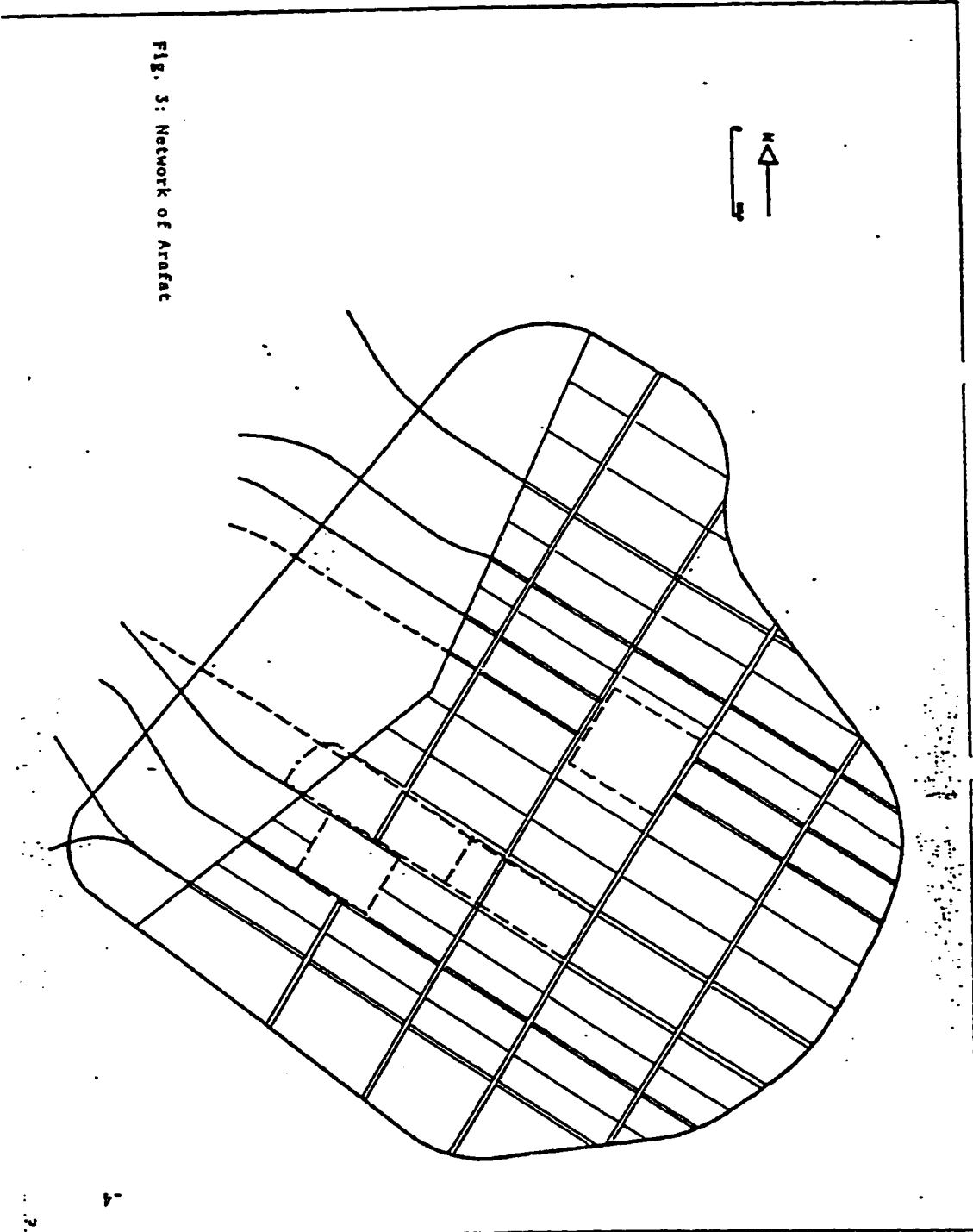
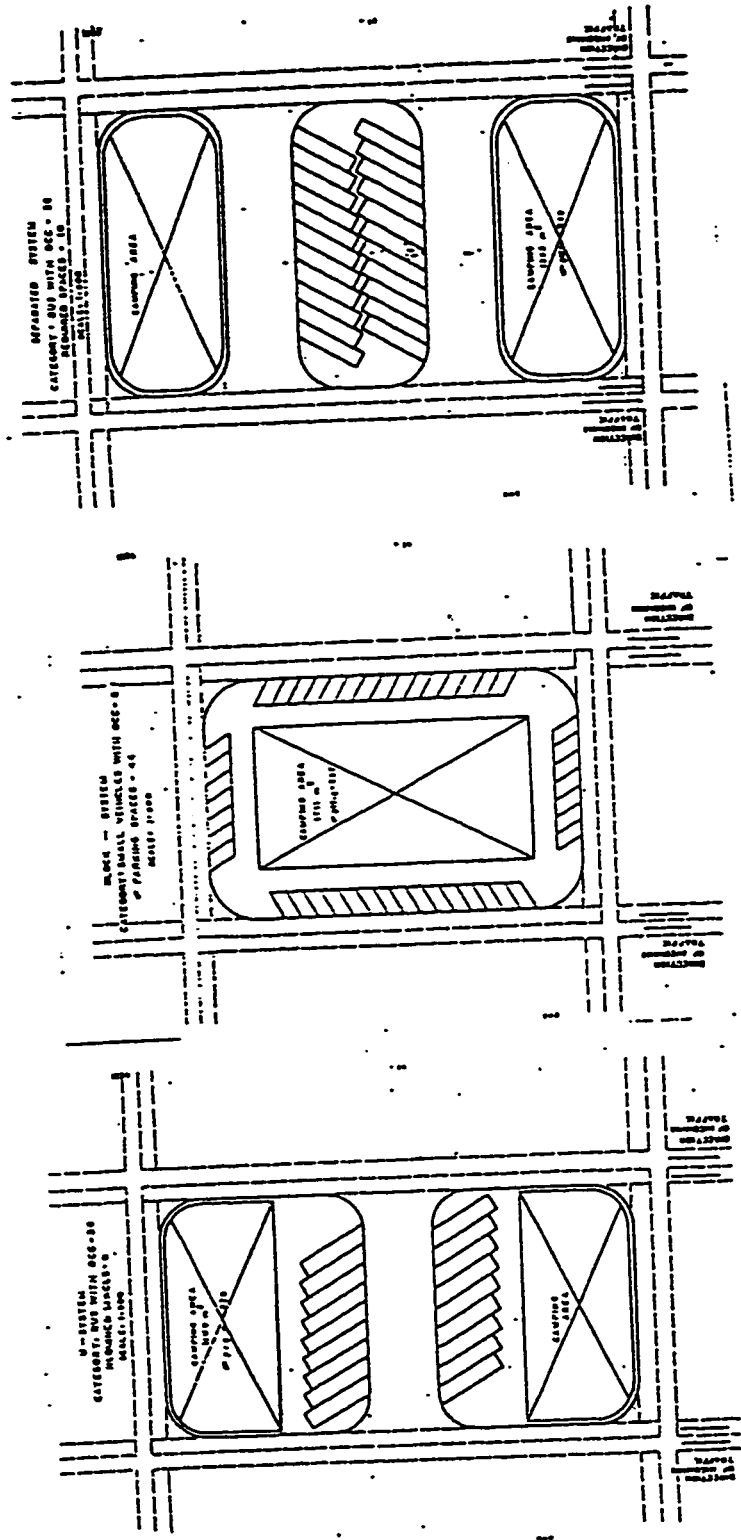


FIG. 3: Network of Arafac



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Figure 2: Design Alternatives.

## II. EVALUATION OF ALTERNATIVES

In this part of the questionnaire we would like you to evaluate the five alternatives on various factors. The evaluation will be done for the factors which are believed to be relevant to parking alternatives.

Indicate your response by circling a number from 1 to 5 indicating the following:

- 1) Strongly Disagree (SD)
- 2) Disagree (D)
- 3) Neutral (N)
- 4) Agree (A)
- 5) Strongly Agree (SA)

QUESTIONS	Do - nothing					U - System					Block System					Separated System				
	SD	D	N	A	SA	SD	D	N	A	SA	SD	D	N	A	SA	SD	D	N	A	SA
1) This system reduces delay due to searching for a space.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2) This system is convenient for the driver.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3) This system minimizes walking distance.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4) This system avoids conflict between vehicles and pedestrians.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5) This system will cause little air pollution.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
6) This system gives a nice view and appearance to Arafat.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
7) This system is consistent with the Islamic feeling and the spiritual side of pilgrims.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
8) This system minimizes fire hazards.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

In the following space mention the alternative you feel is the best, and explain why you think so:

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### III. EVALUATION OF IMPORTANCE OF FACTORS

In this part of the questionnaire we would like you to evaluate the importance of factors relevant to parking alternatives. Use the following five categories to describe your response:

1. Not important At All (NIA)
2. Not Important (NA)
3. Neutral (N)
4. Important (I)
5. Extremely Important (EI)

Please indicate your response to each statement by circling the appropriate number.

	(NIA)	(NI)	(N)	(I)	(EI)
*Reduction in delay due to searching for a space	1	2	3	4	5
*Driver's convenience in using the parking system	1	2	3	4	5
*Minimising walking distance	1	2	3	4	5
*Avoiding conflict between vehicles and pedestrains	1	2	3	4	5
*Minimizing air pollution	1	2	3	4	5
*Giving a nice view and appearance to Arafat	1	2	3	4	5
*To be consistent with the Islamic feeling and the spiritual side of pilgrims	1	2	3	4	5
*Minimizing Fire Hazards	1	2	3	4	5

#### IV. INFORMATION ABOUT EVALUATOR

In the following we would like to have some information about your background.

As mentioned earlier, please do not mention your name or anything that indicates to you directly.

Please answer the following questions:

What is your educational level?

- |   |  |
|---|--|
| <input type="checkbox"/> Did not complete elementary school | <input type="checkbox"/> Some college              |
| <input type="checkbox"/> Completed elementary school        | <input type="checkbox"/> College                   |
| <input type="checkbox"/> Some high school                   | <input type="checkbox"/> Technical school          |
| <input type="checkbox"/> High school graduate               | <input type="checkbox"/> Completed graduate degree |

What is your occupation?

- Teacher/Professor
- Professional/Technical Engineer
- Manager
- Others \_\_\_\_\_

Have you performed Hajj?

- Yes                       No

If yes, how many times? \_\_\_\_\_

which years? \_\_\_\_\_

If no, have you ever been to Hajj area? \_\_\_\_\_

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وزارة التعليم العالي

جامعة الملك فهد للبترول والمعادن

الطهران ٣١٢٦١ المملكة العربية السعودية

No. : ..... : الرقم

Date : ..... : التاريخ

أخي الكريم

السلام عليكم ورحمة الله وبركاته . وبعد :

تجد برفقه تصاميم لمواقف السيارات في عرفات وذلك لمعالجة مشكلة  
المواقف مستقبلا انشاء الله في منطقة عرفات .  
الطول المقترحة هي كالتالي :

- (١) ترك مواقف عرفات على الوضع الحالي دون عمل أي تغيير (الوضع  
الحالي لعرفات)
- (٢) تصميم على شكل حرف U
- (٣) تصميم قلابي الشكل
- (٤) تصميم انغمالي الشكل

برفقه تجد استبياننا لتقييم الحلول الأربعة المذكورة أعلاه . كما تجد برفقه  
أيضا استبياننا آخر لتقييم مدى أهمية العوامل المؤثرة على تصاميم المواقف  
وتجد برفقه بعض الأسئلة المتعلقة بك .  
نرجو الاجابة على جميع الأسئلة المرفقة علما أن الوقت اللازم لتعبئة هذه  
الاستبيانات لن يتجاوز ٢٠ دقيقة .  
وشأمل إعادة الاستبيان البنا في موعد أقصاه ١٤ نوفمبر ١٩٨٢ م .  
شاكرين ومقدرين حسن تعاونكم معنا .  
نشأمل عدم ذكر اسمكم على هذه الاستبيانات ونفهدكم أن جميع المعلومات  
المذكورة ستحفظ في قبة الكتمان .

والسلام عليكم ورحمة الله وبركاته ...

رئيس قسم الهندسة المدنية

د. رشيد ابراهيم الجلال



Telephone : 860-0000

Telex : 801060 KFUPM SJ

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تلفون : ٨٦٠ - ٠٠٠٠ (٠٣)

تلكس : ٨٠١٩٥٠ جافهد

برقيا : الجامعة



### شرح الوضع الحالي في عرفات والحلول المقترحة

#### الوضع الحالي :

ان معظم الحجاج يطون الى عرفات في صباح يوم ٩ ذي الحجة ثم يوقفون سياراتهم في خيامهم للملاة والدعاء وتلاوة القرآن الكريم حتى مغيب الشمس ثم ينادون الى مزدلفه .  
كثير من الحجاج يوقفون سياراتهم داخل المنحيمات أو في الشارع بطريقة غير سليمة وغير منتظمة مما يشكل خطورة بالغة على جميع الحجاج .  
لقد كان عدد الحجاج سنة ١٤٠٥هـ ١٥٨٩٧٧٦ وعدد السيارات التي بقيت في عرفات الى مساء يوم ٩ هو ٤٨٣٣٩ . يوجد حاليا موقف واحد مخصص لحجاج البر أما بقية عرفات فهي عبارة عن مجموعة من الشوارع وبعض المواقف السطحية .  
لقد تم تقسيم الحجاج الى مؤسسات الطوافة حسب جهة القدوم وخص لكل نسبة قطعة أرض في عرفات .  
ان التوقعات المستقبلية تشير الي أنه في سنة ١٤١٠هـ سيكون هناك ١٧٤٨٩٥٠ حاج وعدد السيارات التي ستوقف في عرفات هي ٥٣١٦٧ سيارة من مختلف الأنواع .

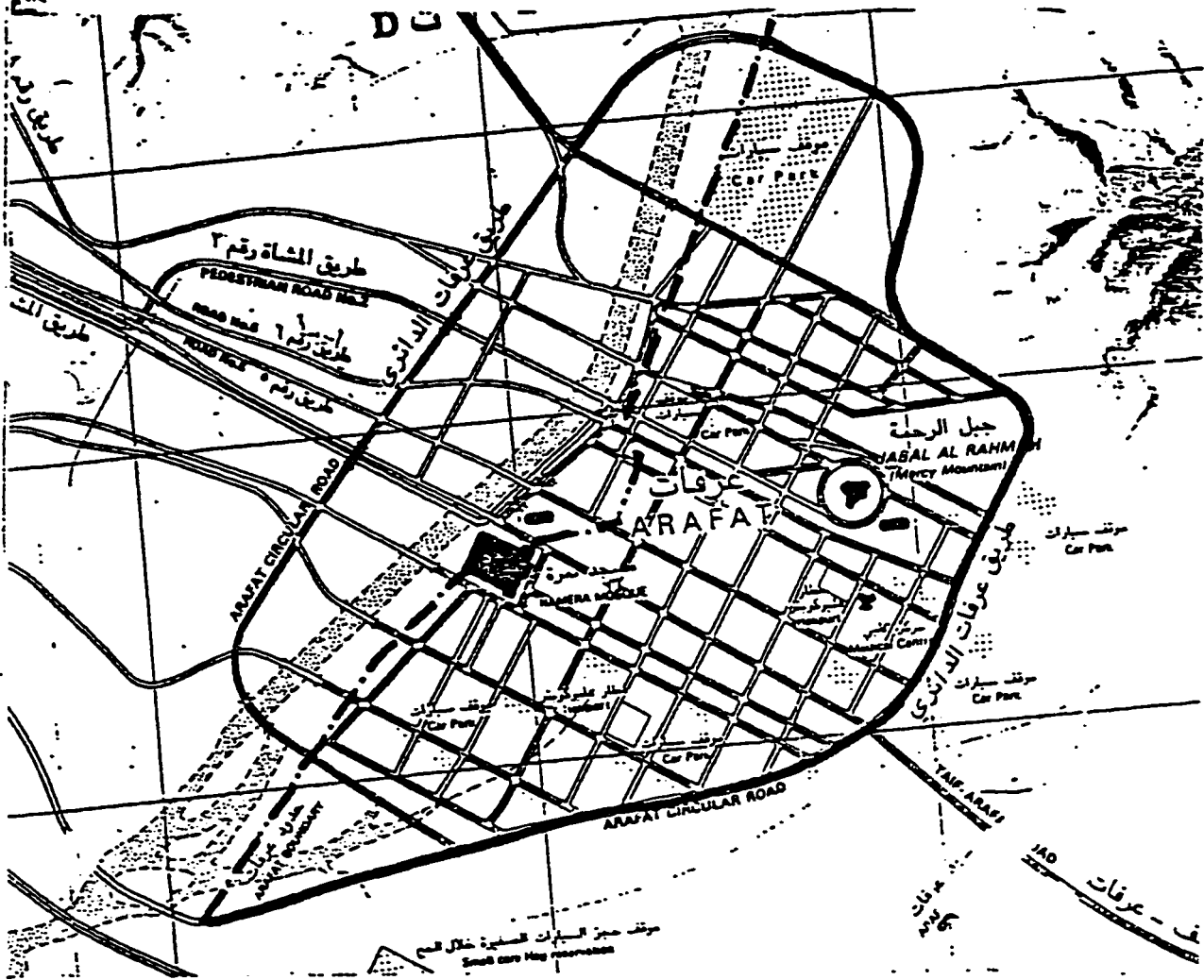
#### الحلول المقترحة :

أولا : ترك عرفات على الوضع الحالي دون عمل أي تغيير في هذا الحالـة  
تفترض أن الوضع الراهن مازال سائدا ( أنظر الشكل ١ ) ، بمقارنة المواقف الموجودة في عرفات بالمواقف المطلوبة نجد أن الموجود حاليا لا يكفي سوى لـ نصف المطلوب لو أن جميع السيارات أوقفت في أماكن صحيحة .  
لذا فان المواقف الموجودة حاليا لن تكون كافية لتغطية الطلب حاليا فضلا عن المستقبل .

حاليا كثير من الحجاج يتركزون حول الشوارع المرصفة ويوجد أماكن ترابية في المنتصف تكاد تكون خالية من الحجاج .  
ومن الملاحظ أيضا أن كثير من الحجاج لا يهتمون بالناحية النظامية أو أصول السلامة في ايقاف سياراتهم ، فالمهم لديهم أن تكون السيارة أقرب ما يكون من المنجم .  
ان المواقف الموجودة حاليا هي نوعان : مواقف على حافة الشارع ، ومواقف سطحية مفتوحة .

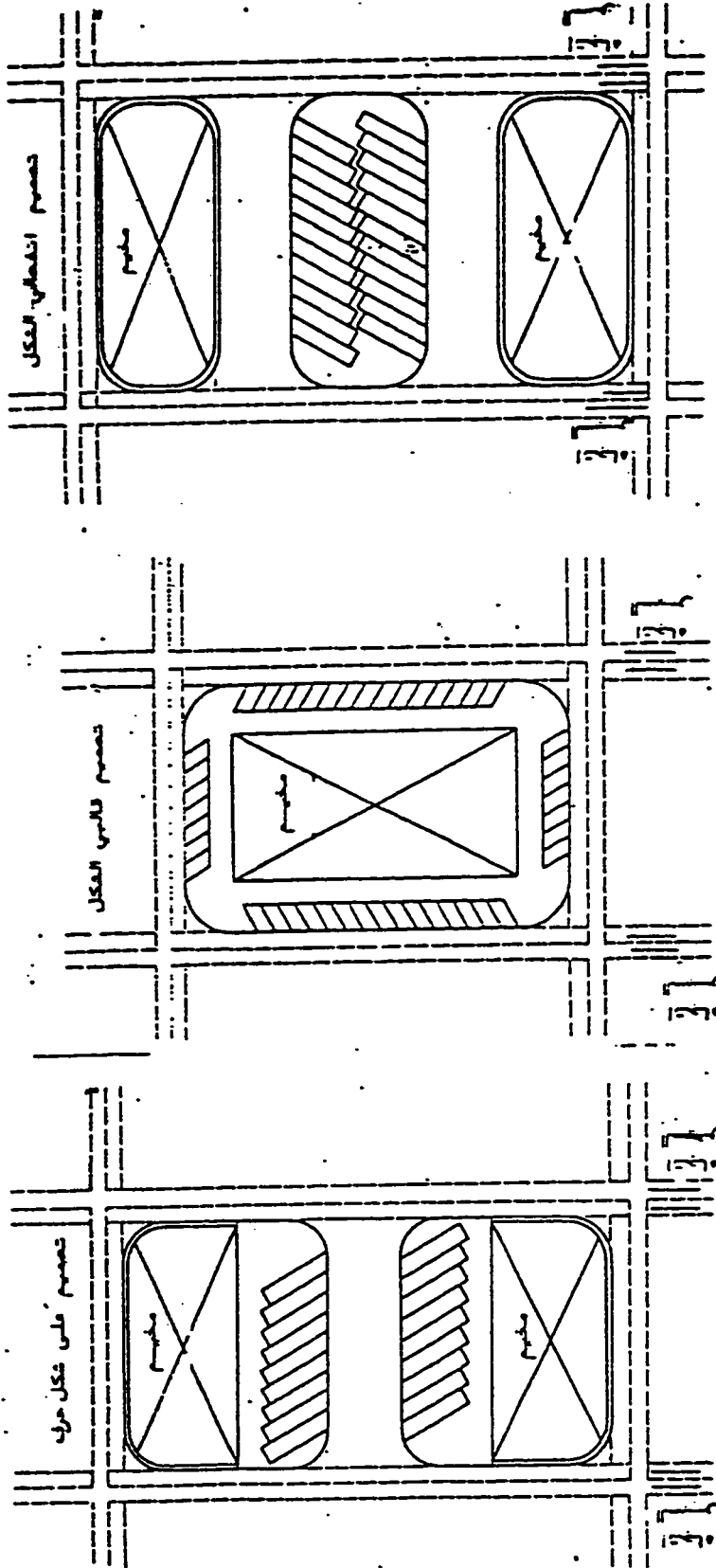
#### التصاميم الجديدة :

هناك ثلاث تصاميم مقترحة ( أنظر الشكل ٢ ) قد صممت لمعالجة مشكلة المواقف في الوقت الحاضر والمستقبل الى سنة ١٤٢٠هـ سيكون انشاء هذه التصاميم داخل شبكة شوارع متماثلة كما يوضح ذلك شكل ٣ .  
كما أن الجدول رقم ١ يوضح مقارنة بين هذه التصاميم من حيث المساحة اللازمة لانشاء تلك التصاميم .

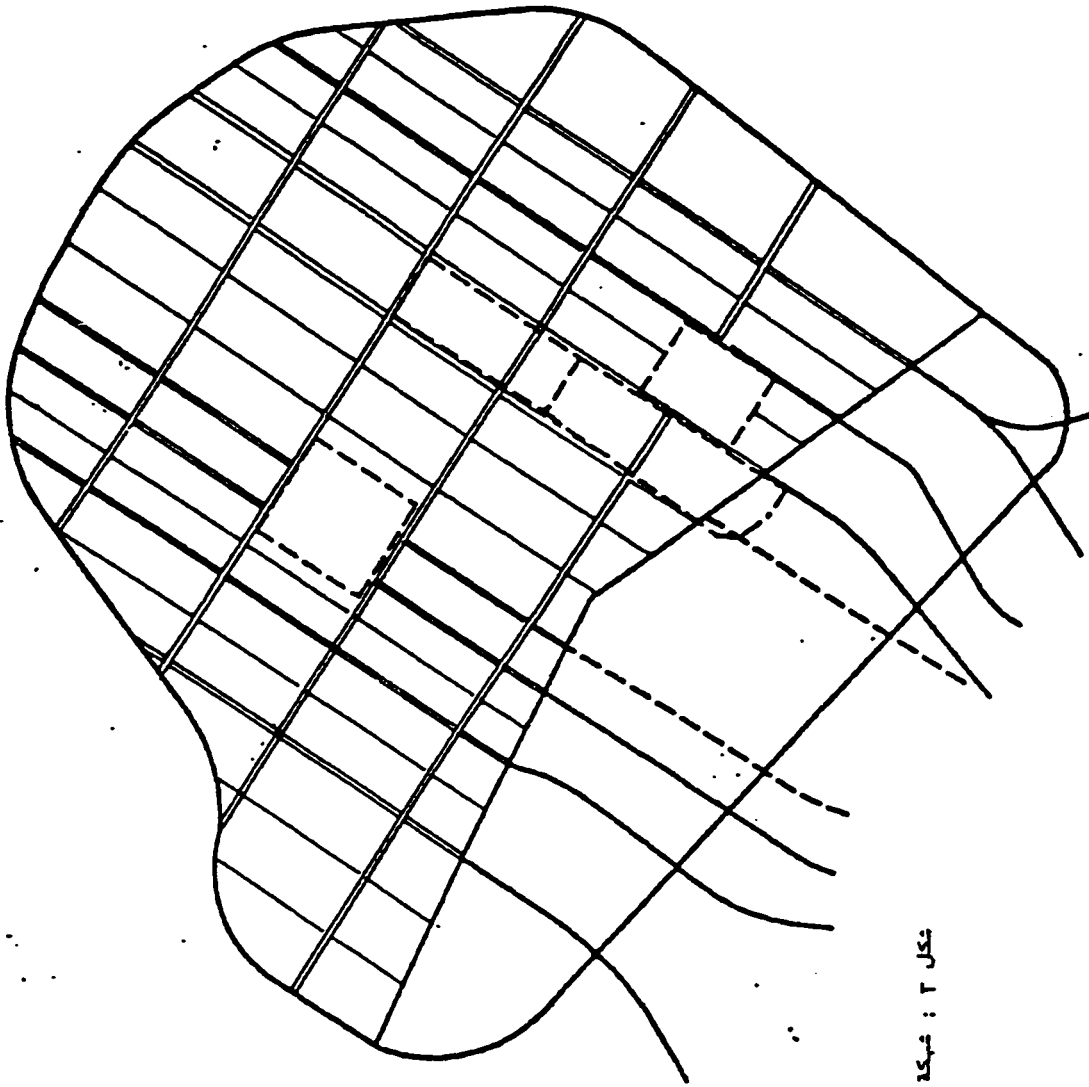


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شكل ١ : الموقع الحالي في عرفات  
 ان مواقف السيارات الحالية في عرفات ثومان (١) وقوى علي جانبي لشارع  
 (٢) ولوف في موالد سطحة مفتوحة



شكل ٢ : التماثل المتكرر



شكل ٣ : شبكة الطرق المقترحة لمراكش



مقارنة بين المساحات اللازمة لإنشاء التمام المقترحة  
جدول رقم (1)

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التصميم	المساحة اللازمة لكل حاء (متر مربع لكل حاء)				
	حمام الداخل		حمام الخارج		
	حساب سيارة صغيرة	أوتوبس	أوتوبس مطبق	حساب حماره صغيره	أوتوبس حماره خاصه
على شكل حرف T	١٠٠٦	٥٧٥	٥٧٥	٢٠٥	٩١٥
قالبى الشكل	٩١٨	٥١٧	٥١٧	٦٥٢	٢١٦
انفصالي الشكل	١١٦	٦٠٠	٦٠٠	٢٦٠	٩٩٠

ملحوظة : المقومود سيارة صغيرة هي أي نوع من السيارات مادون الأوتوبس .

ثانيا : تصميم على شكل حرف T :

هذا التصميم يتألف من قطعتين بينهما منطقة متاورة . كل قطعة بها منطقة للخيام ومنطقة لوقوف السيارات وبينهما رصيف مشاه مرضه م . هذا التصميم له ميزة أن السيارات الداخلة الموقف أو الخارجة منه لن تتسبب أي مضايقة لحركة المرور التي بالشارع كما أن مسافة السير ما بين موقف السيارة الى المخيم قصيرة جدا .

ثالثا : تصميم قالبى الشكل :

هذا التصميم يتألف من قالب للخيام يحيط به أربعة أماكن لوقوف السيارات . يوجد رصيف مشاه معرض م لفصل السيارات عن الخيام . بالنظر الى جدول ١ يتضح لنا أن هذا التصميم اقتصاديا ذلك أنه يحتاج الى أقل مساحة ممكنة بالمقارنة بالتصميمين الآخرين . ولكن هناك عيب في هذا التصميم أن السيارات الداخلة للموقف أو الخارجة منه ستعرقل حركة السير في الشارع .

رابعا : تصميم انفصالي الشكل :

هذا التصميم يتألف من ثلاثة أجزاء : جزء ان للخيام وجزء للمواقف ويوجد منقطسة للمناورة تفصل كل جزء من أجزاء الخيام عن المواقف . هذا التصميم له ميزة أنه يحتوي على منطقتي للمناورة مما يعطي السائق حرية أكبر للدخول أو الخروج من الموقف دون عرقلة حركة السير في الشارع . كما أن في هذا التصميم السيارات معزولة تماما عن منطقة الخيام مما يزيل المضايقة أما في حالة حدوث حريق لاسمح الله . ومع ذلك فإن مسافة السير بين السيارات الى الخيام ليست طويلة .

### استبيان تصميم الحلول الأربعة

في هذا الجزء نرجو منكم تقييم الأربعة الحلول بالنسبة للعوامل الموضحة أدناه والتي نرى أنها هي العوامل الأساسية التي يجب توفرها في أي تصميم للمواقف . نرجو توضيح آجابتكم وذلك برسم دائرة حول الرقم المناسب لكل فقرة من الفقرات الثمان علماً أن الأرقام من 1 إلى 5 وهي تعني التالي :

- 1) لا أوافق بشاتا .
- 2) لا أوافق .
- 3) محايد .
- 4) أوافق .
- 5) أوافق تماماً .

الأمثلة	الوضع الحالي لعرفيات	تصميم على شكل حرف U	تصميم قلابي الشكل	تصميم انفصالي الشكل
1) ان هذا التصميم سيحل الوقت اللازم للبحث عن موقف وقت قصير	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١
2) ان هذا التصميم مره للماشي	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١
3) ان هذا التصميم سيحل مسافة المشي قصيرة للحجاج ما بين موقف المباركة الي المخبئه	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١
4) ان هذا التصميم سيقلل مسن تقاطع المشاء مع المبارات	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١
5) ان هذا التصميم سيقلل من تلوث الجواء في عرفات	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١
6) ان هذا التصميم سيعطي منظرا جميلا لعرفيات	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١
7) ان هذا التصميم يتماشى مع الحالة الذهنية والروحية للحجاج في عرفات	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١
8) ان هذا التصميم سيقلل من حدوث حريق في عرفات	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١	٥ ٤ ٣ ٢ ١

استبيان لتقييم مدى أهمية العوامل

في هذا الجزء نرجو منكم تقييم مدى أهمية العوامل المتعلقة بمواقف السيارات .  
أرسم دائرة حول الرقم المناسب لكل فقرة علما أن الأرقام من ١ الى ٥ وهي تعني  
التالي :

- ١ - غير مهم بتاتا .
- ٢ - غير مهم .
- ٣ - محايد .
- ٤ - مهم .
- ٥ - مهم جدا .

٥	٤	٣	٢	١	تقليل الوقت اللازم للبحث عن موقف
٥	٤	٣	٢	١	راحة السائق في استخدام الموقف .
٥	٤	٣	٢	١	تصميم مسافة المشي للحجاج ما بين موقف السيارة الى الخيمة
٥	٤	٣	٢	١	تقليل التقاطع ما بين المشاة والسيارات
٥	٤	٣	٢	١	تقليل تلوث الهواء في عرفات
٥	٤	٣	٢	١	اعطاء عرفات منظرا جميلا
٥	٤	٣	٢	١	التعشي مع الحالة الدينية والروحانية للحجاج في عرفات
٥	٤	٣	٢	١	تقليل احتمالية حدوث حريق في عرفات

