University of Jordan
Faculty of Graduate Studies

Traffic and Parking Program for University of Jordan

Rana Diab Al-Auran

Supervised By
Dr. Nabeel K. Salman

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Committee Members	Signature
1- Dr. Nabeel K. Salman (Supervisor)	Nabeel Salman
2- Dr. Khair Jada'n	.....
3- Dr. Adli Al-Balbissi	.....

DEDICATION

TO THEM ALL WHO CARE ...

TO ALL MY BELOVED ONES ...

TO MY FAMILY WITH LOVE ...

ACKNOWLEDGMENTS

I would like to express my sincere and deepest appreciation to my supervisor Dr. Nabeel K. Salman for his supervision, guidance and knowledge throughout this thesis.

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List Of Abbreviations

SST	Statistical Software Tools
TPSD	Traffic and Parking Service Department
A	Number of Registered Vehicles Per 100 Population
G.F.	Growth Factor of Staff and Student Car Ownership
$TP_e(F+S)$	Total Existing Parked Vehicles of Faculty and Staff
TP_e	Total Existing Parked Vehicles
m	Percent of Faculty and Staff Having a Sticker
(Ce)	Existing Percent of Faculty and Staff Car Ownership
$TC_e(F+S)$	Total Existing Faculty and Staff Car Ownership
TPV_e	Total Existing Parked Vehicles of Visitors
$TC_{(f)}F$	Total Future Faculty Car Ownership
$TF_{(no.)f}$	Toltal Future Faculty Numbers
$TC_f(S)$	Total Future Staff Car Ownership
$TS_{(no.)f}$	Total Future Staff Numbers
$TS_{(no.)e}$	Total Existing Staff Numbers
$TC_e(S)$	Total Existing Staff Car Ownership
$TP_f(F+S)$	Total Future Parked Vehicles of Faculty and Staff
TP_f	Total Future Parked Vehicles
TPV_f	Total Future Parked Vehicles of Visitors
$PeaK_f(Uni)$	The Future Peak Parking Demand of Total University
$PeaK_f(sec.\ no.)$	The Future Peak Parking Demand of Sector no.
$PeaK_e(Uni)$	The Existing Peak Parking Demand of Total University
$PeaK_e(sec.\ no.)$	The Existing Peak Parking Demand of Sector no.
$(Ce)_i$	Existing Percent of Faculty and Staff Car Ownership in Sector (i).
$TP_f(st.)$	Future Total Parked Vehicles of Students
$T_fst.(no.)$	Future Total Students Numbers

$TP_e(st.)$	Existing Total Students Parked Vehicles
$T_est.(no.)$	Existing Total Students Numbers
$PeaK_f(st.)$	Future Students Peak
$PeaK_e(st.)$	Existing Students Peak

ABSTRACT

Traffic and Parking Program for University of Jordan

By Rana Al-Auran

Supervised by Dr. Nabeel K. Salman

The study is carried out to evaluate the existing and future traffic and parking demands and needs and to regulate the traffic circulation in order to create an efficient, convenient, and safe movements to all users.

The main campus is divided into nine sectors. Data were collected related to campus population and car ownership, in addition to the collected data from the field concerning university parking characteristics and demands. The collection of field data is consisted of parking survey and questionnaire survey which were arranged and analyzed using the computer to estimate the existing and predicted traffic and parking characteristics and demands using regression analysis techniques by statistical software tools (SST) program and the ratios of faculty to student and staff to student.

The recommended traffic and parking program was carried out to meet the predicted demands in the year 2003/2004 which provided convenient services to faculty, staff, students, and visitors. Moreover, the traffic and parking policy and enforcement measures were set-up.

In addition, the parking areas are designed to meet the predicted peak parking demand, however the campus parking spaces are classified in three types according to the type of the permit badges in order to satisfy the projected demand, the study recommended six new parking lots and two parking garages to serve the predicted parking demand and a new gate at the eastern side of university of Jordan.

CHAPTER ONE
INTRODUCTION

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1.1 BACKGROUND

The University of Jordan is the first University in the Hashemite Kingdom of Jordan founded 1962. It started with one college of 167 students.

The number of colleges, technical centers and administrative units increased gradually until it reached 14 colleges and 7 administrative units in the academic year 1993/1994.

The numbers of students, faculty and staff increased to 22893, 927 and 2083 respectively.

Consequently, the number of vehicles utilized by the university population increased due to flexible status of transportation.

However, traffic congestion and the need for parking areas still the major issues that need more attention from the university authorities to study and find the suitable resolution for such problems.

1.2 STUDY OBJECTIVES

The objectives of this study are directed to:

1- Identify existing and future problems of campus traffic and parking.

2- Develop through extensive field survey, a traffic and parking program to meet the existing and future demands for faculty, staff, students and visitors. The program should provide efficient, safe and convenient transportation services, in respect of university streets, parking areas and pedestrian flows.

3- Set up regulations, recommendations and policy to meet traffic and parking needs by:

   a- Recommended relevant solutions and plans for the campus traffic and parking problems to reduce the traffic congestion, delay times,

conflicting movements, and parking demands.

b- Identify suitable and sufficient location of parking areas relating to the destinations of campus users.

The Following information is required to achieve the above objectives:

1- The volume and characteristics of entering and exiting traffic at the campus main gates.
2- The supply and type of parking facilities.
3- The location of parking generators.
4- The present and future parking needs.

1.3 IMPORTANCE OF THE STUDY

The study is intended to analyze and evaluate the existing and future traffic needs and parking characteristics and in the University of Jordan main campus then to recommend parking and traffic program to solve problems identified by improving the present traffic and parking conditions and finding a suitable and efficient new substitutes for the present and future traffic and parking conditions in the main campus.

This study can be undertaken as an essential elements of the urban transportation planning, redesign and improvements programs in Jubieha region where the main campus is located.

Furthermore, this study was carried out to help faculty, staff, students and visitors of main campus by providing and creating safe, successful and continous traffic condition or by selecting the suitable parking areas regarding to campus users and visitors destinations.

1.4 THESIS ORGANIZATION:

In chapter two, the literature related to university parking characteristics was reviewed.

In chapter three, the procedure and methodology that have been used in collecting and analyzing data for this study was described.

In chapter four, the results of analyzing the campus traffic and parking surveys data was discussed including the existing and predicting campus population, car ownership and parking demand. In addition the characteristics of traffic and parking at the university campus was discussed.

In chapter five, a traffic and parking program was recommended to meet the existing and future parking demands and traffic for the coming ten years (2004).

Finally, in chapter six, conclusions and recommendations of the study were presented and recommendation for further studies were given.

CHAPTER TWO
REVIEW OF LITERATURE

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REVIEW OF LITERATURE

2.1 INTRODUCTION

A university campus forms an integral part of its surrounding urban area. The development of the university affects the city, and vice versa, in addition most universities and cities maintain separate infrastructures which includes an efficient transportation and parking system that enhance the campus(1). Special techniques must be applied because of large volume of vehicles and pedestrian traffic occurs on most university campuse to provide for safe and efficient movement of persons traveling through the campus. The needed parking spaces and improvements in traffic flow are provided by the plan, in addition it operates the available parking spaces for the optimum benefit of the university and people associated with it.

As campus continus to expand the campus transportation plan is becoming more important. During the past 30 years in United States, the size of university and college enrollment, faculties, and staff has increased substantially. Moreover, automobile use especially by students has increased dramatically. Major impacts on the physical plant at most universities and colleges has been produced as a result of rapid increases in enrollment and auto usage(2).

A campus parking master plan results from an in-depth study of demand and use patterns, existing supply, traffic impact and financial feasibility which will provide a solution to the campus parking problem that varies with the physical size of the campus and the size of enrollment. Ralf(3) said that "Judgment is needed in its preparation, and it is recommended that the task should be entrusted to not less than experienced, accredited consultant".

If the available financial resources are used in an efficient manner by the traffic and parking plans, the existing system will be preserved to the fullest. The existing plan will require more effort to be spent in solving many day-

to-day problems if the traffic and parking plan does not provide all answers related to the traffic and parking problems(4).

The college or university entrances should be limited in number and be well distributed for controlled with convenient interchange between campus street and adjacent arterials (5). The gates are located on all sides of the campus which will allow any vehicle to leave the campus within a short driving distance(6).

Minimum conflict between the various transportation modes, and maximum safety and convenience of movement between campus activities should be included in the plan of internal campus distribution (5).

Efficiency of the system, accessibility, safety, and feasibility are the objectives of most traffic and parking systems which are applicable to campus and university systems.

2.2 UNIVERSITY CAMPUS TRAFFIC

The control of campus traffic and the provision of an adequate parking system are the two elements of the same campus transportation system and cannot exist independently, also the control principles of campus traffic and parking systems are the same (3).

An efficient entire system will result if the campus traffic facilities are adequately corrdinated with urban street facilities, the congestion and delay will increase as a result of inadequate connected campus street system with the urban area streets because a major arterial street will bring considerable volumes of through traffic to conflict with the already intense campus traffic(4).

Access to the campus should be direct and easy identified from the city's major arterials and freeways and it should carry traffic to intended campus entrances (7).

Edwards(7) mentioned that there are two primary types of travel generated

by the various university activities:

1- Access-travel to and from campus mostly by auto and transit in some cases.

2- Internal-travel within campus primarily between class and other buildings; may include travel between campuses in multi-campus environment, the trips are mainly by foot; most multiple campus environments have intercampus bus service.

The activities are related to the specific characteristics of several groups in the college or university population, each group generates travel in an amount proportional to its size.

Traffic flow at a given location varies by hours of day, days of week, and months of the year, it depends on numerous factors peculiar to that site. Traffic plan can help to provide an adequate vehicular access to all areas of the campus development, and evaluate the existing , future and proposed changes in traffic- related policy, and maximize the available use of financial resources(4). Further, the roadways of campus area should have sufficient capacity in the present and future in order to minimize congestion (7).

2.2.1 Internal Circulation

The internal circulation which is concerned with all types of movement on campus as pedestrians, automobiles, transit, bicycles and emergency and service vehicles; has affected by the growth of universities and colleges because of increased density of campus development which has led to an increase in the magnitude and concentration of the flow of travel between campus activities (5).

Generally, In the campus core areas, a personal vehicular traffic is either limited or prohibited, only service and emergency vehicles are provided access to every facility (7).

A traffic network is established to concentrate development on relatively few streets to minimize land area devoted to transportation and vehicle pedestrian conflicts (4). Therfore, the traffic circulation system can help to provide a mean of movement to conduct the affairs of people.

The principles of any campus circulation should take in to consideration the following points(8):

1) A peripheral and penetrator routes should be designed to serve campus building and provide access to parking gates.
2) The campus circulation system should have efficient connections with existing and proposed major street arterials.
3) The circulation patterns should be direct and easily comprehended, also the routes from major campus entrances to major parking areas should be direct and easily understood by motorists.
4) In order to achieve simplified circulation and provide maximum convenience, the two - way traffic movement should be used, while one- way movement can be used where capacity requirements warrant it, for safety reasons, or as advice to discourage penetration of the campus by non-university traffic .
5) A clearly defined hierarchy of streets serving definite functions must be included in a campus circulation system, those are: major approach routes, penetrators, campus distributors, local service drivers, and emergency access drives.
6) Campus traffic circulation should take place in the campus and not on the surrounding major arterial streets.
7) In order to provide sufficient access to the building complexes and other vehicle oriented areas; local street driving should be limited.

The travel within the area of campus is done 70 to 90 percent on foot. Some of the pedestrian campus travel problems are(5) :

a) increased distances between campus activities due to campus expansion.

b) exposure to inclement weather.

c) pedestrian vehicle conflicts.

2.2.2 Car Occupancy

Car Occupancy is the number of persons traveled by the car. As parking supply decreases or as fees charged for parking increase; the car occupancy ratios will increase for all classes. Table (2.1) shows the average number of persons per car with trip purposes and size of institution. The Table shows that the average number fluctuates more with trip purpose than with size of institution (9).

Car occupancy ratios at universities studied by the associated engineering services at University of Alberta are given in Table (2.2) (10).

Table 2.1: Average Car Loading Factors, By Campus Population Group And Trip Purpose.

Campus Population Group	Trip Purpose to			
	Work	School	Other	All
Under 1000	1.04	1.38	1.77	1.49
1000-5000	1.21	1.15	1.65	1.39
5000-10000	1.25	1.26	1.61	1.36
10000-20000	1.14	1.18	1.76	1.36
Over 20000	1.16	1.24	1.69	1.38
Average	1.17	1.22	1.69	1.39

Source: Ref. (9).

Table (2.2): Car Occupency Rates

Institution	Faculty	Staff	Students	Average
Cornell University	1.04	1.30	1.60	1.30
San Jose State College	1.03	1.36	1.20	1.21
Ohio State University	1.19	1.19	1.41	1.32
Los Angeles State College	1.11	1.20	1.22	1.17
University Of California, Santa Barbara	1.12	1.25	1.56	1.44
University Of California, Berkeley	1.10	1.30	1.70	1.50
University Of Washington	1.06	1.24	1.33	1.26
University Of Alberta	1.02	1.02	1.12	1.10
University Of British Columbia	1.20	1.60	2.20	1.65

Source: Ref. (10)

2.3 UNIVERSITY CAMPUS PARKING

A significant factor in the growth and development of communities is the car parking which is an integral part of transportation. Parking has become a major urban land use (11), and it is an essential infrastructure element serving the needs of academic and residential facilities(12). In fact a major headache for the college or university administrators is the campus parking (9) .

There are four classes of the university parkers which are administrative and service staff, faculty, students, and visitors (13) .The problems of control and supervision of the university parking areas must be recognized by all persons who use these area .The convenience of daily users, the safety of drivers and pedestrians, and the ambiance of the campus environment are affected by the supply, location, design, and operations of parking facilities(12).

The unique character of each campus must be recognized during the parking plan. In estimating parking space requirements , it is important to

identify specific activities (2). An adequate parking should be provided to all users; however, added parking is compatible with expected campus development; and evaluate changes in university policy as related to parking or vehicle registration , all of these can be insured by a parking plan (4).

2.3.1 Parking Demand And Supply

Oflaherty(14) said that "the parking phenomenon is very much based on the law of supply and demand, where supply is the total available number of the spaces within a designated area, and demand is the desire to park based on the location of the trip destination". The parking demand in a particular block is the number of parkers destined to that block in a given time interval, which are varied from hour to hour throughout the day, and the peak accumulation of parkers establishes the parking demand.

Parking demand of zoning ordinance applications is defined as the accumulation of vehicles parked at a given time as a result of activity at a given site. parking accumulations result from interactions between the total daily trips attracted, the time pattern of arrival, and the average lengths of stay(15).

The actual basis for determining parking needs are provided by comparing the parking demand which is the number of parkers attracted to a particular area or activity during specific times of day with the available parking space within acceptable walking distance(2).

Land use and competing forms of transportation influence demand for parking strongly. The parking demand for any activity depends on the nature and size of the activity, where the activity is located and what proportion of the daily population will drive and park or arrive by other means. Parking demands are usually related to a unit of measure, representative of the parking generator such as per faculty, staff member or student at a university(2).

Weant and Levinson(2) mentioned that there are several factors affect the university parking space needs:

(1) Daytime and evening enrollment.

(2) Mix between commuter and residential population.

(3) Size of faculty and staff.

(4) Frequency of special events and their locations.

(5) Availability and cost of parking.

(6) Opportunities for ride-sharing and public transport (often keyed to campus design and location).

(7) University policies regarding automobile usage and parking.

It is not possible to generalize and specify parking space needs ratio because of the variation of administrative policies, campus location, and socioeconomic factors (16).

Whitlock(17) stated that "In addition university parking space needs are affected by socioeconomic factors relating to the cost of education and the financial situation of the student / family".

Also campus parking needs will primarily depend on the characteristics of the university population, peaks in the number of people visiting the campus during the day, and the mode of travel used .

A comparison check of parking ratios against computed needs should be used based on study of actual circumstances and characteristics at the given campus (17).

The parking demand at a university is determined by the numbers of persons served, the need for vehicles to commute to class or office , and policies on vehicle use. The peak parking on campus by user category [faculty, staff, students and visitors] is an important indicator of existing demand(18)

At 19 universities in Great Britain, the parking space ratios for staff and

student populations together with the number of spaces provided were ranged between o.28 to 1.11 with an average of 0.75 parking space per registered vehicle(16). Table (2.3) summarize the off-street parking requirements for American colleges and universities(15).

Table (2.3): The Off - Street Parking Requirements For American Colleges And Universities

Requirement	Space Per Auditorium Seat	Space Per Student	Space Per 100 sq-ft Floor area	Space Per employee
Minimum	0.06	0.10	0.12	0.33
Maximum	0.25	0.75	1.00	1.00
Modal	0.10	0.10	1.00	1.00
Mean	0.15	0.26	0.54	0.59

Source: Ref. (15)

Table (2.4) shows that as population increased, the number of spaces per person will decrease (13,19)

The minimum number of parking space required for college or university is one parking space per staff member plus (0.2) per student for university with good transit access or (0.5) per student for university with auto access only, or one parking space per three students or visitors(13,14)

Table (2.4): Variation Of Parking Supply For Different Campus Population Groups.

University Population	Spaces Per Person
Under 10000	0.3 to 0.4
10000-15000	0.2 to 0.35
15000-20000	0.15 to 0.25
20000-30000	0.10 to 0.2
30000-40000	0.07 to 0.2

Source: Ref. (19)

Young(20) said that "In summary, the most important parameter in the design process is the parking demand. It is a function of the characteristics of the land use being served, the quality of parking facility, the proximity of similar land uses and parking lots, and the catchment area of that land use".

2.3.2 Parking Characteristics

It is important to know the parker characteristics before preparing parking studies, developing programs, locating and designing facilities, and establishing zoning code specifications. In order to establish a parking program, the information on the number of parkers, parking duration, trip purpose, time of arrival, and final destination must be provided (13).

Parker characteristics are related to the size of community, and many are established by habits over a period of time which are not easily or readily changed and must be carefully considered when locating new off- street facility. In the calculation of parking demands, the detailed analysis of parking characteristics are important.

The parking characteristics are as follows : a) Trip purpose; b) parking accumulation; c) parking duration; d) walking distance; and e) parking turnover.

A) Trip purpose

Trip purpose is the major determinations of parker characteristics. Available correlations will be provided by the characteristics of parkers as related to their trip purposes involving parking duration, type of facilities, parking fee incurred, distance walked to primary destinations, and other factors (21,22).

Specific methods of parking control or supply will affect different user groups, therefore the Journey purpose is important for the drivers arriving the car parks (23).

Three basic groups of college and university trips are generally dealt with : work trips, school trips, and all other trips. Sometimes, home trips and social-recreation trips are broken out of the "other trips" mixture for closer examination as shown in Table (2.5) which summarize the percent of trip for different travel modes distribution and different trip purposes for 38 sample institutions. This study was made by keefer, L.e. and witherford, D.K. which was showed that work trips produce a higher proportion of auto driver trips (70.8 percent) than do other travel modes, while school trips produce the highest percent of transit (17.5 percent) trip purposes considered(9).

Table (2.5): Percent Of Travel Mode Distribution By Trip Purpose

Trip Purpose to	Travel Mode				% Of Trip From Total
	Auto Driver	Auto Pass	Transit Pass	Taxi Pass	
Work	70.8	13.2	10.0	6.0	21
School	54.9	25.1	17.5	2.5	40
Social- Recreation	45.1	49.3	4.0	1.6	10
Home	51.1	37.6	5.5	5.8	13
Other	88.4	7.5	2.2	1.9	16
Average	59.6	24.4	13.0	3.0	100

Source: Ref. (9)

The same study when considered all modes together shows that School trips represent about 40 percent of all trips regardless of campus size. Work trips average 21 percent of all trips, but vary by the size of the institutions from nine to 40 percent, the lowest proportions are associated with institutions having the lowest faculty -to- student ratios, socio- recreation trips average 10 percent of all trips (9).

B) Parking Accumulation

Pignataro(11) stated that "Parking accumulation is the total number of vehicle parked within a given area at a specific time ".

The greatly different forms of demand are clearly demonstrate by the accumulation patterns in terms of arrival time and length of stay created by different trip purposes (24) .The total parking accumulation trends within the study area are usually determined from checks taken across an entire business periodically (13) .

Accumulation patterns of employees, faculty, and visitors are some-what similar for all higher education institutions. Figure (2.1) shows the percent of peak parking space requirement based on parking accumulation patterns of 10 universities, includes employees and visitor parkers.

Also this figure shows that the peak-hour of staff parkers occures during late morning hours around 11:00 a.m. while at 8:00 a.m., the staff parking demand is less than 50 percent of it's peak parking accumulation. Based on the accumulation patterns of all on-campus persons and their model choice and vehicle occupancy characteristics , the peak parking space needs would be develop(17).

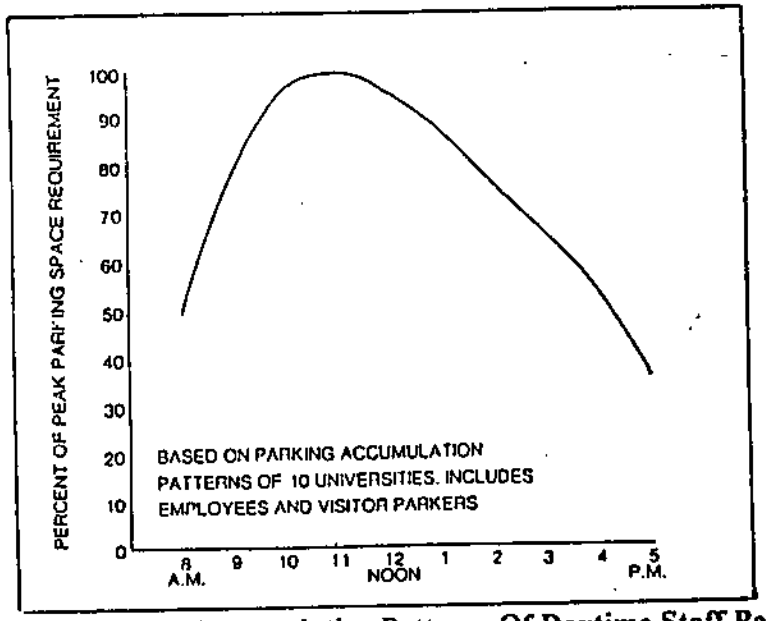

Figure (2.1): Accumulative Patterns Of Daytime Staff Parkers (17)

c) Parking Duration

parking duration is the length of time a vehicle is parked at a parking bay. Its average gives an indication of how frequently a parking space becomes available(25).

Parking duration, or length of stay, varies with type of trip and increase with the size of urban area (13). It also depends on the type of parking facility. For example, 70-80 percent of curb parking duration is less than one hour while off-street parking are 10 - 20 percent of less than 1 hour in duration (11). The car parking survey would be use to find the length of time vehicles were parked in each car park and on the university as a whole(16). The sampling of average parking duration at four American Campuses is as follows : (5.7, 4.9,2.7,3.2) (18).

D) Walking Distance

Weant and Levinson(2) said that the walking distance is the shortest normal walking path between parking space and nearest pedestrian entrance at the parkers' trip destination, it varies by trip purpose and urban area population size.

The parking duration and trip purpose are very much relevant to the vehicle terminus of parker in relationship to the distance walked to the primary destination (21). The factor of walking distance is introduced in any decision to locate additional parking spaces (11).

Walking distance is a direct and useful indicator of convenience from where the vehicle is parked to the ultimate trip destination . Average walking distance is determined by the questionnaire and inventory data (4).

Schulman(26) showed that the maximum distance that a trip maker is willing to walk between the parking space and the ultimate destination is the maximum acceptable walking distance.

Faculty and staff members in most university would like to park at the doors of their classrooms and offices. Students can be expected to accept

longer walking distances from parking spaces to destination than would be acceptable to faculty, staff or visitors ." An average walking distance of 500 feet (150 meters) should be acceptable at any campus" (27).

Trial(28), classified the parking condition according to walking distance as shown below :

walking Distance	value	condition
over 550 ft	0	very poor
450 - 550 ft	1	poor
350 - 450 ft	2	Below Medium
250 - 350 ft	3	over medium
150 - 250 ft	4	Good
less 150 ft	5	Excellent

E) Parking Turnover

The utilization of a parking space is measured by a parking turnover which gives an indication of how many times different vehicles use the parking space during a specified time period (13). Turnover is obviously a function of trip purpose and direct function of parking duration.

The sampling of parking turnover for four campuses is ranging between (0.78-2.96)(18).

Trial (28), classified the parking condition according to turnover as shown below :

Turnover	Value	Condition
0 per day	0	poor
1 per day	1	Medium
2 -3 per day	2	Good
> 3 per day	3	Excellent

2.3.3 Parking Locations

The prime factor in parking use is the location of a parking facility in relation to the user's destination, the convenience is measured in terms of walking distance(13).Drivers usually choose parking lots with recognizable and within 200 meters from their destinations. Depending on the location of parking lots; a significant difference in the utilization will be observed.
The analysis process must examine the following (2):

1- Accessibility for vehicular and pedestrian traffic.

2- Site suitability for intended type of development.

3- Site availability and cost implications.

Walking is the major form of campus travel, therefore campus parking should be placed as near as possible to major buildings and activity centers. Special attention should be given to pedestrian connections between parking areas and campus attractions. Parking can be sited to intercept traffic at points where traffic enters the campus in order to minimize vehicular traffic penetration of the campus, and reducing unnecessary circulation campus streets (2).

Most campus parkers who use the facilities nearly every day are faculty, staff and students .The number of campus visitors are varied greatly from day to day, also some spaces should be reserved for visitors; therefore the facilities may not be fully utilized every day (29).

Edwards(7) illustrated the most important points that should be taken in the location of parking which are summarized below:

1- Major parking facilities should have direct or reasonably direct access to the primary approach routes serving the campus area.

2- Should be located peripheral to the campus core, but within a reasonable walking distance of all portions of the campus.

3- Should be located in relation to driver's destinations and major access routes.

4- Street access to major parking facilities should be located and designed to minimize conflicts with pedestrians and not disrupt other on-street traffic movement . Adequate queuing capacity should be designed in to each ingress and egress point.

5- Should not be located where desirable expansion or functioning of university activities would be blocked.

6- Commuter, visitor, and errand parking facilities should be easily identified by infrequent users of facilities .

Proper locations are essential if optimum use is to be gained .An appropriate locations for individual facilities could be determined by the degree of parking shortages and types of nearby generators, facility user considerations [walking distances as related to parking charges, security, and convenience of access], development costs [land values as related to costs of alternate facilities], and by street system elements such as capacity, directional flows, and turn restrictions (13,30).

Finally, Parking facilities are preferred to be near parkers destination, that can be accessed with ease, that can be used without fear for one's personal safety, and that cost little or no money (31).

2.3.4 Design Parking Lot

"The operation of a parking facility is greatly influenced by its design"(13). The following successive steps identify the design considerations and their associated operational features (13) :

1- Vehicular access from the street system (entry driveway).

2- Parking stall (circulation and / or access aisles).

3- Maneuver space to enter the stall (access aisles).

4- Sufficient stall size to accommodate the vehicle's length and width plus space to open car doors wide enough to enter and leave vehicle .

5 - Pedestrian access to and form the facility boundary (usually via the aisles).

6- Maneuver space to exit from the parking stall (access aisles).

7- Routing to leave the facility (access and circulation aisles).

8- Vehicular egress to the street system (exit driveway).

There are three primary objectives of parking lot design (2):

1- A parking lot must be convenient and safe for the intended users.

2- A parking lot should be space efficient and economical to operate

3- A parking lot should be compatible with its environs.

Pignataro(11) mentioned that parking lots must be designed to achieve the following objectives :

1- Provide maximum number of spaces.

2- Minimize travel discomfort while parking, unparking, and driving within the lot.

3- Minimize interference of entrance and exit lanes with pedestrian and vehicle movements external to the lot.

The design of campus parking should accommodate all types of vehicles. Most university policy recognize the different types of users that may be present at the same or different times of the day.

The following are the interrelated steps of design process (32):

1- The components of the system.

2- The determination of need.

3- The network, its "level of service" and the choice of an appropriate layout.

This note discusses the design process via a number of parking principles. These principles are (32):

a) Provide adequate size for each component.
b) Determine the parking demand.
c) Efficient use of parking space.
d) Introduce a discernible hierarcy of road.
e) An appropriate entrance and exit conditions should be provided.
f) Minimize conflicts.
g) Separate decision points.
h) A clear information should be provided to users of the parking facility.
i) Adequate sight distance must be provided.
j) Reduce impediment to circulating vehicles.
k) Maximize the amenity of the facility.
l) Reduce visual intrusion.

The layout of surface parking areas is more flexible and from time to time can be changed easily (27) . The design volume, the available land area and the size and the number of other parking lots in the area will determine the size of parking lot (14).

The most important aspect of a parking facility is its design while the capacity is the most important consideration in the design. In order to make sure that aisle space has been minimized and parking space maximized; the geometric design of every lot should be checked. When checking the geometric it is important to make sure that as many spaces as possible are in each row of parking lot (29) .

The location of entrances and exits of parking lot should be well defined and as few in numbers as practicable to reduce conflicts with street

traffic (33).

Whitlock(17) illustrated that since students and staff are familiar with campus parking facilities; a maximum efficient area can after be provided by using a 90 degree parking with two- way traffic while for safety and convenience reasons, angle parking and one-way traffic aisles may be more desirable for campus parking areas catering to visitors or short-duration parkers.

2.4 THE UNIVERSITY PARKING AS A SPECIAL GENERATOR

Kanafani(34) defined parking generator as a point of trip attractions to the destination of significant number of auto- drivers and which thus constitutes a point of parking demand. The university has been identifications the largest institutional type parking generator(13).

The positive impact of a university on the communities are economically, socially, culturally, and educationally in which the major traffic generators are located. Also the university has a significant impact on the transportation systems of the surrounding area.

The size of both the university and the community will affect the impact of university and the community highways. Small institutions may pose no difficulty . But large institutions may pose create critical capacity problems for campus bound traffic and for all traffic depending on their location and on the adequacy to the adjacent highway network(9).

The campus should not be treated in isolation from its neighboring developments therefore the provision for vehicle parking should be coordinated with the institution's overall traffic planning, as well as that of the surrounding area because the campus is large traffic generator (17). Sometimes a university campuses which are a significant part of an urban area will generate more daily trips to and from the campus area than the Central Business District of the city in which the campus is located.

In summary, the university or campus has all the characteristics of a major

trip generator such as : high trip making activity, congested local streets, and severe limits on parking supply.

2.5 UNIVERSITY CAMPUS FORECASTING AND GROWTH

Transportation is one of the campus development phase that has experienced difficulty during the expansion period (5). An adequate traffic and parking facilities are needed to grow as the population of persons and automobiles grow (13).

The provision of traffic and parking facilities are influenced by a physical growth of a campus. The traffic flow problems will be created in terms of circulating traffic as a result of an adequate consideration concerning the physical location of parking facilities (4).

"Forecasting is an integral part of the decision making activities of management. An organization establishes goals and objectives, seeks to predict environmental factors, then select actions that will result in attainment of the goals and objectives". One of the techniques used to forecast is the simple regression technique (35).

Finally, it is need to forecast campus population, car ownership, parking demand in order to develop a parking program in the future.

2.5.1 Campus Population

University population consists of faculty, staff and employees, students and visitors(17). For planning purpose it is normally reported in full-time equivalent (FTE) persons. A FTE student is one carrying a normal full class load (15) credit hours at many schools while a part -time student carrying six hours which is 0.4 FTE. The FTE population is a better prediction of campus activity and needs than are acreage, square feet of building, or other physical measures(7).

Many problems have been created as a result of increasing students

population in particular at institutions of increasing educational demands. In an attempt to provide for increasing enrollments, a shift from a residential to a commuter orientation often takes place at a university that will increase the volumes of commuting traffic(4).

Growth in the number of students and staff at universities in Great Britain accelerated during the 1970 and reached a peak in 1980 - 1981 while this peak both staff and student numbers have been fallen in the academic year 1983 - 1984(16).

2.5.2 Car Ownership

The rapid growth of the automobile has a risen and will continue to increase for the reasons of the fact that the automobile is a very flexible method of transportation and the car can be afford in ever increasing numbers by the western society. The number of vehicles registered at a university gives an indication about the level of car ownership for both staff and students(16).

Table (2.6) " Summarizes the number and percentage of automobile drivers in the staff/student population at selected universities. The higher value reflects an institution located in a suburban automobile-oriented area. The use of automobiles by staff is higher than that of students (as a population percentage), largely because of the journey- to- work trip" (16,17)

The private automobile will continue to serve for many years, even if more efficient public can be provided. In order to plan adequate transportation systems which will meet the demand, the automobile travel which is the major growth mode of travel must be investigated and analyzed continuously.

Table (2.6): Car Registered At Selected British Universities

University	Staff			Students		
	Population	Vehicles registered	%	Population	Vehicles registered	%
Bath	1 500	900	60	3 600	800	22
Birmingham	4 500	2 000	44	10 000	740	7
Bradford	1 750	1 003	57	4 600	N/A	-
Bristol	3 000	870	29	7 000	270	4
Brunel	1 100	900	82	3 750	1 500	40
East Anglia	1 894	1 791	95	4 000	1 750	39
Essex	1 000	N/A	-	2 881	N/A	-
Kent	1 500	1 400	93	4 150	1 020	25
Lancaster	1 418	1 093	77	4 724	1 106	23
Loughborough	1 800	1 749	97	6 000	1 056	18
Manchester	4 500	4 000	89	12 000	450	4
Nottingham	3 500	1 620	46	7 221	942	13
Reading	3 500	2 500	71	6 000	1 500	25
Salford	1 373	727	53	4 202	457	11
Sheffield	3 700	1 479	40	7 700	232	3
Southampton	3 094	1 300	42	6 782	2 664	39
Surrey	1 700	1 420	84	5 800	1 500	26
Marwick	1 900	988	52	5 614	1 408	25
York	1 500	840	56	3 400	300	9
		Average:	65		Average :	20

Source: Ref. (16).

2.6 CAMPUS TRAFFIC AND PARKING STUDIES

Studies may be made to identify parking inadequacies or to develop proposals to improve parking supply in a specific area such as a university campus . Where motorists can and do park, where they would like to park and how their parking practices affect the use of other transportation modes all of these can be determined by a parking study(13).

The purpose of a parking study is to provide recommendations for the development of a parking program in order to meet the area requirements(11). In order to determine the parking needs, a parking studies

must be made to provide the necessary information for comparing parking demands (present and projected) with the amount of available space . Also parking studies can be used to address different types of parking concerns and problems (2).

Schulman and Sout(36) mentioned that three types of data are required to define and study the parking activity:

a) A measure of parking supply and its characteristics location, cost, turnover, and restriction.

b) A measure of parking demand and its characteristics-location, arrival time, duration and purpose.

c) A measure of usage characteristics-walking distance, parking cost and duration.

The supply of a parking space in each block of a study area is the most valuable information. This is often expressed in space- hours rather than the number of vehicles entering the area.

Parking studies can generally be classified in to three major types : Comprehensive or full- scale, limited or partial, and special- purpose. The type of study needed depends on the scope and purpose, the area to be surveyed, available information, and financial considerations.

There are five basic elements essential to any parking study(13) :

1) Preparation - planning and organizing the study;
2) Data collection- surveying existing parking conditions
3) Data Analysis- determining needs and developing alternatives
4) Evaluation- examining the effects of each alternative.
5) Implementation recommendations- selecting a program of improvement

Many traffic and parking studies are conducted on university and college campuses, some of them are made on the same university or college

campus at different time periods. A transportation plan is prepared as the result of an existing circulation, parking or transit problem at other colleges and universities.

A comprehensive campus parking and transportation study is the most complete of all other types of studies and the most costly because of the extensive data collection and detailed analysis required. This type of studies are used at some U.S.universities such as Chicago, Wisconsin, Illinois, Michigan, Purdue ,Indiana, North western, State university of Iowa, Ohio state and Michigan state University (6, 27, 28, 37).

A comprehensive Transportation plan of the university of Oklahoma was developed and analyzed with respect to parking, traffic circulation, and transit service (38).

The study area in Michigan state University was defined and divided into 23 sectors. The current and future traffic and parking demand are conducted for each sector according to the study objectives and goals, and the university policy, development, car ownership, and population with visitors. where all traffic and parking characteristics are evaluated and established with the safe and efficient conditions(6).

The collection of study data was done by several methods of survey. Louisiana state university, Loughborough university, and university of Canterbury are used the inventory and interview or questionnaire survey (4, 39, 16), other universities are used the origin-destination method like university of Colorado(4).

In Great Britain; a questionnaire survey of traffic and parking at 19 universities was undertaken to determine the relationship between the user, the characteristics of the institution and the amount of traffic and parking space provided(16).

Also, each study used different methods to analyze the collected data. In stanford university study, the university's office of transportation program

has developed a computer based linear optimization model to examine the distribution of current and projected parking spaces on campus and determine the level of service for each planning region. The objective of the model was to empty the origins [supply] and to fill the destinations [demand] in such a way that the total cost [walking distance] is minimized(12). In university of MaryLand study, a mathematical planning model has been developed, using the regression and stepwise analysis to forecast parking requirements(40).

In Carnegie-Mellon university, a simplex network obtained from linear programming was used to determine the combination of facilities to serve future parking needs with maximum utility and minimum cost(41).

Many suggestions and solutions are obtained from many studies. On American universities, suggested that the only solution of parking problems is to provide more parking spaces. Also they suggest that the positive organization of campus parking is essential to procurement and maintenance of operational efficiency(42).

In Arizona state university, an open-air tram system was installed to solve the problem of utilizing the available parking spaces(43). Other studies show that many educational facilities operate successful ride sharing programs (a program devoted to developing and promoting the various means of obtaining high- occupancy vehicle use). There are four types of ride sharing activities: vanpools, carpools, shuttles and / or public transit services.

Al-Harbawee(44) studied the parking and traffic circulation at University of Mosul in Iraq and recommended a traffic and parking service department (TPSD) to be responsible for the implementation of traffic plans and parking program.

2.7 PARKING POLICY

Parking policies normally are an outgrowth of economic, political, and historical circumstances. They vary among cities and are influenced by each city's goals and objectives, by street traffic conditions, and by transit availability and use (2).

Planning transportation for college and university campuses involves technical analysis, and evaluation of existing and potential campus policies. "Some policies which affect the transportation plan are operational; other may be political" (7). Parking policy toward the automobile has been traditionally associated with public policy(45).

Barton and Johnson(5) mentioned that in order to develop a campus parking policy, the following principles must be considered:

1- Trade-offs between such factors as safety, convenience, efficiency, economy, aesthetics and campus space requirements for other users.

2- Determination of the varying parking requirements of different segments of the campus population and the development of assignment priorities based on the needs.

3- Establishment of a rate structure that reflects the relationships of parking supply to demand.

4- Establishment of a program for enforcing policy regulations and restrictions.

5- Development of a program for financing campus parking.

The following categories are the proposals of policy improvement as studied by lin(46):

1- Regression or adjustment of parking space demand :

a) Restriction on growth of car ownership.

b) Decrease car usage.

c) Adjustment of staggered hours and space distribution of parking space demand.

2- Provision of parking space supply : The demand and supply of parking spaces is always induced from providing more parking spaces supply.

3- Other supplement policies :

a) Improve mass transportation management.

b) Revise laws or regulations which concern with parking construction or management.

c) Establish an organization to be responsible to parking management.

CHAPTER THREE
METHODS OF DATA COLLECTION AND ANALYSIS

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3.1 INTRODUCTION

This chapter describes and identifies the procedure and methodolgy that have been used in collecting and analyzing all needed data for this study. The aim of this chapter is also to study present and future parking demands for the provision of additional parking facilities to the main campus of University of Jordan. This chapter will be presented in several stages. These include the collection of data, analysis of data and methods of future projections.

This chapter will be organized as follows:

1- Definition of the study area.

2- Collecting background information on campus growth (population, car ownership and land-use), policies, regulations, management and enforcement.

3- Collecting necessary data on traffic and parking characteristics and estimating parking demand on campus.

4- Description of the methods of forecasting the campus population and car ownership.

The organizational steps necessary to accomplish the objectives of this study included the following:

(a) Definition of the study objectives.

(b) Selection and description of the field works.

(c) Collection of current traffic and parking data.

(d) Preparation of the existing and future development campus maps and plans.

(e) Designing the questionnaire form.

(f) Analysis of all collected data and information.

3.2 DEFINITION OF THE STUDY AREA

The study area as shown in Figure (3.1) illustrates the main campus location of the University of Jordan in Amman city. The campus is located in northern sector of the Amman region, in Jubaiha region within Municipality Of Greater Amman with an area of 28.044 km^2 and population density of 728 pop/km^2 in 1990. Jordan University is located about 14 km from Amman city center, and is surrounded by a variety of land uses including hospitals, technical institute, commercial area and urban housing.

The campus is well served by an arterial street called University street and is surrounded by three collectors streets named Al-Ahmasi, Al-Qabas and Khaleel Al-Sakit which serve Jubaiha and Abu-Nuseir region in addition to Yajos street and Dahiat Al-rashid.

The campus has five gates numbered (G1 to G5) as shown in Figure(3.2) (the first and second gates are main gates, the third and fourth gates are local gates, finally the fifth gate is a faculty housing gate which opens daily between 7:00-8:30 a.m. and 13:00-14:30). While, there are another four pedestrian gates numbered from (PG1 to PG4), these gates are used by pedestrians only.

The survey area is divided into nine sectors as shown in Figure (3.2). The main streets in the campus are considered as the best boundaries between sectors. The division and classification of these sectors are made according to :-

a) Characteristics and topographics of sector area.

b) Physical properties that connect the building in each sector.

The campus community has a population of 25903 persons during the academic year 93/94 {927 faculty members, 2083 staff members and

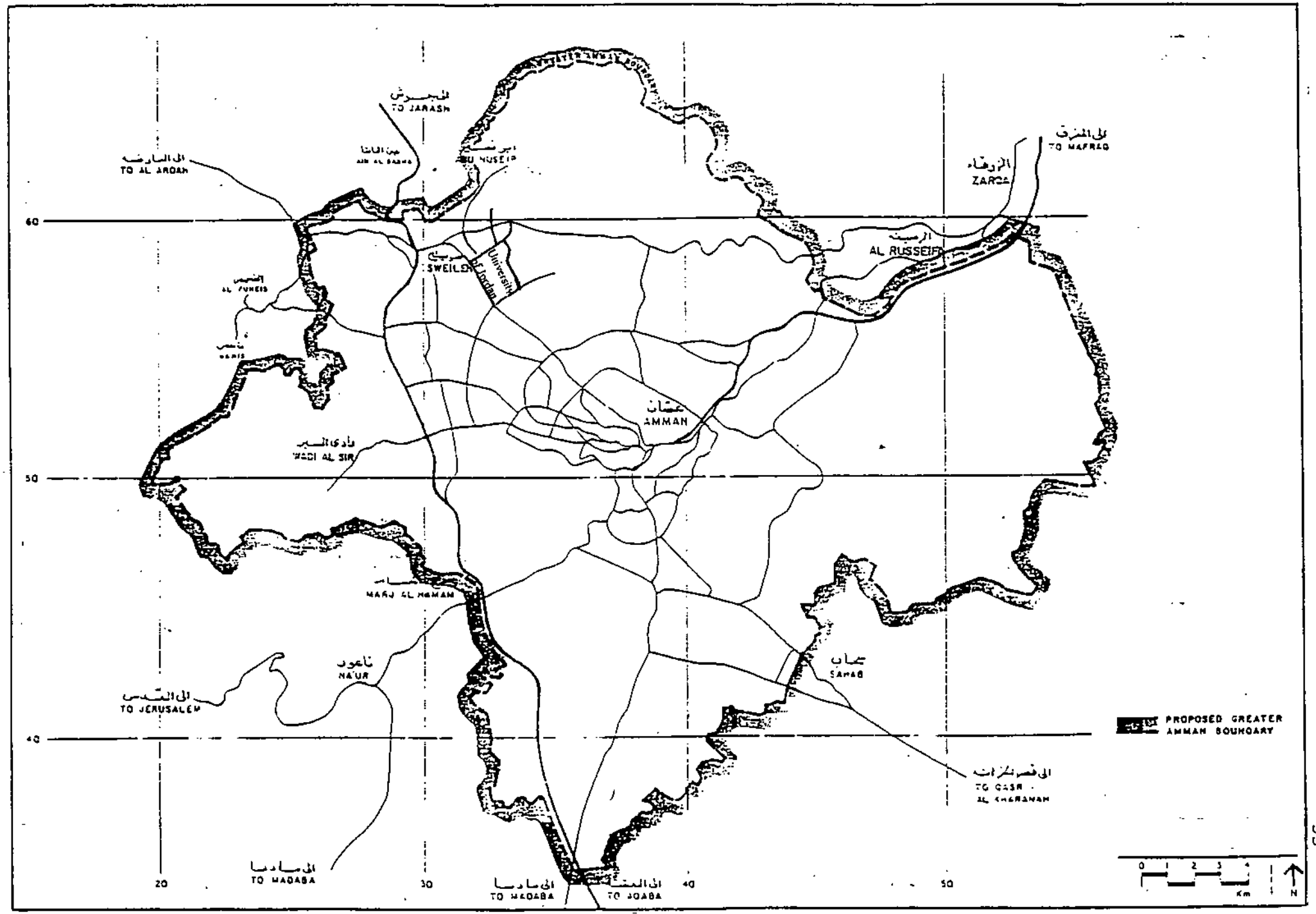

Figure (3.1): Location Of University Of Jordan In Amman Region

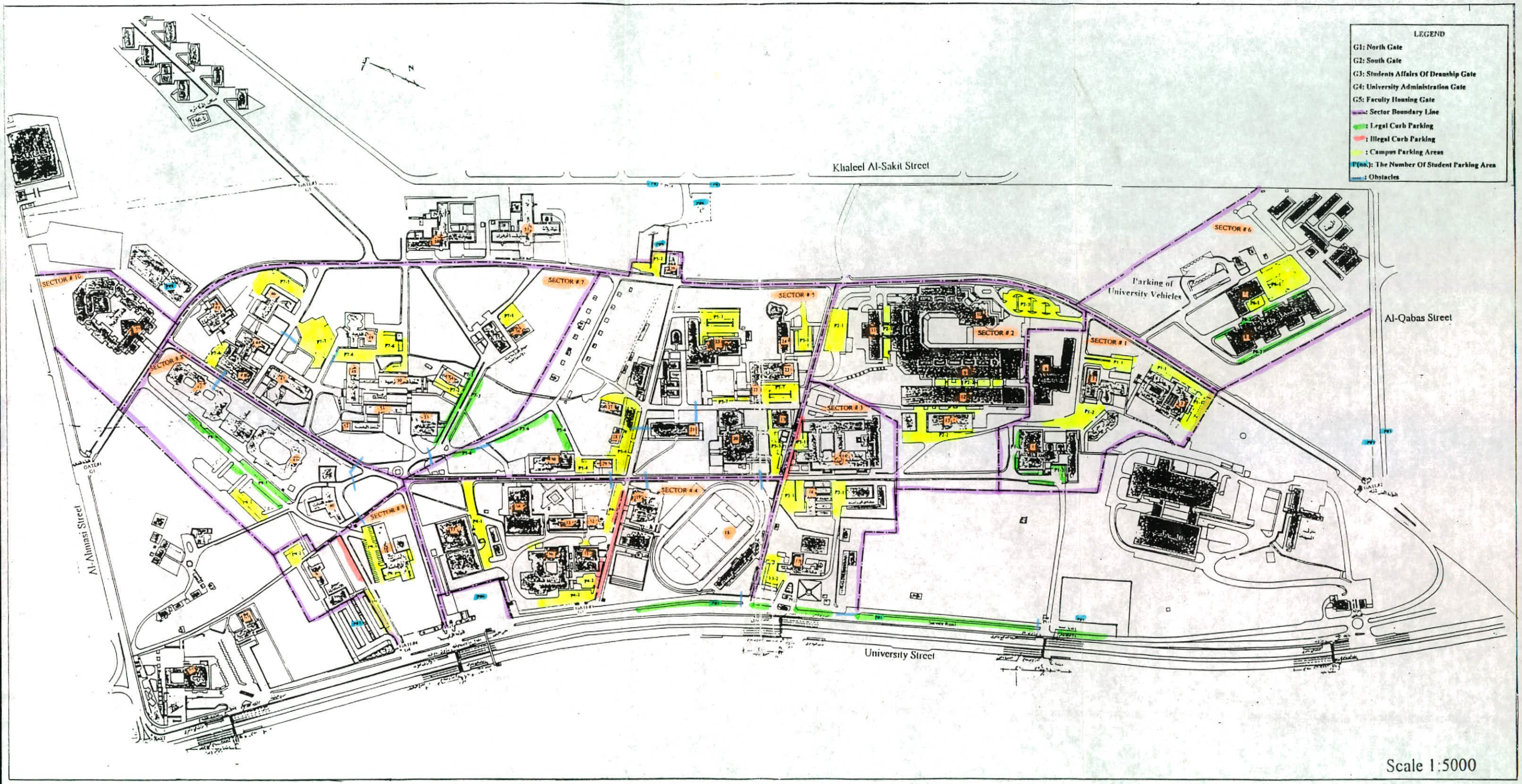

Figure (3.2): The Locations Of University Sectors And Gates

22893 students}. It consists of fourteen colleges and seven administrative offices in addition to technical, scientific, and service centers. All details, location and description of these buildings are shown in Figure(3.2). Students curb parking is located at the service street, back street and southern street numbers 1,2 and 3 respectively on Figure(3.2). The parking on service street is legal while at other locations is illegal. Students' off-street parking are consist of four parking lots and one parking garage numbers (5-9) as shown in Figure(3.2).

3.3 DATA COLLECTION

The data collection phase is an important step; it supplies information needed to determine and analyze existing traffic and parking characteristics of the campus, in addition to the needed data for forecasting .

3.3.1 Background Data

These data include campus population, car ownership, land use, policies , regulations mangement and enforcement.

The campus population from the academic year 1983/1984 to 1993/1994 is taken from the university administration-Department of planning and statistics. The numbers of faculty and staff members, and students are collected for all buildings located in each sector at the campus. The available statistics for the last 10-years are undertaken to establish and evaluate the pattern of population growth in each sector.

The number of vehicles with sticker of the academic year 1993/1994 which are allowed to enter the campus is taken from the university administration. These data are classified according to the profession of population in each building and for each sector. These information provide an indication on the level of car ownership in each sector for faculty and staff members.

The existing campus land use information is taken from engineering department at the university of Jordan. The department supplies data on the university proposed developing program for the coming year only 1996/1997. The collected data are presented on the campus maps as shown in Figure (3.2). It is difficult to predict the university policy for the next 10-years in terms of future development plans.

3.3.2 Field Survey

The data on current traffic and parking loctions, facilities, characteristics, and demands are determined from the field surveys at each sector in the study area.

The field surveys were conducted at time when favourable and unbiased results can be obtained. Therefore, Monday and Tuesday were chosen as typical days for conducting the field survey. Days of extreme inclement weather or days before or after holidays were disregarded. The normal survey work hours was between 7:00 a.m. to 5.00 p.m.

Internal parking survey was conducted in two stages: the first stage was in the 4th and 5th of April and the second stage was in the 11th and 12th of April 1994. In addition a survey was made inside the campus parking lots to record the vehicles with and without stickers between (10:00-12:00) a.m. on 18th of April 1994.

All entry vehicles and exit vehicles were counted on all gates of the university and classified by their uses as private, official and taxi during 4th and 5th of April 1994. All external students parking areas survey were conducted in 11th and 12th of April 1994. In addition the questionnaire survey was conducted in the 11th of April 1994.

A) Parking Survey

The purpose of a parking survey was to determine the parking requirement and to identify the parkers habits and the relation of these considerations with other use of existing parking facilities(13). Also the parking survey was carried out in order to find the effect of land-use on the parking demand and to compare it with the available parking supply at each sector. In addition a parking survey was made at each students parking lots, curb parking and garage parking with trip destination inside the university and car occupancy.

The first step, as a fundamental part of any parking survey, is an inventory of all parking facilities and the possibilities for new development and improvement within the campus. By means of an inventory, information is assembled about loction, capacity , physical features, operating features and regulations. In addition parking accumulation survey is conducted at each curb and off-street parking facilities manually for all vehicles parked in the study area, hour by hour during the survey days. While student parking survey was made by recording the license-plate number of each car entered the parking lot every 15-minutes and asking the driver about their trip destination building and recording the number of persons inside the car.

B) Traffic Survey

The traffic survey inside the University was carried out in order to identify the efficiency and the characteristics of the traffic circulation system inside the campus streets. The data were collected from the field inventories on the main street and interesections inside the campus. Moreover, the physical properties {cross section in pavement, sign and marking} of the main street and intersections were recorded in this inventory.

C) Questionnaire Survey

The questionnaire survey was carried out on Monday 11/4/94 {between 7:00 A.M. and 5:30 P.M} where 1850 questionnaire forms were distributed at the campus entrance gates to every vehicle entering the campus.

Four persons did a survey at the first and second gates (two person per gate). The task of the first person was to handle the questionnaire form to the entering driver and recording the time of entering and gate number. The second person received the completed questionnaire from the drivers leaving the campus and record the leaving time and gate number.On gate (G5) there is only one interviewer between (7:00-8:30) a.m. and (1:00-2:30) p.m., the times when the gate is open. On gates G3 and G4 one person was assigned for each gate was used, since the traffic volume at both gates was very low. A typical questionnaire form used in the survey is shown in Figure (3.3).

The total number of the questionnaire forms distributed to the drivers entering the campus during the survey day were 1850 while number of return forms were 923 which represent 49.9 percent of the total distributed forms and the number of questionnaire forms did not return were 927 which represent 50.1 percent of the total distributed forms.

The questionnaire forms were distributed only to drivers of private cars. The 923 questionnaire forms were distributed among the various categories of the campus population as follows:-

- Faculty = 374 forms(40.5%).
- Staff = 296 forms(32.1%).
- Visitors = 133 forms(14.4%).
- Others = 120 forms(13.00%).

Car Parking Survey Form For University Of Jordan

entering gate no.	entering time
exiting gate no.	exiting time

FOR THE PURPOSE OF PROVIDING BETTER PARKING SERVICES INSIDE THE UNIVERSITY OF JORDAN, WE APPRECIATE YOUR COOPERATION IN ANSWERING THE FOLLOWING QUESTIONNAIRE. THANK YOU.

Place of Living	
Place of work in the University	College ..... Department ..... Other place of work .....
Type of work	☐ Staff ☐ Faculty ☐ Visitor ☐ Others

Location of car park usually used or nearest point of identification inside the University:

.....

.....

.....

Days car park used weekly:

☐ Sat. ☐ Sun. ☐ Mon.

☐ Tue. ☐ Wed. ☐ Thur. ☐ Friday

In general how many times do you use the parking place daily:

☐ Once ☐ Twice ☐ More than twice

Please handle this form when you finish it to the university guards at any gate..

Figure (3.3): The Questionnaire Form Used At University Gates

Design of Questionnaire

One Method of maximizing the return of the questionnaire forms is to take special care in questions selection so as not to ask a lot of information. Therefore, the questionnaire form was designed with simple and direct general questions, so that the requisite time of filling the form, do not exceed a minute. The questionnaire form shown in Figure (3.3) was prepared and designed to include the following questions:

Question 1

The name of housing location which represent the trip origin that basically started from the driver's home.

Question 2

The location of working (college, division, others) inside the university gave an indication on the destinations of the parkers or occupants who entered the campus.

Question 3

The type of work which are divided into four choices {faculty, staff, visitor, and others}. The aim of this question was to classify the parking demand of all buildings in each sector by the users profession, and to determine the purpose of all travel trips to the campus.

Question 4

Parking location was put to describe the current daily parking location of the vehicle inside the campus. The advantage of this question was to evaluate the present parking demand at each parking location, and the distribution of vehicles at these locations. The present circulation of the vehicles and the entering gate number can be predicted from this question.

Question 5

The number and name of days through the week are using the parking can help to indicate weekly variation in the number of parkers who use parking lots, also it gives indication about the number of regularly users of these parking lots.

Question 6

Number of times using the parking location through one day which gave an indication about the frequency of using the parking during a day.

Time of entering and leaving the university campus and gate of entering and leaving are recorded above the questionnaire form by the persons assigned at each gate.

Unfortunatly, some questions in the returnable questionnaire were not filled, so it was considered as unknown in the analysis stage.

3.4 DATA ANALYSIS

Upon completion of the field surveys, the collected data were combined and arranged together with the data obtained from the questionnaire survey. Some of these data were fed in a computer program for analysis while other data were analyzed manually. The results are summarized below:

1- Classification of the entering and exiting vehicles with time of entrance and exit at the main gates according to the type of vehicle.

2- The number of entering and exiting vehicles to and from the campus every 15 minutes during the peak hour at the main gates and for the campus as a total.

3- Accumulation of entering and exiting vehicles at the main gates and for the campus as a total .

4- Distribution of the entering vehicles according to :
   a) Trip origin and arrival route; b) Driver profession;
   c) Trip destination; d) Gate number; e) Times of using the parking each day; and f) Number of days using the parking areas.

5- The existing car ownership according to the campus population professions in each sector and at the university.

6- Average parking duration in each sector and at the university.

7- Existing parking demand for each sector.

The recommendations and remarks of the questionnaire survey were arranged according to their importance. The data related to the parking survey were analyzed in order to determine the hourly variation of parked vehicles at each location {number of parked vehicles at each parking location hour by hour}.

In addition, the parking duration time for students in all parking areas, thier average walking distances and their trip destination to each sector were determined. Finally, the car occupancy and the accumulation of parked vehicle (hour by hour) were also determined.

3.4.1 Forecasting

The predicted period of this study was selected for the next 10-years (2004). The important step for estimating the future parking demand is the forecasting of the campus population and car ownership during the projected period. The essential element to control the forecasting process of the campus population is the policy of University of Jordan to decide the maximum number of the enrollment students, faculties members, and staff

during the next 10-years. The policy of the University may change from year to year depending on the general policy and regulation of the Higher Education Council. Therefore; there is no fixed plan to estimate the number of the campus population growth during the projected period . Accordingly, a number of methods were used to predict the number of campus population groups{ faculty , staff and students} such as simple and multiple regression techniques .

Simple regression technique was used to predict campus population groups using the program of statistical software tools (SST) during the next 10-years. According to the recent and general policy set-up by the university administrations for the future, the total number of the campus population may reach 28400 person for the academic year 2003/2004 which was mentioned by University Chairman distributed as follows:

- Students = 25000
- Faculties = 1200
- Staff = 2200

At the begining , the future forecasting for the number of faculty, staff and students was conducted to the year 2004 using their numbers for the last 10 years. The results of faculty number for the next 10 years was near to the expected number according to university chairman. Therefore, these numbers were considered to find the numbers of staff and students. By using the ratio of faculty to student for the last 5-years and by taking the average of these ratios; the number of student was calculated in each sector and for the total university as well. Also the number of staff was calculated by using the average ratio of staff to student for the last 5- years. The result of these calculation was similar to the expected numbers mentioned by university chairman.

The regression technique was used to find a prediction model of faculty, staff and students numbers with the data for the last 10-years and the

projected number to the year 2004 (The regression equations are shown in Appendix A). The resulted model yielded a results very near to the previous results. Therefore, the ratio method was undertaken to find the number of faculty, staff and students during the analysis stage.

The population and number of registered vehicles between the years (1984-1994) were taken from the Population Division in the Department of Statistics and Department of Vehicles and Drivers Liciencing in Directorate of Public Security respectively.

The car ownership of the campus population groups for the year 2004 was determined at each sector using the growth factor of car ownership of Jordan populuation for the last 4-years as shown in Figure (3.4). The growth factor was found to be 1.37 for staff and students car ownership.

The growth factor was estimated as follows:

1- The slope of the line between the year 1991 and 1994 was calculated according to equation (3-1):

$$\text{slope} = \frac{(A_{1994} - A_{1991}) / A_{1994}}{\text{no. of year intervals}} * 100\% \quad \text{..... (3-1)}$$

where:

A_{1994} = number of registered vehicles per 100 population in 1994

A_{1991} = number of registered vehicles per 100 population in 1991

$$\text{slope} = \frac{(7.4 - 6.7) / 7.4}{3} * 100\%$$

$$\text{slope} = 3.2\%$$

2- The growth factor was estimated by the following equation (3-2):

$$\text{growth factor} = (1+r)^n = \left(1+\frac{3.2}{100}\right)^{10} = (1.032)^{10} \quad \text{.....} \quad (3\text{-}2)$$

growth factor (G.F.) = 1.37

The growth factor with the ratio of existing student and staff car ownership to the total number of students and staff, and the forecasting numbers of students and staff are used to find the future number of car ownership for both staffs and students. The existing percent of faculty car ownership is equal 89.45 therefore, future faculty car ownership are found by supposing that 100 percent of faculty could obtain the car ownership.

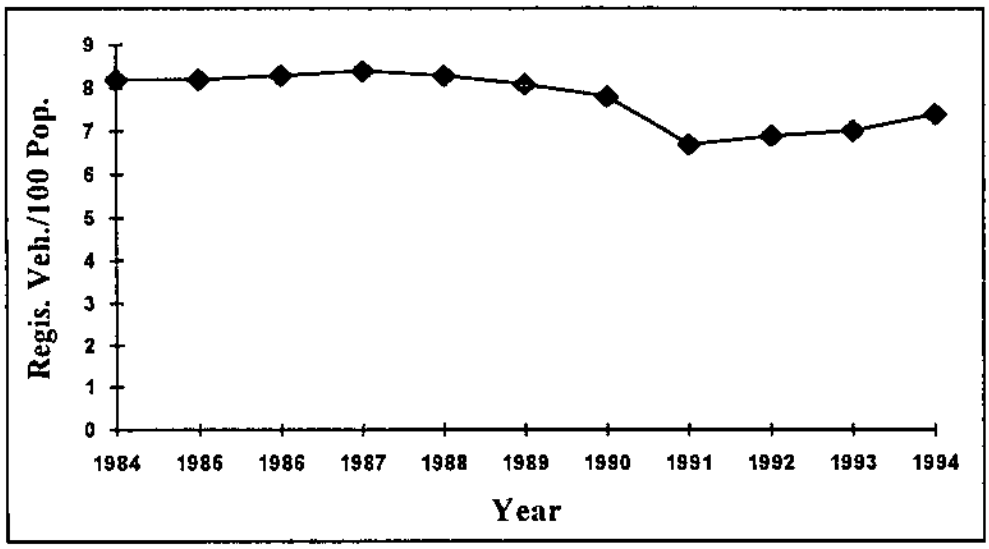

Figure (3.4): The Variation Of Vehicles Registration in Jordan (1984-1994)

3.4.2 Parking Demand For Faculty And Staff

The peak parking demand during the survey day is considered as the main element of parking design. Therefore the present and future peak parking demand were calculated for each sector. The present peak and total parking demands were determined by the results of the parking survey, while the future peak and total parking demand are determined by two methods to check each other as described below:

A) First Method

The total future parking demand for the University was calculated and then divided for each sector as shown below :

1- The total existing parked vehicles of faculty and staff was found by equation (3-3):

$$TP_e(f+s) = TP_e * m \quad \ldots\ldots\ldots\ldots \quad (3\text{-}3)$$

Where :

$TP_e(f+s)$ = Total existing parked vehicles of faculty and staff.

TP_e = Total existing parked vehicles

m = Percent of faculty and staff having a sticker.

2- The existing percent of car ownership was determined as the ratio between existing total parked vehicles of faculty and staff and total existing car ownership of faculty and staff.

$$(C_e) = \frac{TP_e(f+s)}{TC_e(f+s)} * 100\% \quad \ldots\ldots\ldots\ldots \quad (3\text{-}4)$$

Where :

(C_e) = Existing percent of faculty and staff car ownership

$TC_e(f+s)$ = Total existing faculty and staff car ownership.

3- The total existing parked vehicles for visitors was determined as the difference between the total existing parked vehicles and the total existing parked vehicles of faculty and staff.

$$TPV_e = TP_e - TP_e(f+s) \quad \ldots\ldots\ldots\ldots \quad (3\text{-}5)$$

Where :

TPV_e = Total existing parked vehicles of visitors.

4- Total future faculty car ownership was determined to be equal the future faculty numbers:

$$TC_{(f)}F = TF_{(no.)f} \quad \text{..... (3-6)}$$

Where :

$TC_{(f)}F$ = Total future faculty car ownership

$TF_{(no.)f}$ = Total future faculty numbers

5- Total future staff car ownership was determined by equation (3-7) below:

$$TC_f(S) = Ts_{(no.)f} * G.F. * \frac{TC_e(S)}{TS_{(no.)e}} \quad \text{..... (3-7)}$$

Where :

$TC_f(S)$ = Total future staff car ownership

$TS_{(no.)f}$ = Total future staff numbers

G.F. = Growth factor of staff car ownership = 1.37

$TS_{(no.)e}$ = Total existing staff numbers

$TC_e(S)$ = Total existing staff car ownership

6- Total future parked vehicles of faculty and staff was determined by the equation (3-8) :

$$TP_f(F+s) = TC_f(F+S) * (C_e) \quad \text{..... (3-8)}$$

Where :

$TP_f(F+S)$ = Total future parked vehicles of faculty and staff

7- Total future parked vehicles was estimated by divide the total future parked vehicles of faculty and staff over the percent of faculty and staff having s sticker.

$$TP_f = \frac{TP_f(F+S)}{m} \quad \text{..... (3-9)}$$

Where :

TP_f = Total future parked vehicles

8- Total future parked vehicles of visitors was determined by the difference between the total future parked vehicles and total future parked vehicles of faculty and staff.

$$TPV_f = TP_f - TP_f(F+S) \quad \ldots\ldots\ldots\ldots \quad (3\text{-}10)$$

Where :

TPV_f = Total future parked vehicles of visitors

9- Then by using the existing ratio, the total future and peak parking demand for each sector will be determined by the equations (3-11), (3-12) and (3-13).

$$TP_f(\text{sec.no.}) = TP_f(\text{uni}) * \frac{TP_e(\text{sec.no.})}{TP_e(\text{uni})} \quad \ldots\ldots\ldots\ldots \quad (3\text{-}11)$$

$$Peak_f(\text{uni}) = TP_f(\text{uni}) * \frac{Peak_e(\text{uni})}{TP_e(\text{uni})} \quad \ldots\ldots\ldots\ldots \quad (3\text{-}12)$$

$$Peak_f(\text{sec.no.}) = Peak_f(\text{uni}) * \frac{Peak_e(\text{sec.no.})}{Peak_e(\text{uni})} \quad \ldots\ldots\ldots\ldots \quad (3\text{-}13)$$

Where :

$Peak_f(\text{uni})$ = The future peak parking demand of total university.

$Peak_f(\text{sec.no.})$ = The future peak parking demand of sector no..

$Peak_e(\text{uni.})$ = The existing peak parking demand of total university.

$Peak_e(\text{sec.no.})$ = The existing peak parking demand of sector no..

B) Second Method

The future total and peak parking demand for each sector(i) was determined and then the results were added to find the future total and peak parking demand for the whole university, the steps are mentioned below :

1- The future faculty and staff car ownership were determined in each sector(i) by the equations (3-14) and (3-15).

$$TC_f(F)_i = TF(no.)_{fi} * 100\% \quad \text{.....} \quad (3\text{-}14)$$

$$TC_f(S)_i = TS(no.)_{fi} * G.F * \frac{TC_e(S)_i}{TS(no.)_e i} \quad \text{.....} \quad (3\text{-}15)$$

2- The existing total parked vehicles of faculty and staff in each sector(i) was determined by the existing total parked vehicles in each sector(i) multiply by the percent of faculty and staff having a sticker in each sector(i).

$$TP_e(F+S)_i = TP_{ei} * m_i \quad \text{.....} \quad (3\text{-}16)$$

3- The existing percent of faculty and staff car ownership in each sector(i) was determined by the following equation :

$$(C_e)_i = \frac{TP_e(F+S)_i}{TC_e(F+S)_i} \quad \text{.....} \quad (3\text{-}17)$$

where:

$(C_e)_i$ = Existing percent of faculty and staff car ownership in sector i.

4- The future total parked vehicles for faculty and staff and visitors was determined in each sector (i) by the following equations :

$$TP_f(F+S) = TC_f(F+S)_i * (C_e)_i \quad \text{.....} \quad (3\text{-}18)$$

$$TP_{fi} = \frac{TP_f(F+S)}{m_i} \quad \text{.....} \quad (3\text{-}19)$$

$$TP_f V_i = TP_{fi} - TP_f(F+S)_i \quad \text{.....} \quad (3\text{-}20)$$

5- The future peak in each sector(i) was determined by equation (3-21) below :

$$Peak_{fi} = TP_{fi} * \frac{Peak_{ei}}{TP_{ei}} \quad \text{.....} \quad (3\text{-}21)$$

6- Then the results of all nine sectors of future total and peak parking demand were added to find the future total and peak parking demand for the whole university.

The results of this method are nearly equal to the results of the first method. The results of the second method were used because the analysis is done in a macro level (for each sector). A sample of calculation of sector one is presented in Appendix A.

3.4.3 Parking Demand For Students' Parking Areas

The future total and peak parking demand were determined by the two equations (3-22), and (3-23) below :

$$TP_f(st.) = T_f st.(no.) * G.F. * \frac{TP_e(st.)}{T_e st.(no.)} \quad \text{..... (3-22)}$$

$$Peak_f(st.) = TP_f(st.) * \frac{Peak_e(st.)}{TP_e(st.)} \quad \text{..... (3-23)}$$

Where :

$TP_f(st.)$ = Future total parked vehicles of student.

$T_f st.(no.)$ = Future total students numbers

G.F. = Growth factor of student car ownership = 1.37

$TP_e(st.)$ = Existing total student parked vehicles

$T_e st.(no.)$ = Existing total students numbers

$Peak_f(st.)$ = Future students peak

$Peak_e(st.)$ = Existing students peak.

Then by existing ratios of total and peak parking demand in each parking area to the total and peak parking demand of students parking areas; the future total and peak parking demand in each parking area will be calculated.

3.4.4 Parking Generation Rate

The land uses generate trips as well as generate a need for parking spaces. The parking generation rate was estimated for the campus population by dividing the total available number of parking spaces at the university over the total number of campus population multiplied by 100, in order to obtain the ratio of number of parking spaces per 100 population. However, the ratio of the number of parking spaces per 100 student was calculated by dividing the total available number of students parking spaces over the total number of students multiplied by 100.

In addition, the total available number of faculty and staff parking spaces were divided by the total number of faculty and staff members multiplied by 100.

Finally the parking generation rate was found in each sector by dividing the number of spaces in each sector over the area of that sector multiplied by 1000 square meters, in order to estimate the ratio of parking space/1000 m^2. The ratio was also calculated for the total university.

The above ratios will be used as guidelines in parking planning studies.

CHAPTER FOUR
DISCUSSION OF RESULTS

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This chapter discuss the results of analyzing the campus traffic and parking surveys data described in chapter three. The discussion includes the existing and prediction of campus population, car ownership and parking demand, also discuss the characteristics of traffic and parking at the whole campus.

4.1 CAMPUS POPULATION

The campus population groups from 1983 to 1993 are shown in Table (4.1) and Figure (4.1). The effective factor of this variety is the number of enrollment students in each year which was controlled by the policy of the university administration and higher concil of education.

The maximum number of faculty and staff members was reached during the academic year 1993/1994, and the maximum number of students occured also during the same academic year. The analysis of the data on the existing parking demand in each campus sector are dependent on the population groups of all buildings located in each sector for the academic year 1993/1994 which represent the maximum traffic and parking demands during the last 10 years.

4.1.1 Existing And Predicted Campus Population

The forecasted number of campus population groups in each sector for the academic year 2003/2004 was determined using the method of forecasting described in chapter three. Table (4.2) shows the campus population groups in each sector for the existing academic year 1993/1994 and the predicted number of these groups for the academic year 2003/2004. Sector number four includes part of the physical education college where

most of their faculties, staff and students are found in the primary physical education building outside the University of Jordan. it was decided to take the ratio 0.25 only from the total faculties, staff and students to exist at the University campus area. This Figure was estimated after interviewing some of the college faculty members and students.

Table (4.1): University Of Jordan Main Campus Population Groups

pop. group / year	Faculty	Staff	Student	Total
1983	674	1615	11518	13807
1984	699	1732	11457	13888
1985	780	1631	11629	14040
1986	778	1683	12644	15105
1987	784	1711	14385	16880
1988	793	1829	15609	18231
1989	880	1960	17346	20186
1990	882	1983	19116	21981
1991	797	2002	21042	23841
1992	891	2056	22723	25670
1993	927	2083	22893	25903

Table (4.2): Existing And Predicted Main Campus Population Groups By Sectors.

Sector No.	Existing (1993/1994)			Predicted (2003/2004)		
	Faculty	Staff	Student	Faculty	Staff	Student
1	208	150	2580	254	186	2896
2	123	118	2769	151	145	3126
3	69	192	1446	84	246	1818
4	6	290	157	7	366	191
5	134	464	2216	164	589	2785
6	0	330	0	0	418	0
7	233	201	9269	285	257	11282
8	137	49	3984	167	63	4849
9	0	262	0	0	332	0
Total	910	2056	22421	1112	2602	26947

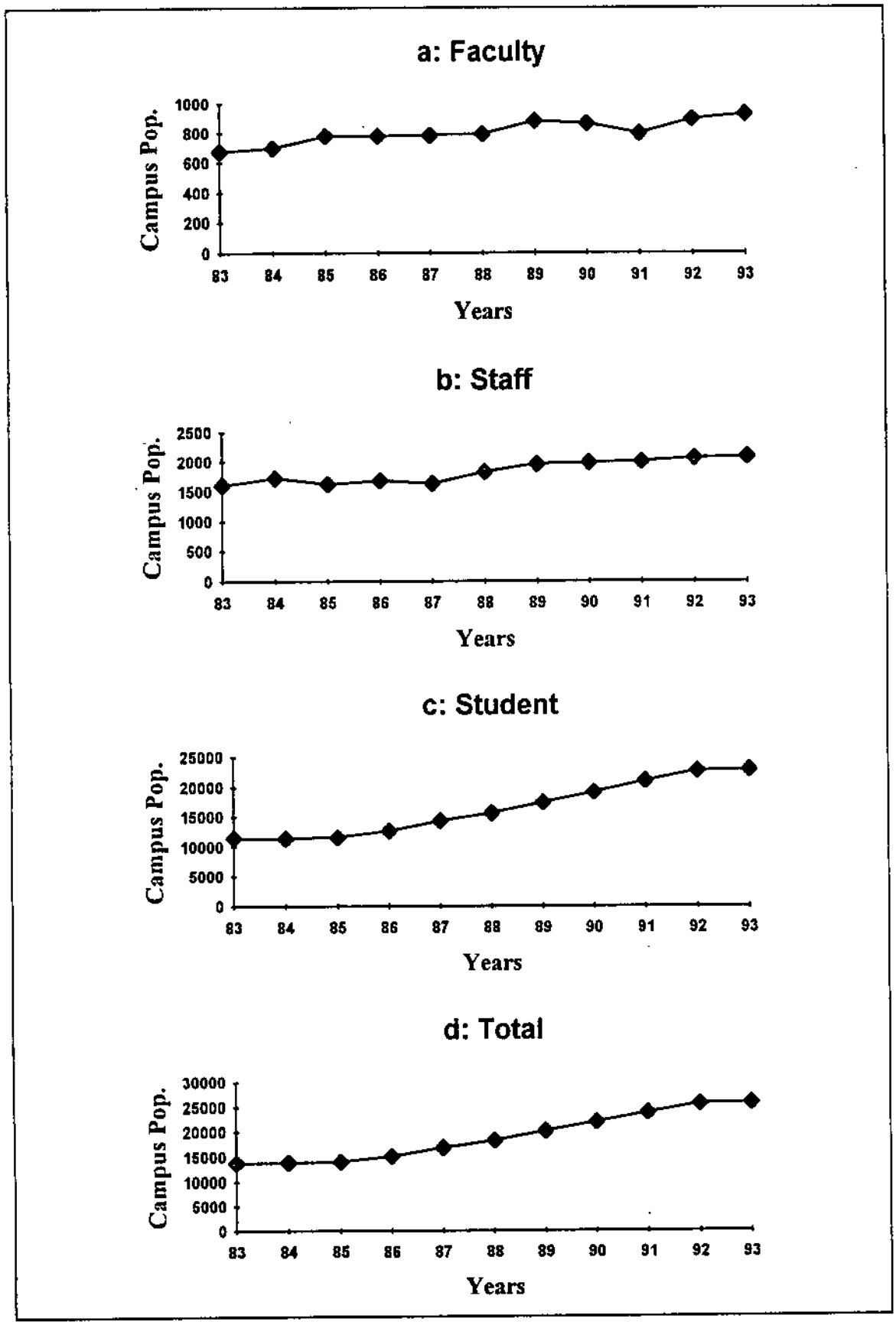


Figure (4.1): The Trend Of Growth Of Population Groups At University Of Jordan Main Campus From 1983-1993

4.2 CAMPUS CAR OWNERSHIP

The University policy during 1993/1994 permit only private vehicles owned by faculty and staff member to enter the campus after getting badges from the University administration office to allow them to enter their vehicles. The existing number of vehicles having permit badges for the academic year 1993/1994 is 1789 vehicles, distributed as 814 and 975 for faculty and staff respectively. The existing car ownership of the campus population is about 60.3 vehicles per 100 population. The campus car ownership for faculty and staff were 89.45, and 47.4 vehicles per 100 faculty and staff respctively.

Temporary badges are issued to vehicles in order to permit them to enter the main campus during a definite period such as one month to one year. The temporary badges are issued under the following conditions:

1- Vehicles are not owned by faculty and staff but are used by them.
2- Staff and graduate students who work for a short period at the University for a purpose of conducting a research.
3- Vehicles owned by institutions and companies which work inside the university campus for a limited period of time.

The existing number of vehicles having temporary badges for the academic year 1993/1994 is 147 vehicles, distributed as 15, 71, 2 and 59 vehicles for faculty, staff, students and institutions and companies respectively. The temporary badges are not considered in the prediction of car ownership because the permit badges are permanent which could be depend on it in this study, also the parking spaces are utilized by them daily.

Table (4.3) shows the existing and future number of campus faculty and staff who own cars in each sector and the present and predicted percent of car ownership.

Table (4.3): Existing And Predicted Number And Percent Of The Car Ownership In Each University Sector

Sector No.	Existing (1993/1994)			Existing % Car Ownership			Predicted (2003/2004)			Predicted % Car Ownership		
	Faculty	Staff	Total	Faculty	Staff	Total	Faculty	Staff	Total	Faculty	Staff	Total
1	208	83	291	100	55.3	81.3	254	141	395	100	75.8	89.8
2	123	114	237	100	96.6	98.3	151	145	296	100	100	100
3	69	62	131	100	32.3	50.2	84	109	193	100	44.3	58.5
4	6	115	121	100	39.7	40.9	7	199	206	100	54.4	55.2
5	115	152	267	85.8	32.8	44.6	164	265	429	100	45.0	57.0
6	0	151	151	0	45.8	45.8	0	262	262	0	62.7	62.7
7	158	114	272	67.8	56.7	62.7	285	200	485	100	77.8	89.5
8	135	38	173	98.5	77.6	93.0	167	63	230	100	100	100
9	0	146	146	0	55.7	55.7	0	253	253	0	76.2	76.2
Total	814	975	1789	89.45	47.4	60.3	1112	1637	2749	100	62.9	74.0

The higher number of faculty car ownership for the existing academic year 1993/1994 was 208 which occured in sector one while the higher number of staff car ownership was 152 occured in sector five as shown in Figure (4.2).

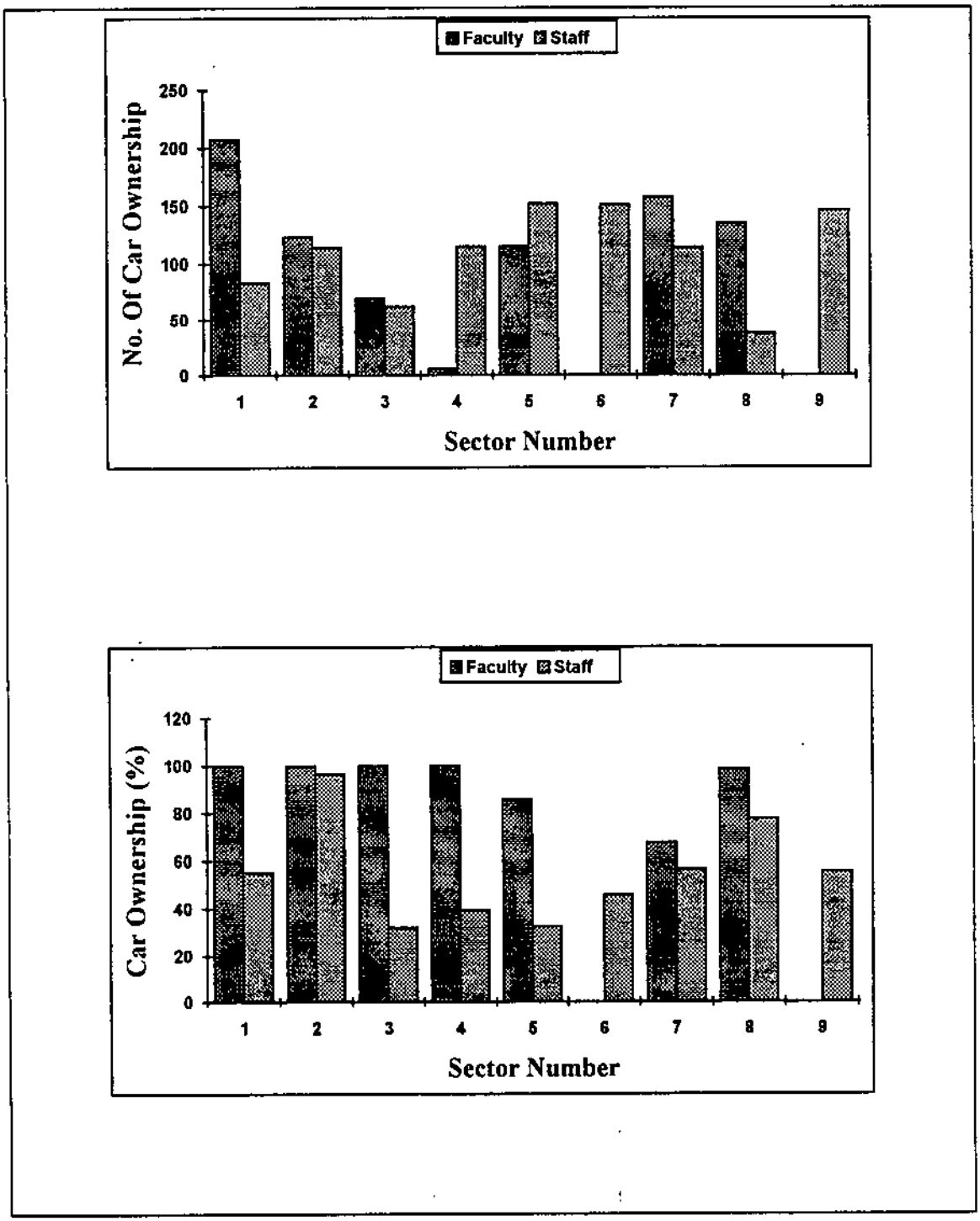


Figure (4.2): Existing Number And Percent Of Faculty And Staff Car Ownership(1994).

4.3 CAMPUS TRAFFIC CHARACTERISTICS

The existing street network of Jordan University consists of a main street between gates G1 and G2 and minor streets which lead to the main parking areas.

The following remarks describe the existing traffic characteristisc at the campus streets:

1- Most of the campus streets are two lanes, two-way streets. Therefore, temporary congestion and delays are particularly occured during peak hours.

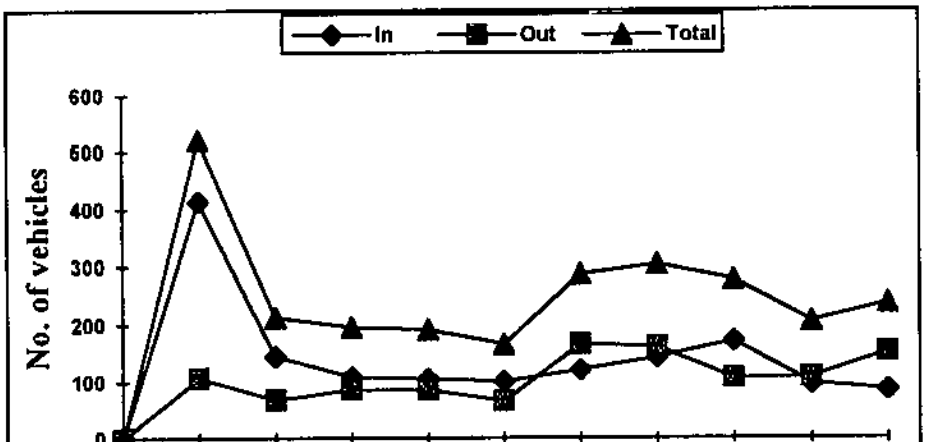
2- The sight distance at some of the campus intersections is less than that required to provide safety. However, this is due to location of trees close to street corners.

3- Speed limit signs and humps exist on the main street in order to control vehicles speed.

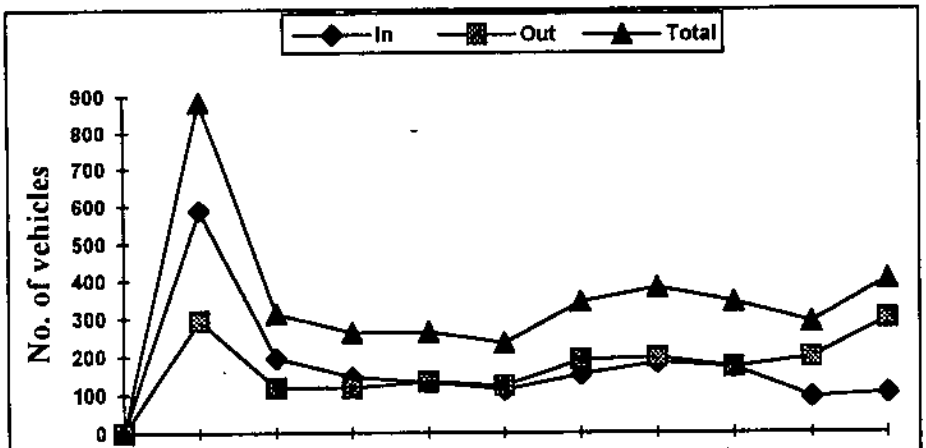
4- Streets surface condition are considered poor. There is no efficient and continous maintenance on campus streets.

5- There is a deficiency in the traffic signs and markings, in addition to disobedience and ignorance of most drivers to the campus traffic regulations and rules. Even though some regulations are existed which include do not enter signs, no parking signs, stop signs, ...etc.

Figure (4.3) shows the northbound and southbound traffic volume of main street in both directions at gates G2 and G1 respectively. The traffic volume was high during the times (7.00-8.00), (13.00-14.00), and (16.00-17.00) which represent begining of workday, lunch hour and termination of workday respectively.



a) South Bound (G1)



b) Northbound (G2)

Figure (4.3): Total Traffic Volume For The Northbound And Southbound Of Main Street In Both Directions

4.3.1 Entering Vehicles

The total number of vehicles entering the campus during a typical weekday, from 7.00 a.m. to 17.00 is 3541 vehicles. The classification of the entering vehicles is as follows:

A. *Trip Origin And Arrival Routes*

The trip origin is obtained from the questionnaire form which require the name of housing region. The following will show the trip origin and arrival route toward each gate of the university as shown in Figure (4.4):

Gate No. 1:

27.1%	from Sweileh and Salt region through University Street.
6.8%	from Jubaiha and Abu-Nuseir region through Al-Athmasi Street.
29.6%	from Dahiah Al-Rashid region through Khaleel Al-Sakit.
9.1%	from Sport City Region through University Street.
27.4%	Unreported.

Gate No. 2 :

13.7%	from Jubaiha region through Khaleel Al-Sakit and Al-Qabas street.
25.3%	from Sport City region through University Street.
30.4%	from Zahran and Tila' Al-Ali region through Madena Al-Mounwara Street.
7%	from Sweileh and Ma'daba region through University Street.
23.6%	Unreported.

Gate No. 3 and 4:

100%	from Sport City region through University Street.

Gate No. 5:

100%	from Jubaiha region through faculty housing street.

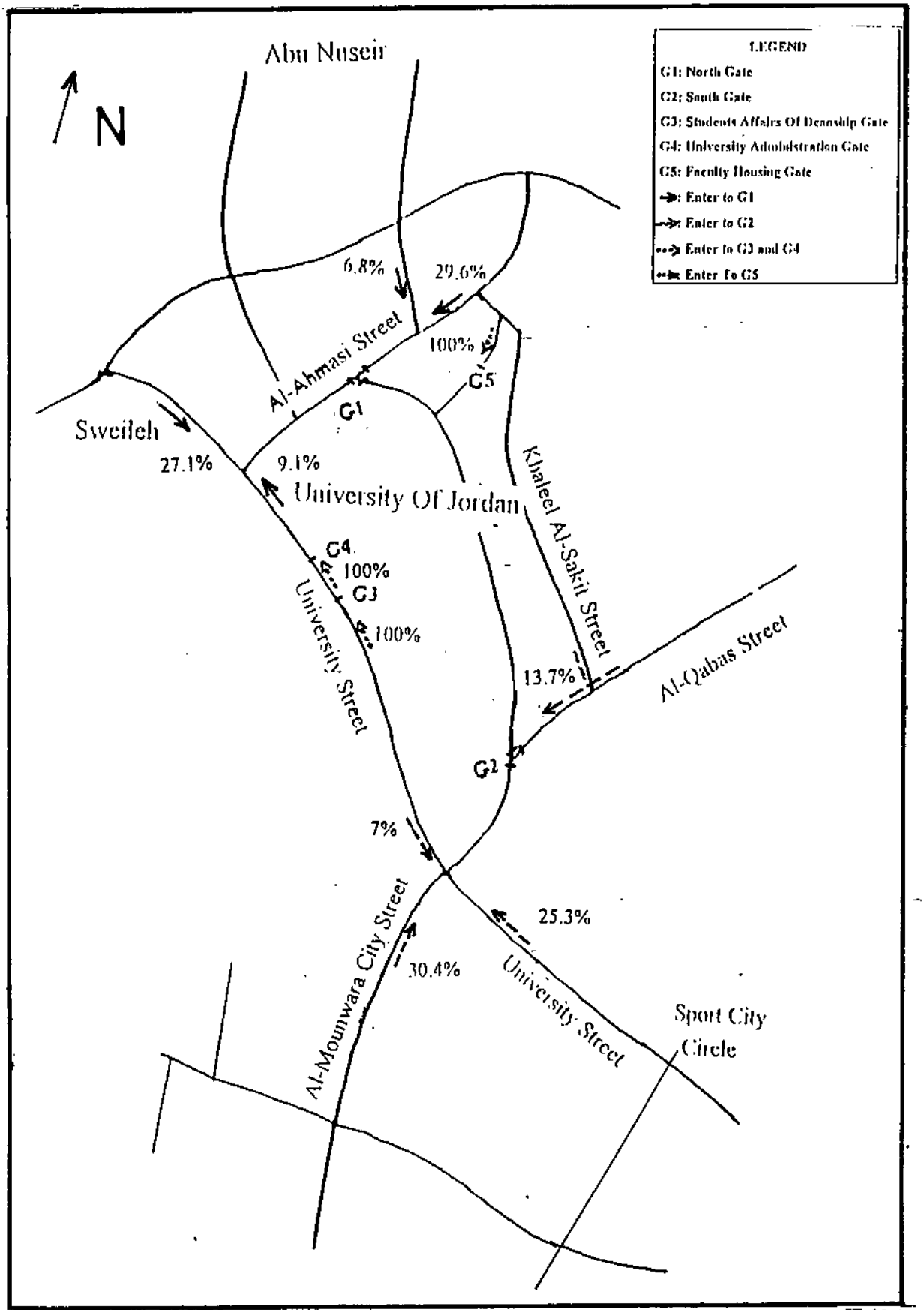


Figure (4.4): The Percent of Vehicles Origin Arrived to University Campus in 1994

B. Entering Gates

The total number of vehicles entering from gate G1 was 1490 (42.1%) vehicles, and from gate G2 1878 (53%) and 173 (4.9%) from gates G3, G4 and G5. Figure (4.5) represents the classification of entering vehicles to the campus at each gate according to their types. Three types of vehicles are presented in this Figure, private, taxi and official. The study found that there were 3106(87.7%) private vehicles, 240 (6.8 %) taxi vehicles and 195 (5.5%) official vehicles entering the campus during the survey time.

C. Peak Hour

The peak hour of entering vehicles to the campus occured between (7.00 to 8.00) a.m., where 1070 vehicles entered the campus. The maximum number of entering vehicles during 15 minutes was 314 vehicle between (7.45 to 8.00) a.m.. Normally, the peak hour occured during this period because the office hour start at 8.00 a.m. and the first lecture at most colleges starts at 8.00 a.m. as well. Figure (4.6) illustrates the distribution of the entering vehicles to the campus at the gates G1 and G2 and total gates during the peak hour.

D. Trip Destination

The distribution of the entering vehicles from each gate to their destination sectors is shown in Table (4.4) as determined from the questionnaire survey. The distribution was made according to the assignment of each department, college or office location on the campus buildings in each sector.

The total number of vehicles used in this distribution was 765 vehicles, this number represent only the personal vehicles which parked at least 15 minutes inside the campus. This Table shows that sector seven has a higher percent of entering vehicles destination from gate G1 because of the

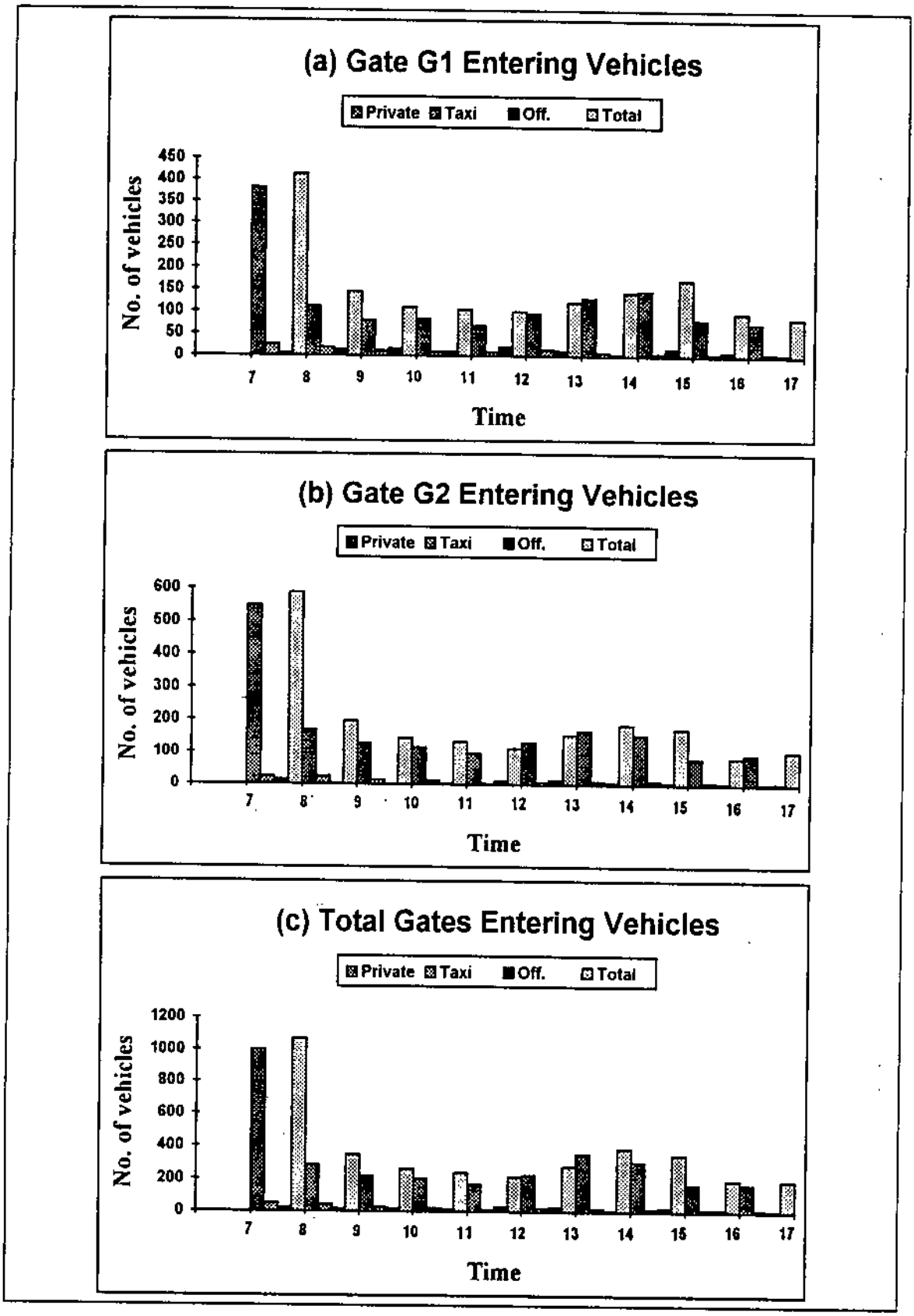


Figure (4.5): Classification Of Vehicles Type Entering The Main Campus Gates.

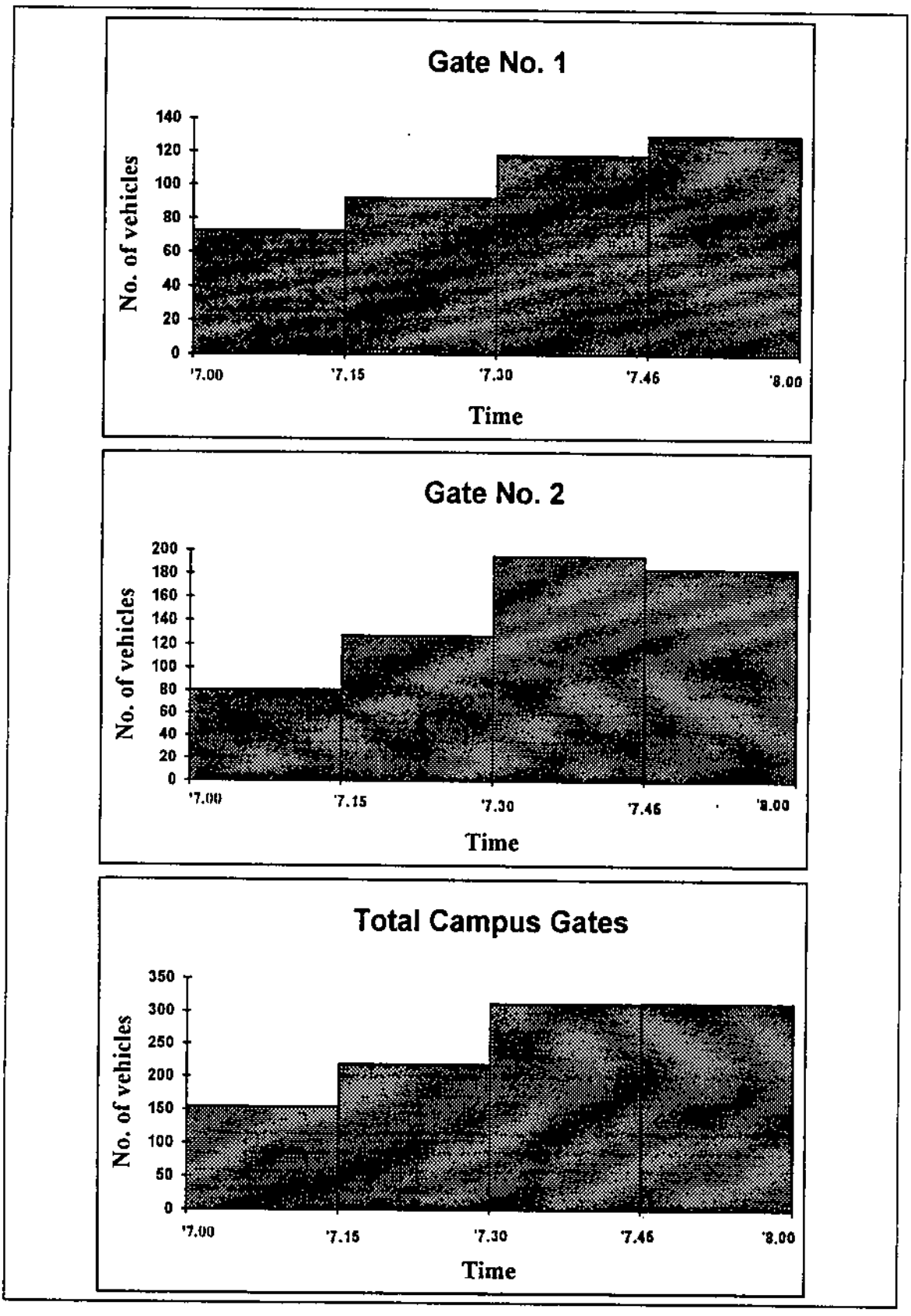


Figure (4.6): Distribution Of Entering Vehicles During The Peak Hour At The University Main Gates.

Table (4.4): The Distribution Of Entering Vehicles From Each Gate To University Sectors.

Sector No.	Gate Name					Total
	G1	G2	G3	G4	G5	
1	23 (6.8%)	82 (15.4)	-	2 (13.2%)	1 (3.3%)	108 (11.7%)
2	31 (9.1)	79 (14.8)	-	-	3 (9.7%)	113 (12.2%)
3	16 (4.7)	32 (6%)	-	-	3 (9.7%)	51 (5.5%)
4	18 (5.3)	27 (5.1)	(100%)	1 (6.7%)	2 (6.4%)	53 (5.7%)
5	43 (12.7)	83 (15.6)	(100%)	-	4 (12.9%)	130 (14.1%)
6	11 (3.2)	22 (4.1)	-	1 (6.7%)	-	34 (3.7%)
7	70 (20.6)	67 (12.6)	-	1 (6.7%)	8 (25.8%)	146 (15.8%)
8	34 (10.1)	33 (6.2)	-	-	6 (19.4%)	73 (7.9%)
9	25 (7.4)	21 (3.9)	-	9 (60%)	2 (6.4%)	57 (6.2%)
Unknown	68 (20.1)	87 (16.3)	5	1 (6.7%)	2 (6.4%)	158 (17.2%)
Total	339	533	5	15	31	923

near distance between gate G1 and sector seven while other sectors have farther distances from it. Sectors six and three have the lowest percent of entering vehicles from gate G1.

The higher percent for the destination of the entering vehicles from gate G2 was occured in sectors one, two, and five which are (15.4%, 14.8% and 15.6%) respectively. Also sector seven has a high percent of (12.6%), moreover there is a long distance between sector seven and gate G2. From this point we can conclude that the arrival route of trip origin for the entering vehicles affects the selected gate in addition to the vehicles destination.

All the entering vehicles from gate G3, were destined to sector four which is the nearest one to this gate, also few vehicles entered from this gate. While, the higher percent of vehicles destination entered from gate G4 which is (60%) occured in sector nine because it is the nearest one to this gate. In addition, sector seven has a higher percent of vehicles destination which is (25.8%) of entering vehicles from gate G5.

The distribution of the entering vehicles in relation to the driver profession is illustrated in Table (4.5). The number of visitors and others which their destination unknown was equal to 146 vehicles. The results of a

parking survey which was made in 18/4/94 (Monday) during the times (10.00-12.00) a.m. to record the vehicles with or without stickers are shown in Table (4.6). The total university vehicles which have stickers are 650 (68.4%) while 300 (31.6%) of vehicles were without stickers which include visitors and temporary badges. The results obtained from the questionnaire surveys indicated that 670 (72.6%) faculty and staff were parked with stickers and only low number of temporary badges, and 253 (27.4%) are visitors parked without stickers. These results are compared to the previous results and found nearly equal in both cases. Finally, the results of parking survey for vehicles with or without stickers are used during the analysis for calculating the predicted demand in each sector. In addition Table (4.6) shows that sector four has a higher percent of parked vehicles without stickers which is 44.4 percent from the total parked vehicles in this sector. Moreover, this sector consists admission and registration offices, students affairs deanship, library, stadium and sport activity building.

Table (4.5): Distribution Of Vehicles Destinations At Main Campus In Relation To Driver Profession

Sector No.	Faculty and Staff	Visitors and Others	Total
1	92 (85.2%)	16 (14.8%)	108
2	94 (83.2%)	19 (16.8%)	113
3	45 (88.2%)	6 (11.8%)	51
4	48 (90.6%)	5 (9.4%)	53
5	111 (85.4%)	19 (14.6%)	130
6	24 (70.6%)	10 (29.4%)	34
7	124 (84.9%)	22 (15.1%)	146
8	70 (95.9%)	3 (4.1%)	73
9	50 (87.7%)	7 (12.3%)	57
Unknown	12 (7.6%)	146 (92.4%)	158
Total	670 (72.6%)	253 (27.4%)	923

Table (4.6): Distribution Of Parked Vehicles With And Without Stickers In Each Sector.

Sector No.	With Stickers	Without Stickers	Total Surveyed Sample
1	73 (61.9%)	45 (38.1%)	118
2	80 (73.4%)	29 (26.6%)	109
3	53 (74.6%)	18 (25.4%)	71
4	35 (55.6%)	28 (44.4%)	63
5	126 (69.2%)	56 (30.8%)	182
6	35 (67.3%)	17 (32.7%)	52
7	112 (67.5%)	54 (32.5%)	166
8	73 (76.8%)	22 (23.2%)	95
9	63 (67%)	31 (33%)	94
Total	650 (68.4%)	300 (31.6%)	950

4.3.2 Exiting Vehicles

There are 471 vehicles entered the university and stayed through the survey period without exiting which constitute 13.3% of total parked vehicles. The total exited vehicles are 3070 which represent 86.7% of total entering vehicles during the survey period since the total number of vehicles exiting from gate G1 was 1108 (36.1 %), and from gate G2 1844 (60.1 %), and from gates G3, G4 and G5 118 (3.8 %). Figure (4.7) illustrates the classification of exiting vehicles from each gate according to the type of vehicle. The peak hour of exiting vehicles were 470 vehicles occured between (16.00 to 17.00), since the last lecture in most departments at the university are between 16.00 to 17.00, and the end of campus workdays at (17.00). The maximum number of the exiting vehicles during 15 minutes were 188 vehicles between 16.45 to 17.00 as shown in Figure (4.8).

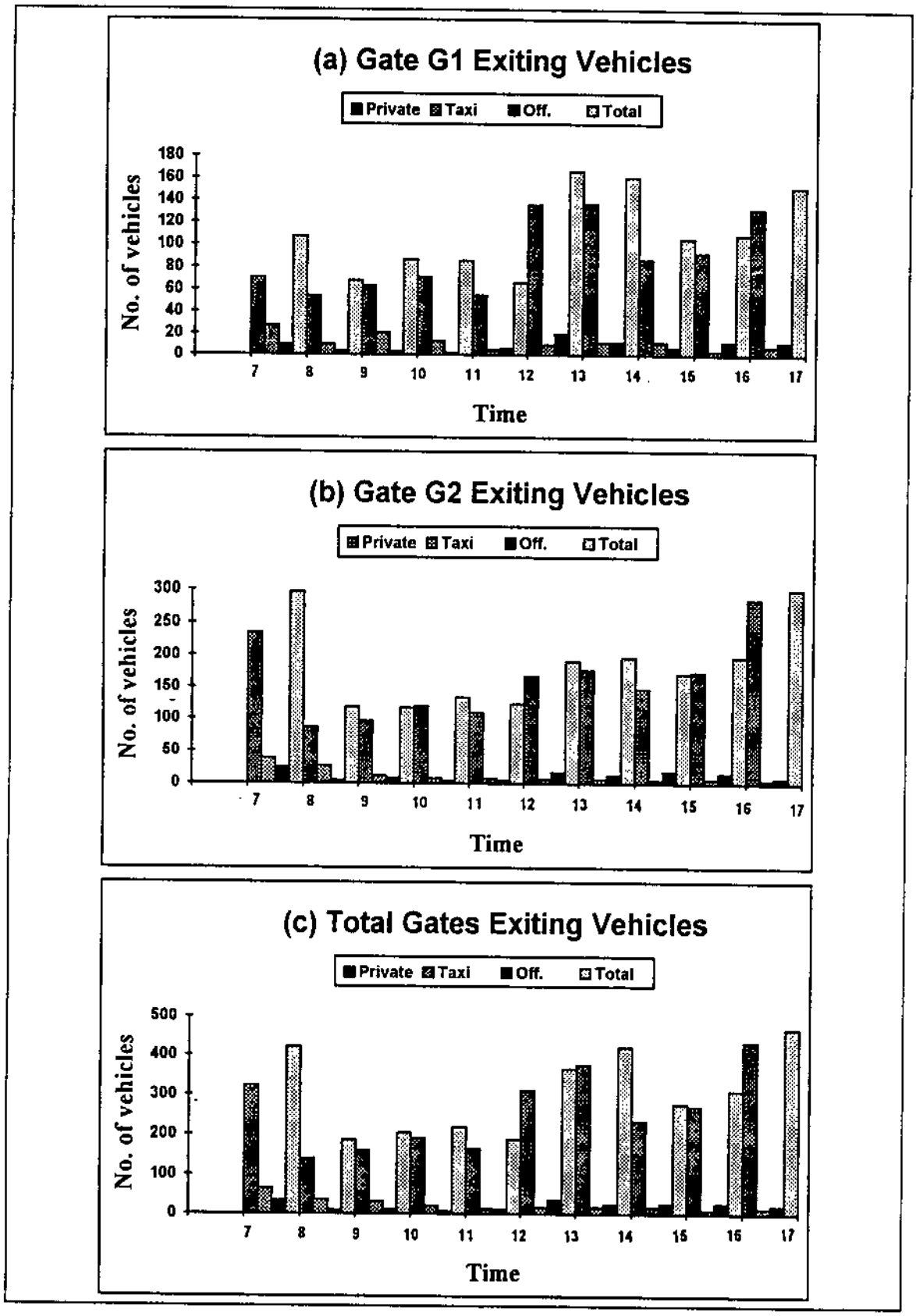


Figure (4.7): **Classification Of Vehicles Type Exiting The Main Campus Gates.**

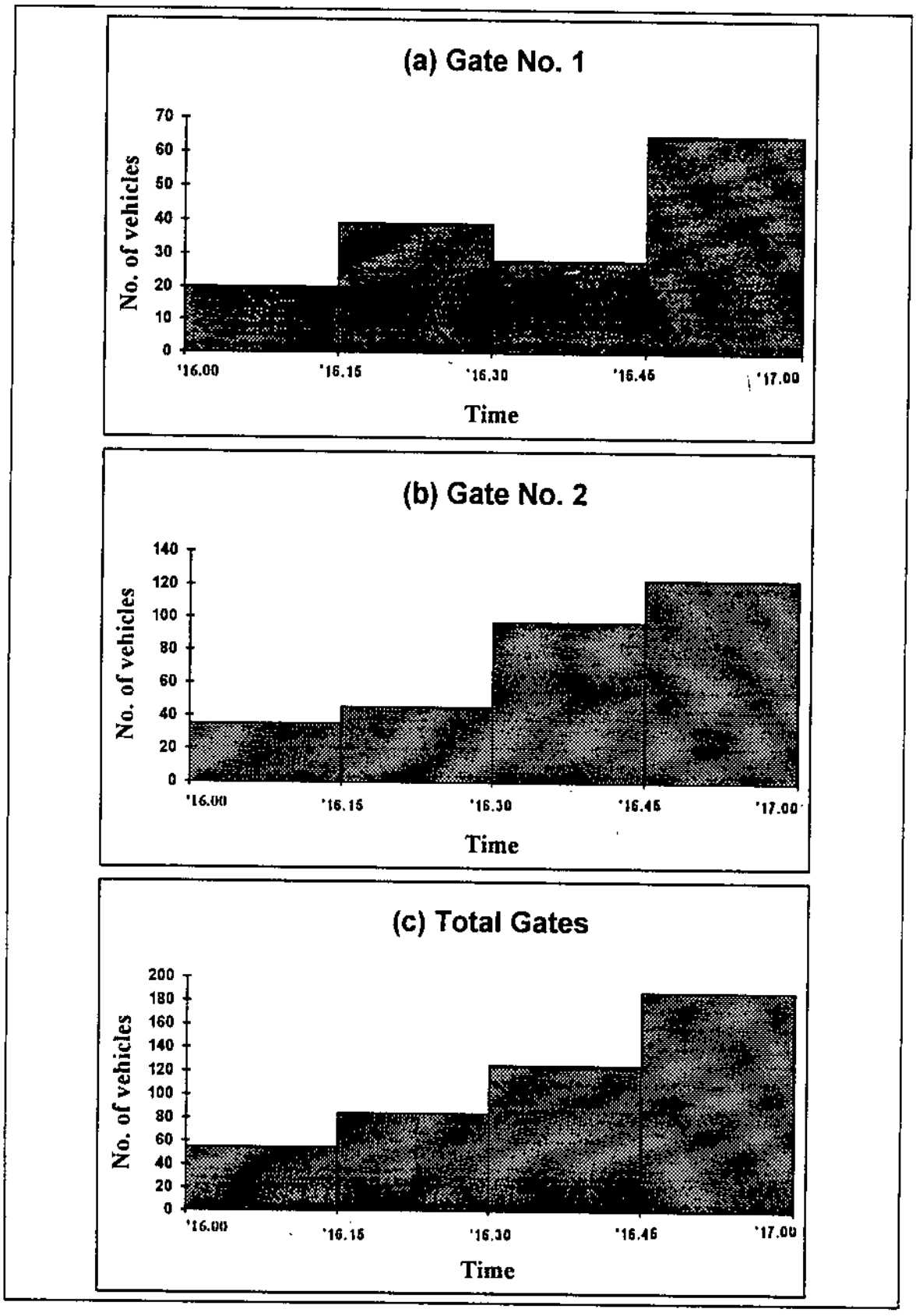


Figure (4.8): Peak Hourly Distribution Of The Exiting Vehicles From The Main Campus Gates

4.3.3 Vehicles Accumulation

Time patterns for vehicles accumulation have been developed by using their arrivals and departures times to and from the campus. The accumulation between the entering and exiting vehicles at main gates is illustrated in Figure (4.9). The difference of these two values yields the number of parked and circulating vehicles as shown in Figure (4.10). The maximum difference at gates G1, G2 and total campus gates were 461 vehicles between (14.00-15.00), 396 vehicles between (9.00-10.00) and 915 vehicles between (11.00-12.00) respectively.

4.4 CAMPUS AND STUDENTS PARKING CHARACHTERISTICS

Trip purpose, parking accumulation, parking duration, walking distance, and parking turnover, present the best and efficient elements to identify the parking characteristics. Therefore, these elements are calculated from the data collected in the questionnaire forms, and from the parking surveys. The results of the characteristics will be presented in the following sections:

4.4.1 Trip Purpose

The basic campus trips are generally: Work trips, school trips, and all other trips. The trips conducted by the campus faculty and staff members are considered work trips, students make school trips, while trips conducted by visitors and other users are termed other trips.

The dominant purpose of the trip for drivers entering the campus has an important bearing upon their choice of existing parking facilities and its location, design and operation of future parking facilities.

From the questionnaire survey the percentage of total daily work trips which parked their vehicles inside the university campus was 72.6 percent while the percentage of other daily trips are 27.4 percent.

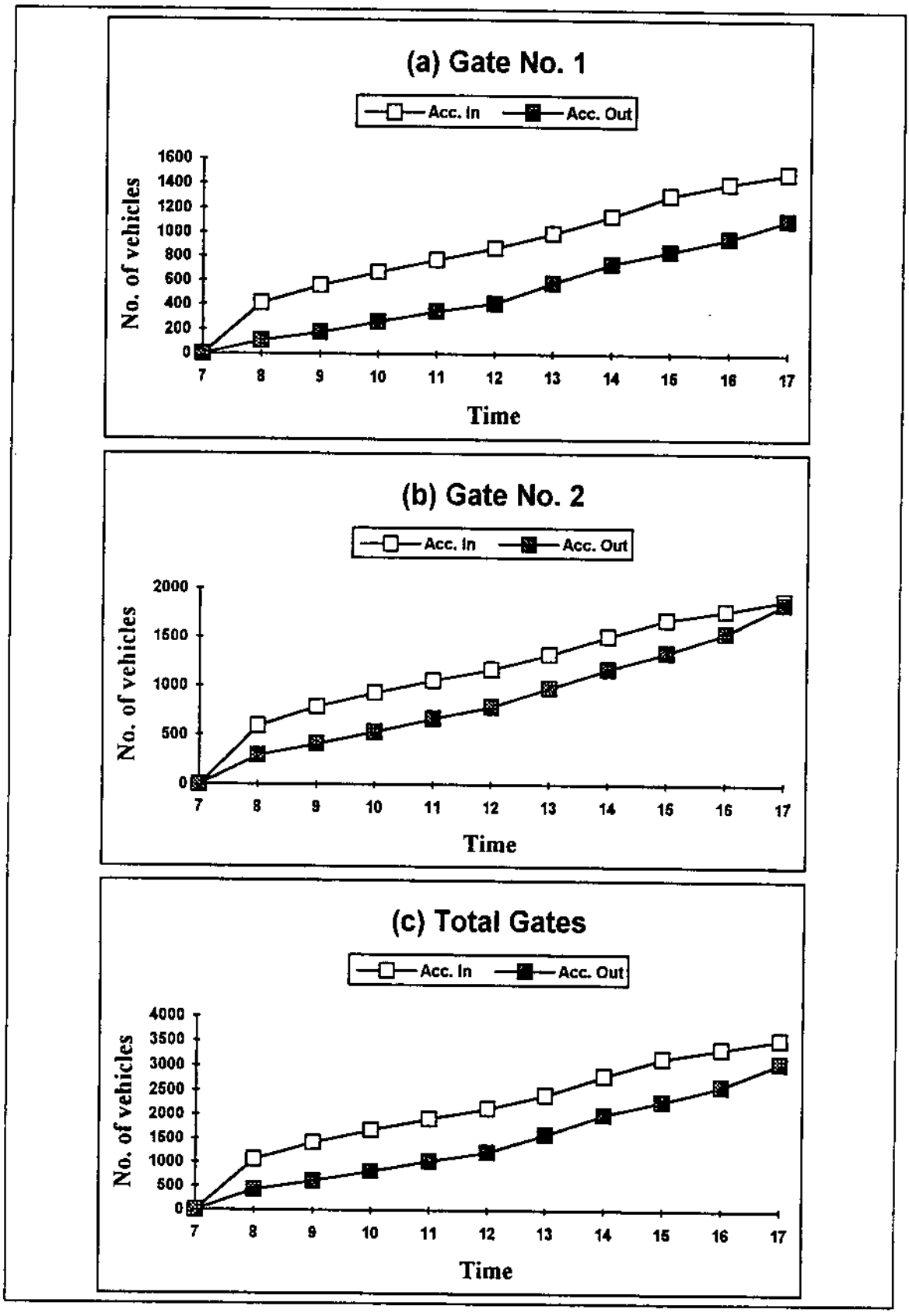


Figure (4.9): Total Vehicles Accumulation At The Main Campus Observed At Main Gates

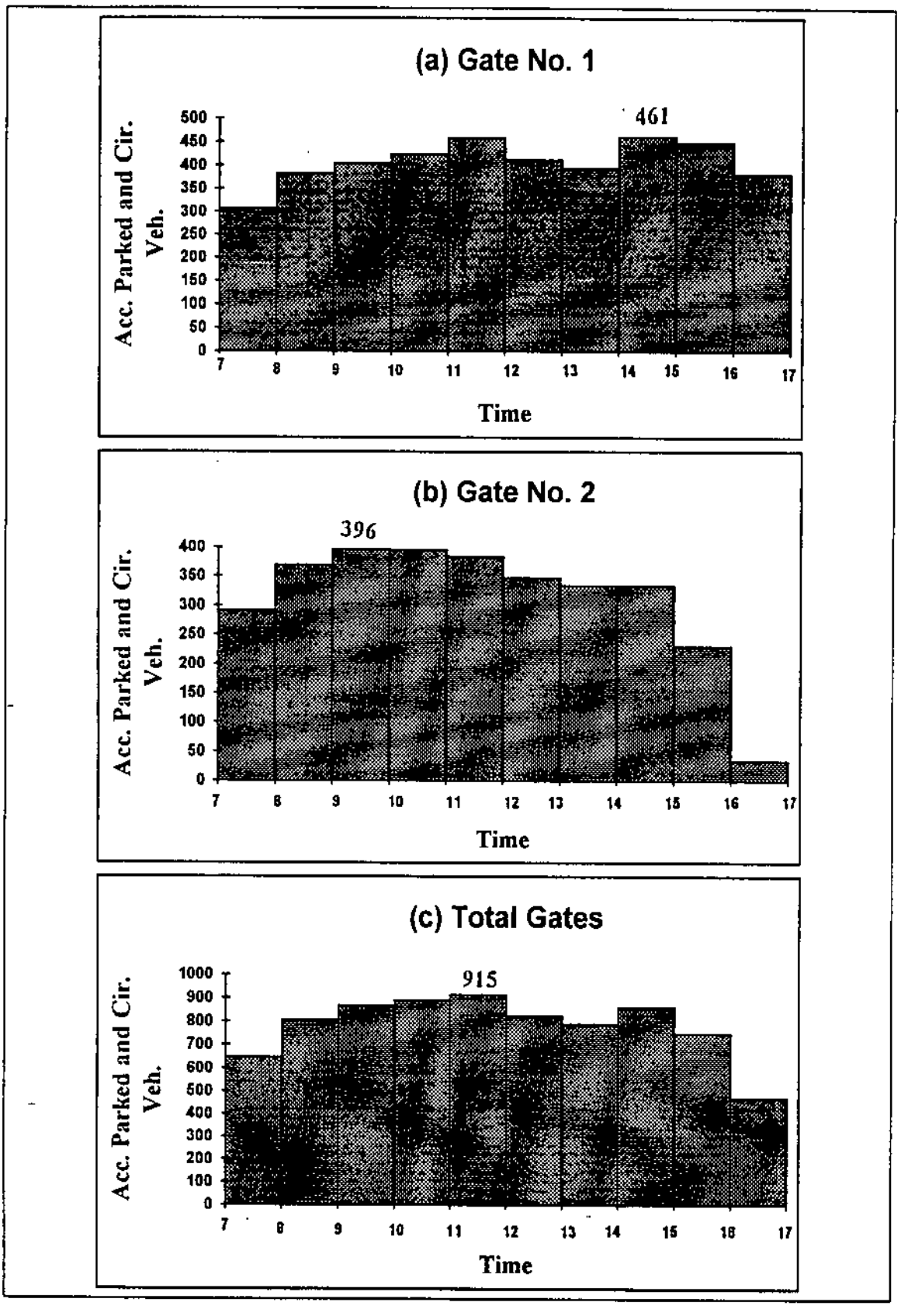


Figure (4.10): Accumulation Of Parked and circulating vehicles at University Campus Gates.

While the trip purpose of parked vehicles in all students parking areas are considered school trips except parking number seven which including "other" trips of 58.3 percent of total parked vehicles in this parking area because its location near to the consultation center and university administration. Finally, the percentage of school trips in all students parking areas at the university was 87.7% percent of total parked vehicles while the percentage of "other" trips was 12.3 percent.

4.4.2 Parking Accumulation

The campus parking accumulation entering the main gates was illustrated in Figure (4.9) and discussed in section 4.3.3. The maximum parking accumulation at each parking area is equal to the maximum number of parked vehicles observed during a given time interval (usually one hour). The following sections will discuss the parking accumulation for the faculty and staff parking areas, students parking areas and the whole university.

4.4.2.1 Parking Accumulation For Faculty And Staff

Parking accumulations were surveyed at all campus parking areas during typical weekdays from 7:00 to 17:00. There were 30 parking areas (25 parking lots and 5 curb parking) where the capacity of each parking area was more than 15 parking spaces, other parking areas were omitted and their demands were added to the nearest parking area. The locations of the parking areas in each sector at the University of Jordan are illustrated in Figure (4.11). The abbreviation (e.g. P1-1) of each parking lot means that the first number (P1) is the sector number while the second number(1) means the number of the parking area in the sector. The parking accumulation and the capacity of the major parking areas in sector one and other sectors are shown in Figure (4.12) and Appendix B respectively. This figures show the hourly variation of accumulated parking demands compared to the effective capacity of each parking area in each sector during Mondays and Tuesdays which showed approximatelly similar hourly

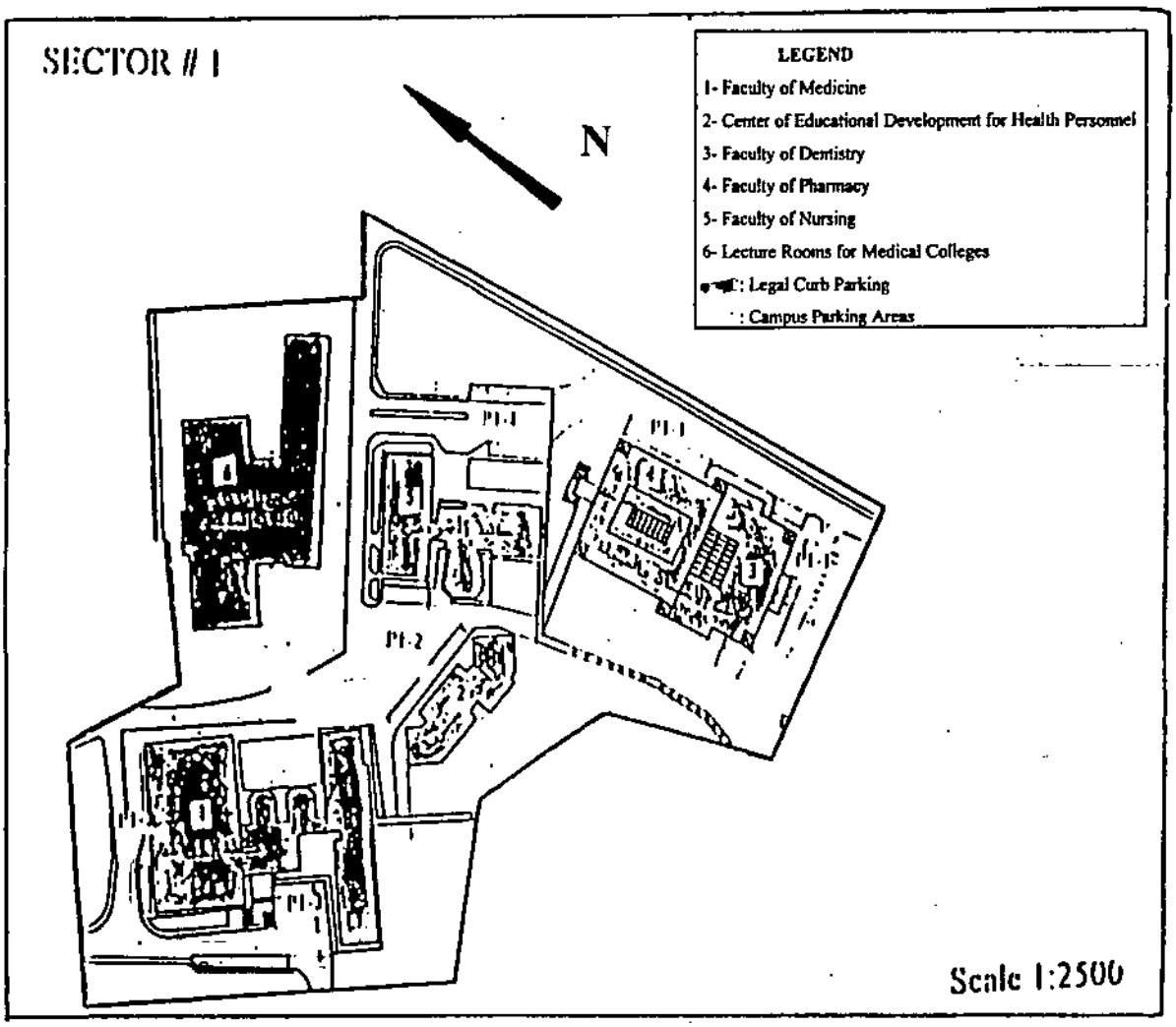
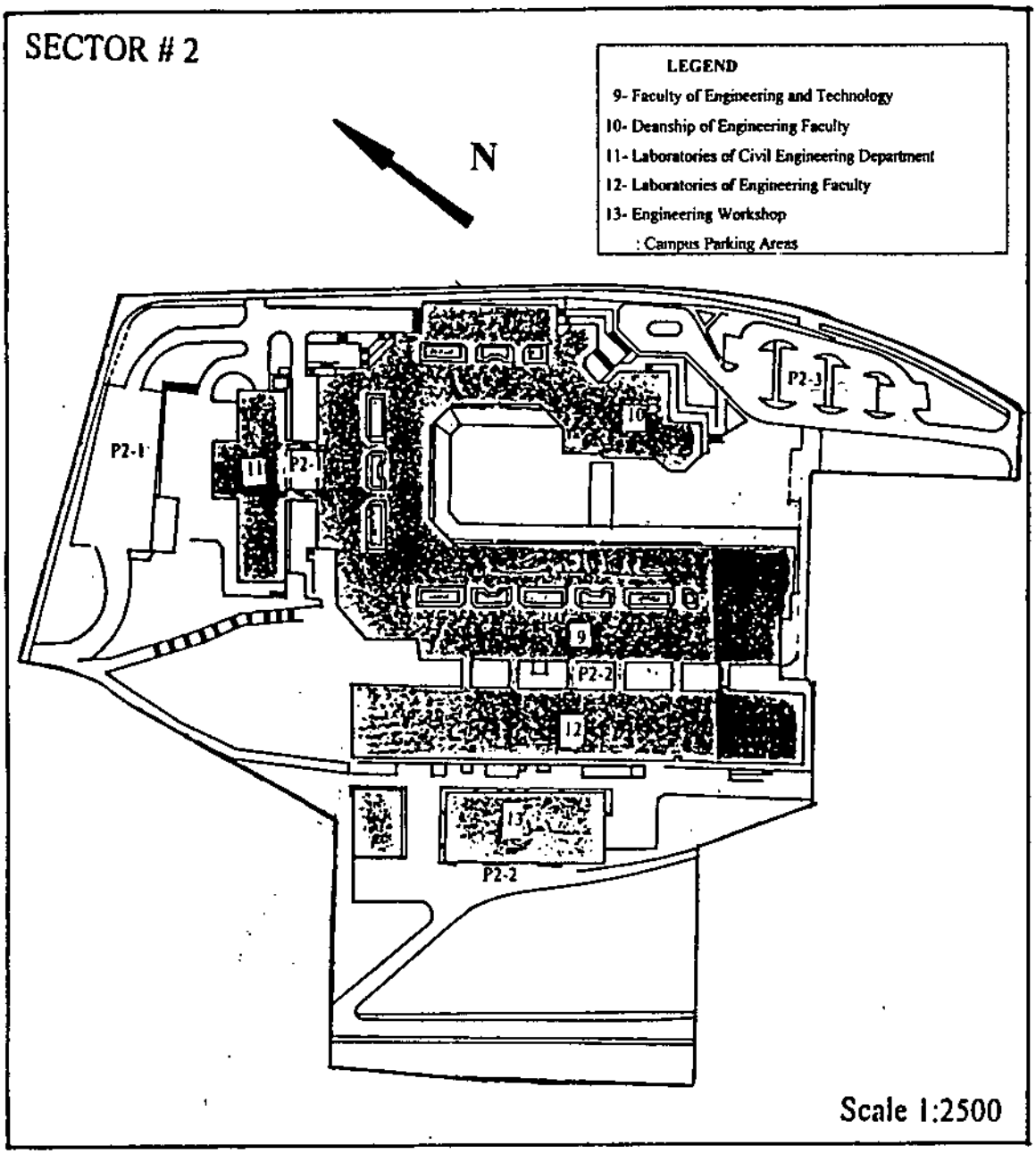


Figure (4.11): Location of Parking Areas In Each Sector of The University of Jordan



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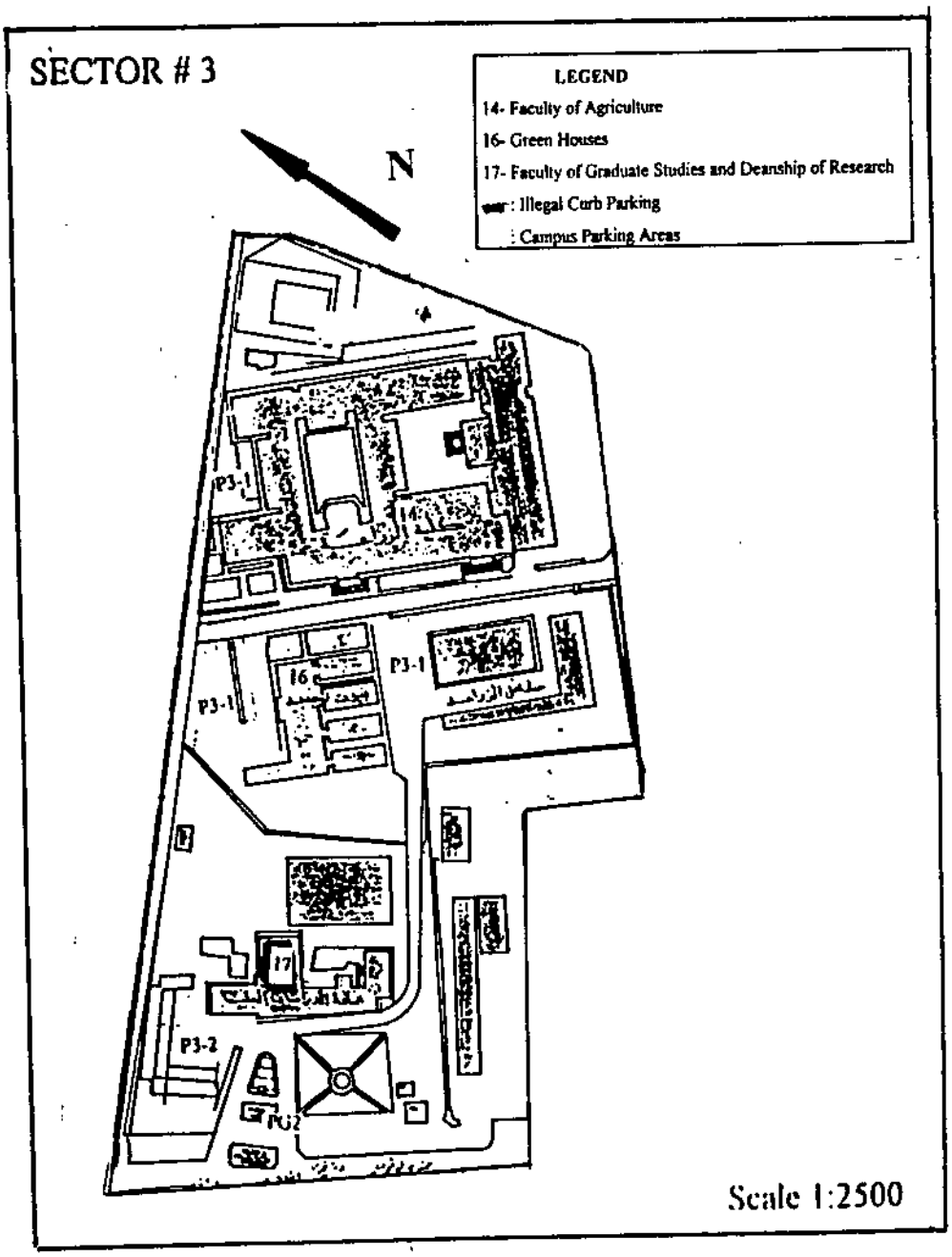

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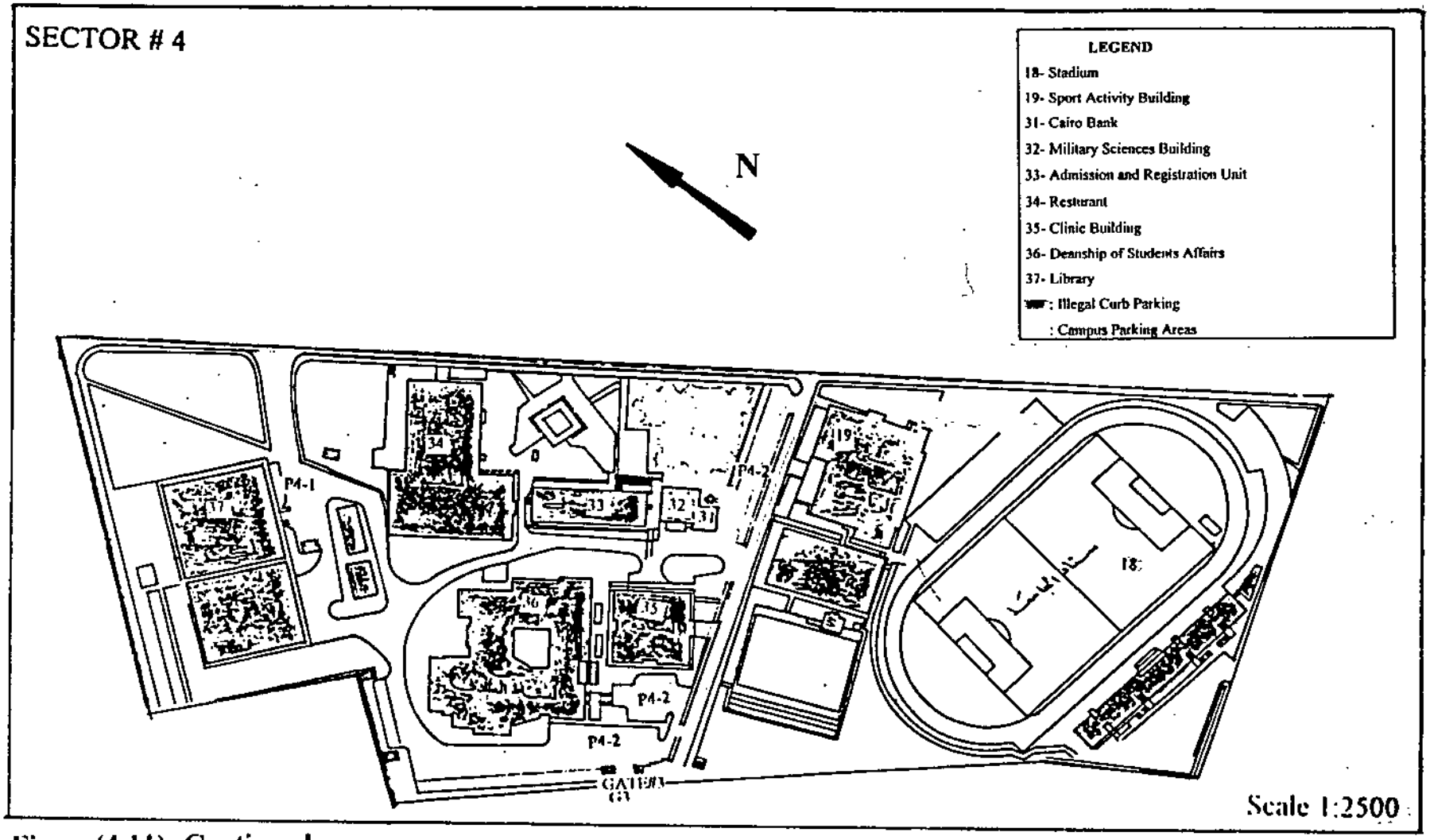

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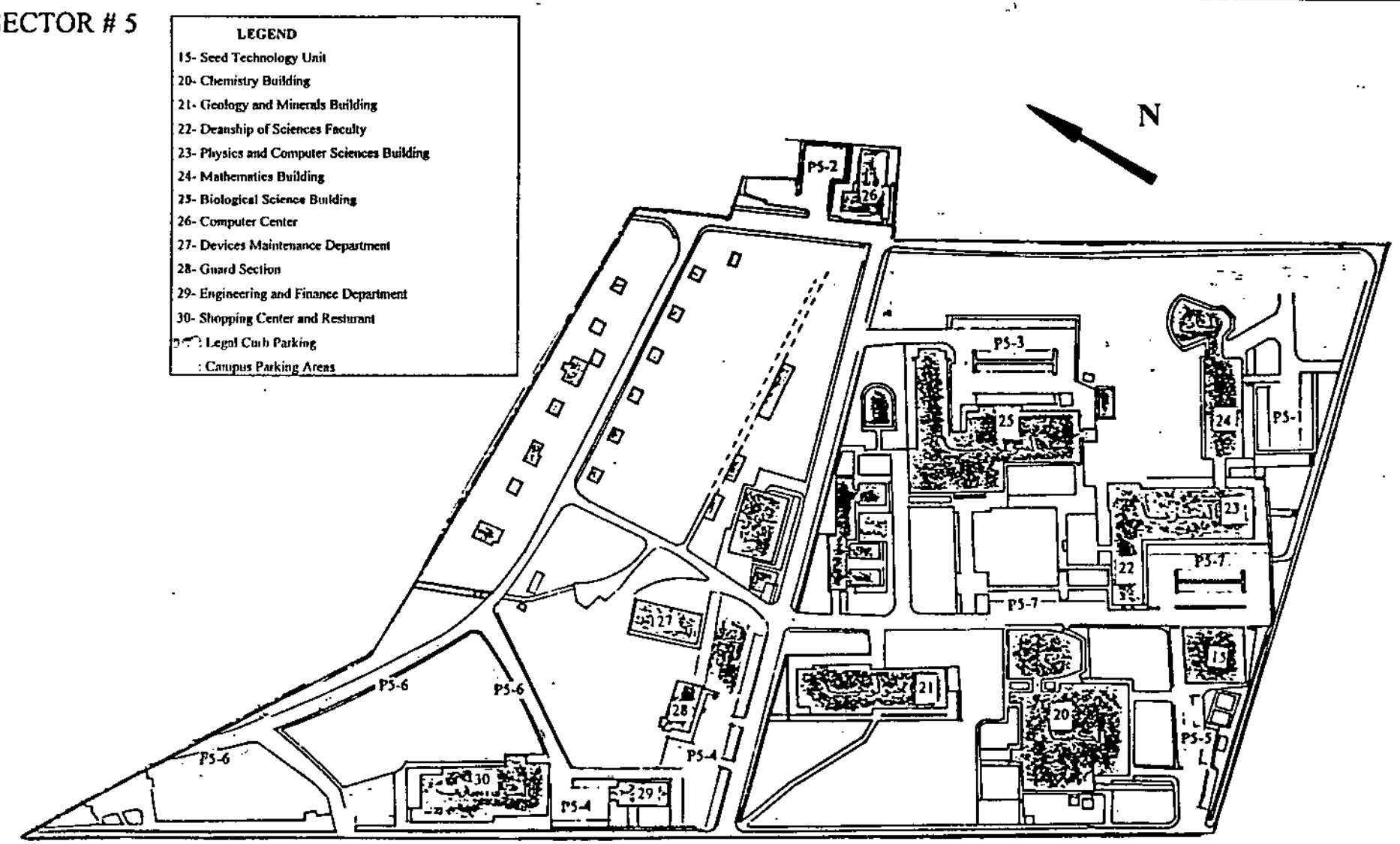
SECTOR # 5



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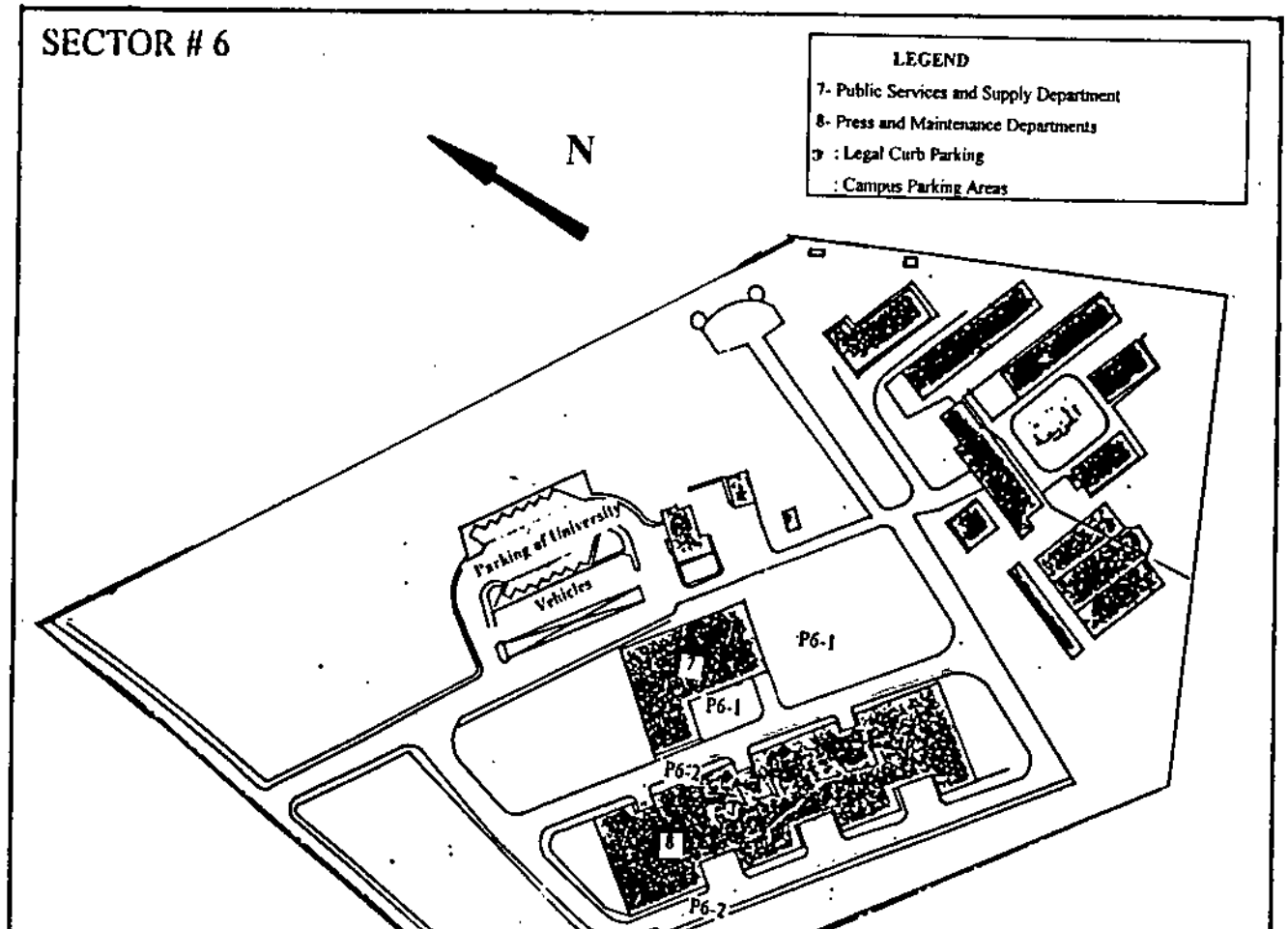

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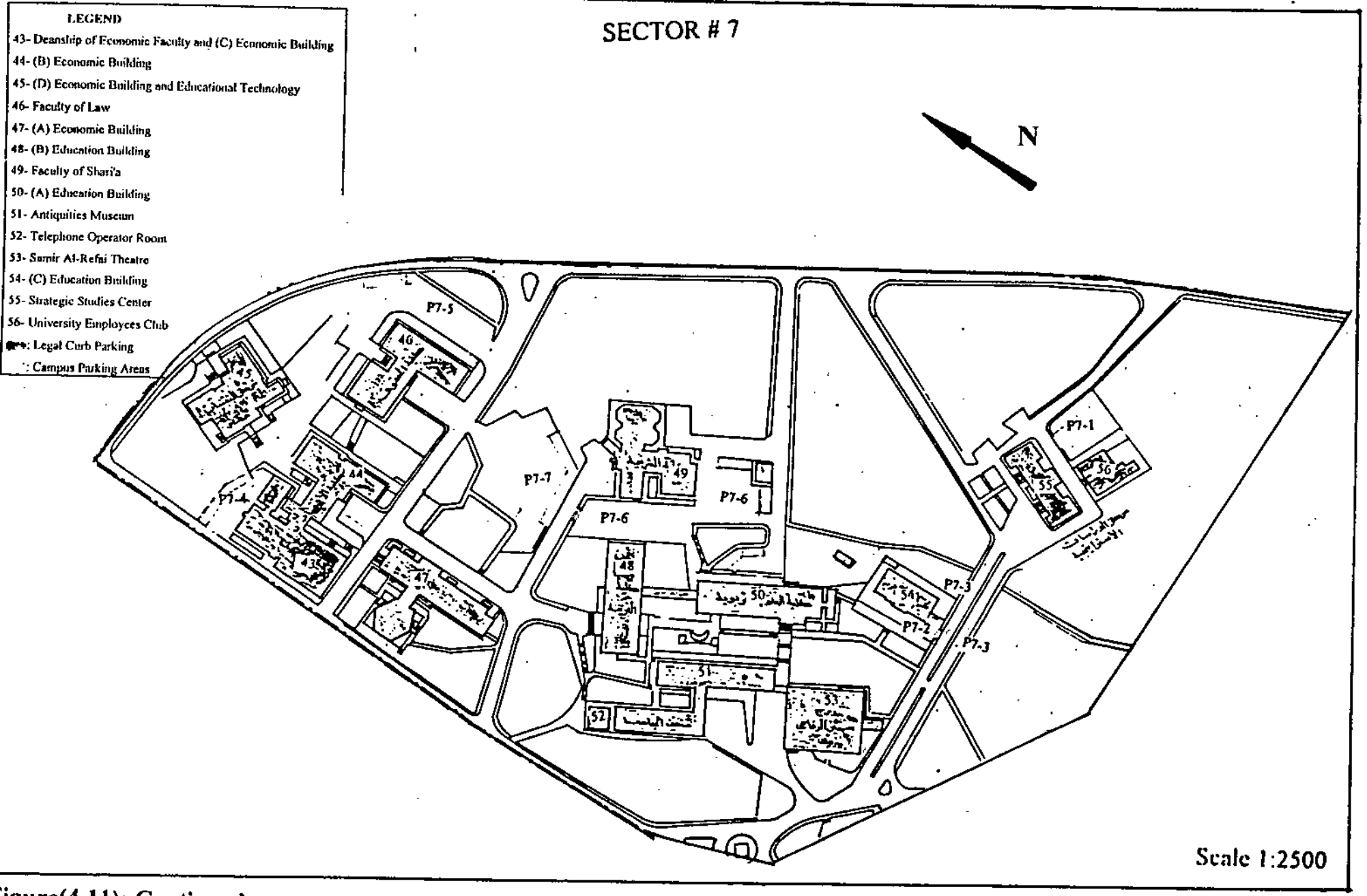

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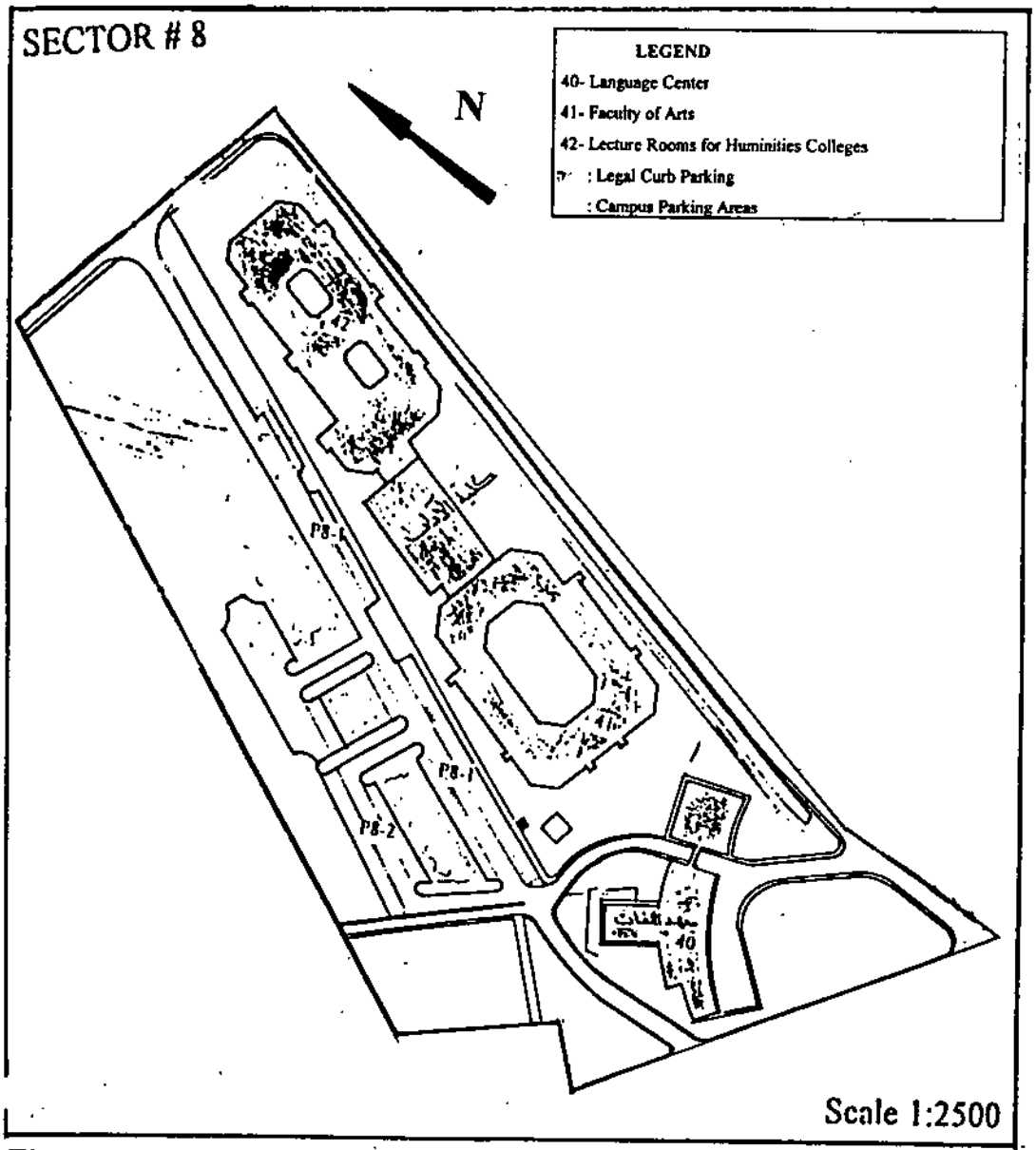

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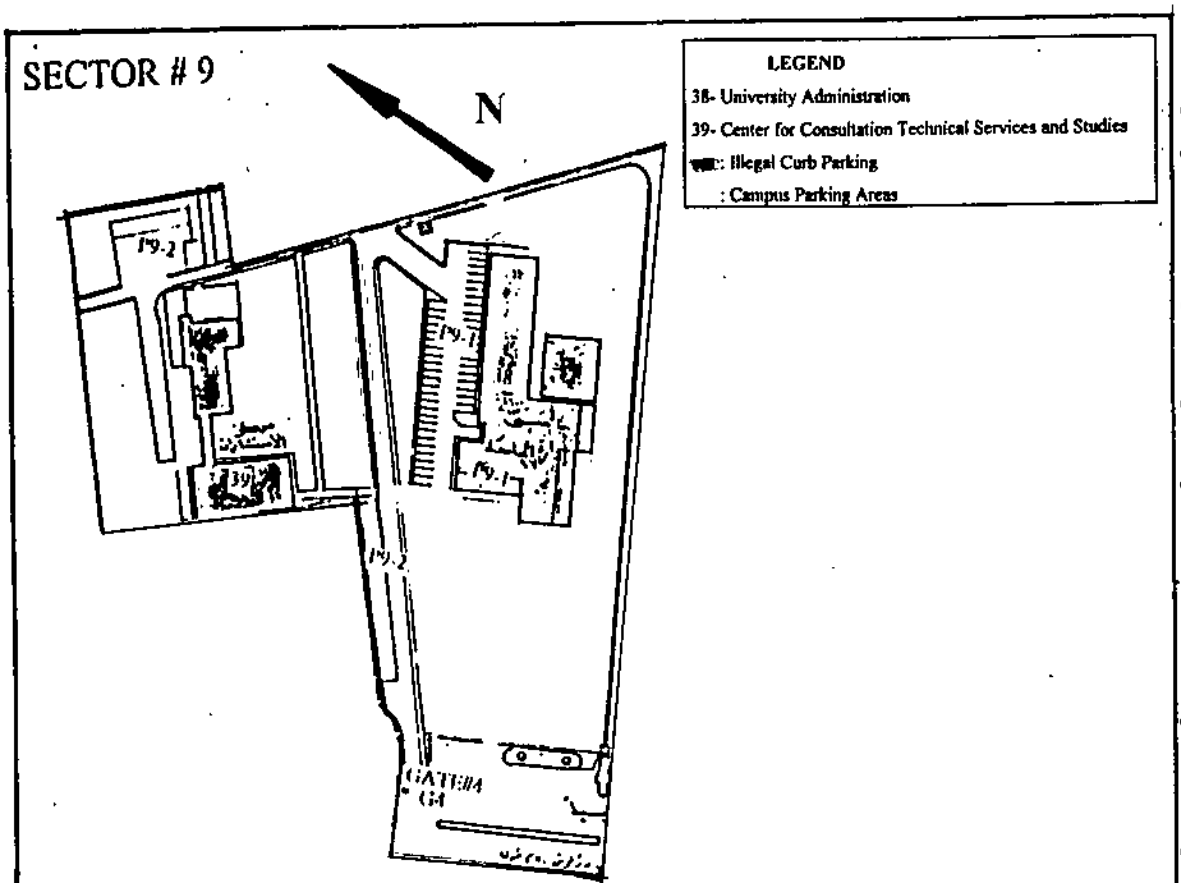


Figure(4.11): Continued

variation of parking demand with slight increase during mondays. Therefore, Monday was selected for the caculation of existing and predicted parking demands. The effective capacity is equal to the existing capacity multiplying by the factors (0.85) for parking lots and parking garages and (0.9) for curb parking,(37).

The parking demand in sector one exceeded the effective capacity at the parking area (P1-2) between the time (9:00-14:00), while the parking demand of other parking areas (P1-1 and P1-3) did not reach the effective capacity. Moreover, some of the parkers of this sector were parked their vehicles at the parking area of university hospital.

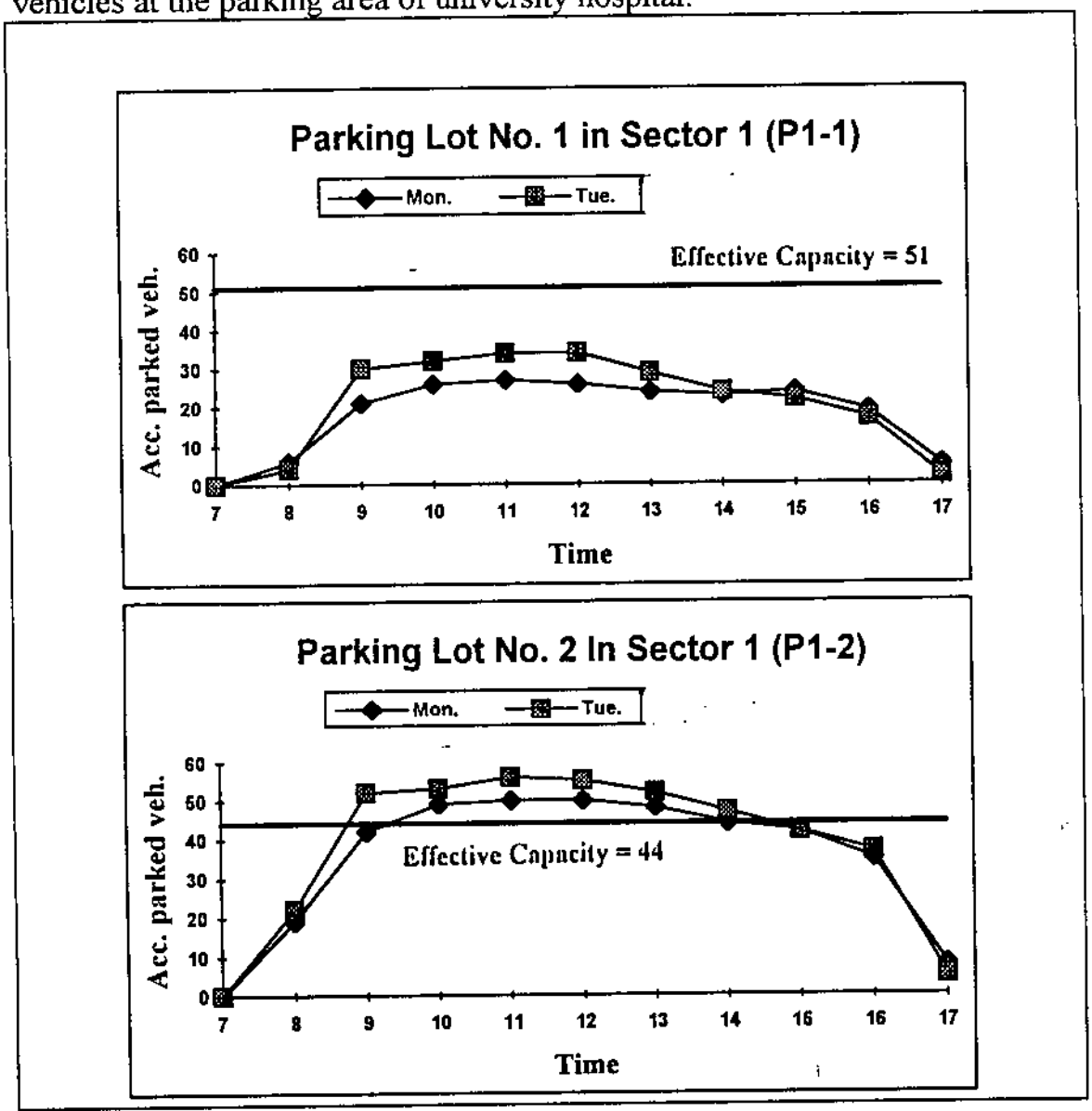


Figure (4.12): Typical Acuunulation Of Parked Vehicles in Sector One

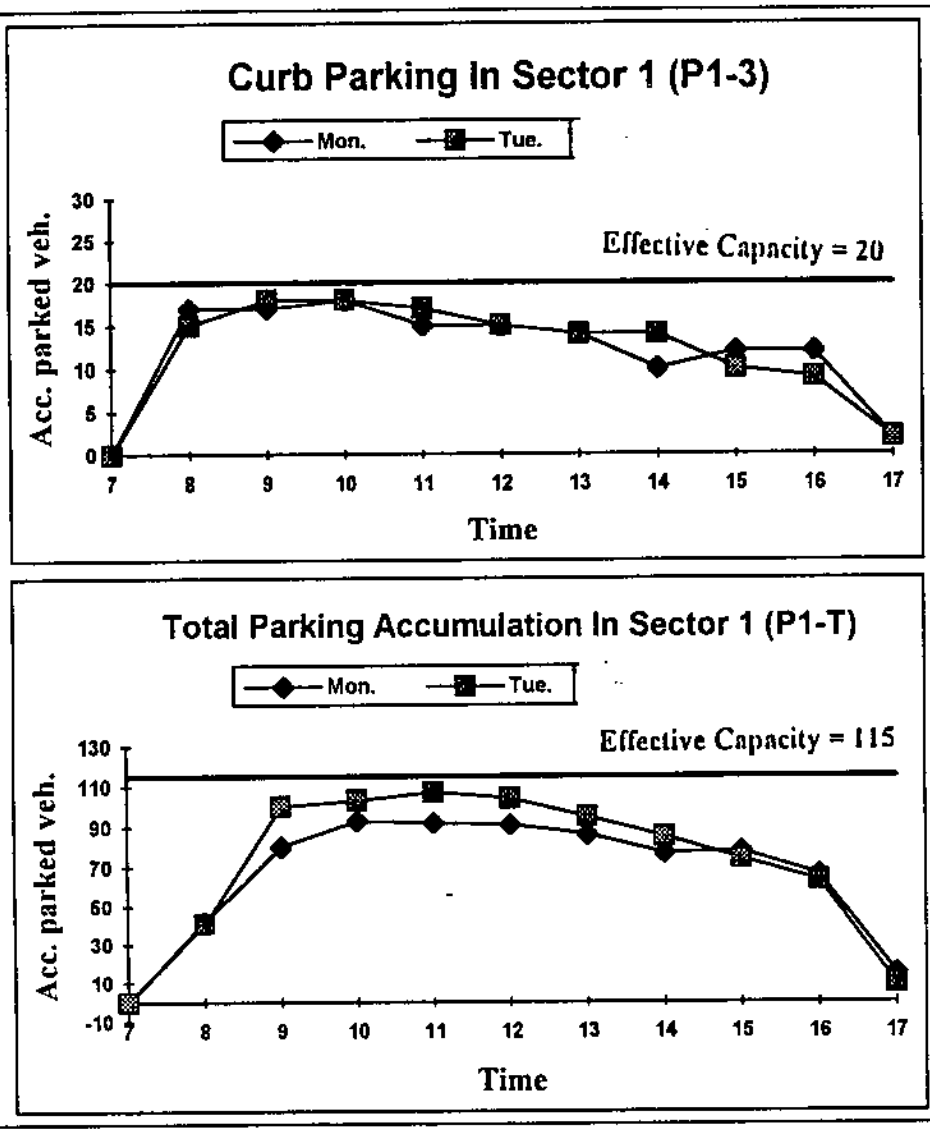


Figure (4.12): Continued

The parking demand of parking area (P2-3) in sector two exceeded the effective capacity between the time (10:00-12:00)a.m.. Other parking areas for the same sector (P2-1 and P2-2); their parking demand was less than the effective capacity. In the parking area (P2-1) was consisted of two locations, one of them was the parking of civil engineering department, and the other one was at the lower level of civil of engineering department. All of the vehicles were parked in the parking area of civil engineering, while the other one had not parked vehicles because of uncomfortable parking location and uncomfortable way to the entered gates of the faculty of

engineering and technology. The entrance and exit of the parking area (P2-3) is near to the intersection which was made a dangerous point.

The parking demand of parking areas (P3-1 and P3-2) in sector three did not exceed the effective capacity. Some of the parkers were parked their vehicles along the street of illegal curb parking between the faculty of agriculture and chemistry building especially during the summer because of the high trees which protects the vehicles from the sun ray. One of the exit and entrance of P3-1 was located at the intersection directly.

In addition the parking demand did not exceed the effective capacity of the parking areas (P4-1 and P4-2) in sector four.

Some of the parking areas in sector five; their parking demand exceeded the efective capacity as P5-1 and P5-4 while other parking locations as P5-2, P5-3, P5-5, P5-6 and P5-7, their parking demand was less than the effective capacity. One of the exit and entrance of P5-4 was located at the intersection directlty.

In sector six; the parking demand of all parking areas (P6-1 and P6-2) was less than the effective capacity. In addition the parking area of (102) university vehicles is located in this sector with (44) spaces and (14) space for buses parking which was not considered during the parking survey because of continous moving through and out of the university.

The parking demand exceeded the effective capacity of the parking areas (P7-2, P7-3, P7-4 and P7-7) in sector seven, while the other parking areas (P7-1, P7-5 and P7-6); their parking demand was less than the effective capacity.

The parking demand of the curb parking (P8-1) exceeded the effective capacity in sector eight while the parking demand of the parking lot (P8-2) was less than the effective capacity. Moreover, most of the parkers were parked their vehicles at the curb parking (P8-1).

Finally, the parking demand of the parking area (P9-1) in sector nine exceeded the effective capacity. In the parking area (P9-2), their parking demand was less than the effective capacity.

The study found that the total number of accumulated parked vehicles in all university sectors has increased after 8:00 a.m., but decreased between (13:00-14:00) during lunch break followed by a slight increase then tend to decrease at the end of the workday as shown in Figure (4.13). In addition this figure shows the percent of total capacity of accumulated parked vehicles where the maximum degree of utilization of all parking areas in the university sectors during the peak hour between (10:00-11:00) was equal 72.5 percent.

4.4.2.2 Parking Accumulation For Students and Whole University

There are two illegal curb parking (P2 and P3) and one legal curb parking (P1) of 110 capacity as illustrated in Figure (3.2). In addition there are five parking areas (P5, P6, P7, P8 and P9) of 979 parking spaces which include one parking garage (P8) of 496 parking spaces.

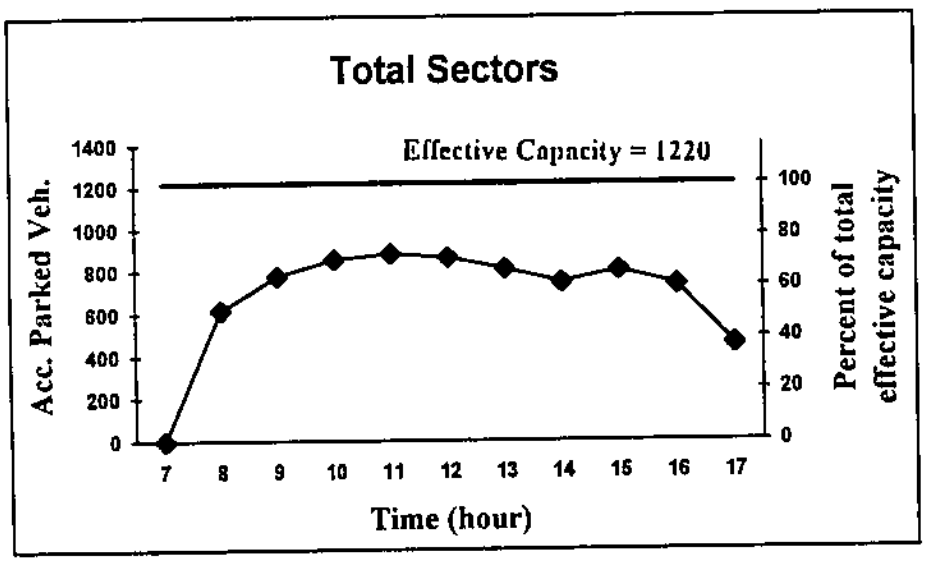


Figure (4.13): Comparison Between Accumulated Parking Demand And Of Total effective Capacity At All University Sectors.

The total accumulation resulted from the difference between entering and existing parked vehicles for the five parking areas (P5, P6, P7, P8 and P9) and the total of these parking areas (P10) are shown in Figure (4.14). The difference between the cumulative entering and existing vehicles to the university is the total accumulated parked vehicles at the university campus as presented in Figure (4.15). The parking demand exceeded the effective capacity for all of the parking lots (P5, P6, P7 and P9), while the parking garage (P8); their parking demand was less than the effective capacity, also the capacity of last level did not include which was equal 108 parking spaces. In addition the parking demand of the total five parking areas (P10) exceeded the effective capacity during Mondays.

The total accumulated parked vehicles for the legal curb parking (P1), illegal curb parking (P2 and P3) and the total of these parking locations (P4) are shown in Figure (4.16). The parking demand of P1 exceeded the effective capacity.

Figure (4.17) shows the accumulation of total parked vehicles of all students parking areas, and the percentage of their total capacity. The Figure shows that the degree of utilization (120 percent) exceeds the effective capacity during the peak hour between (10:00-11:00) on Mondays.

In general, the students parking areas; their accumulation of total parked vehicles increased after 8:00 a.m. then slightly decreased between 11:00 a.m. and 13:00, then decreased sharply after 13:00 because most of the undergraduate student lectures are scheduled in the morning while the laboratories scheduled mostly after 14:00. The postgraduate students lectures was scheduled mostly after 14:00. However, their number constitute 13:0 percent of total university students.

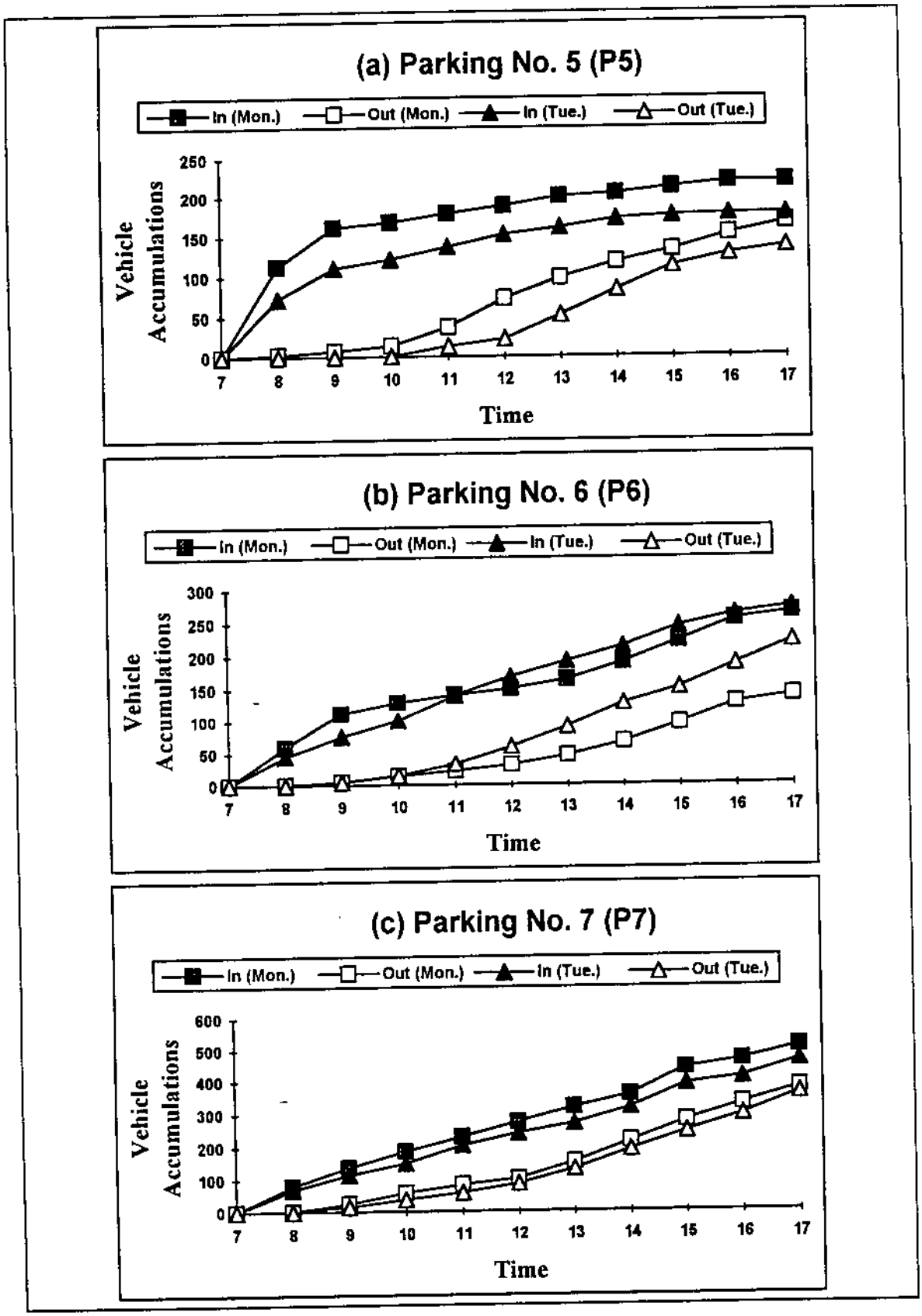
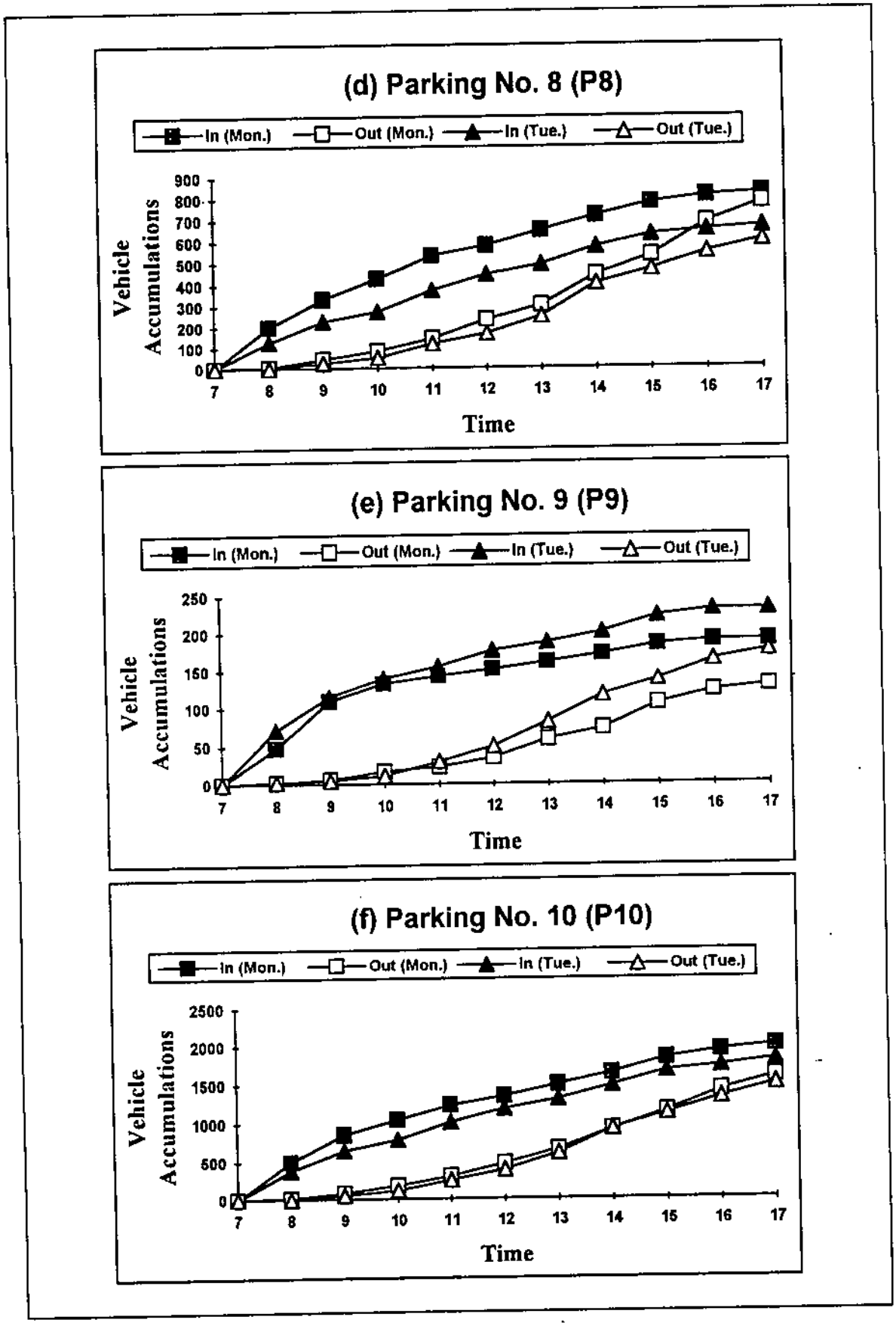


Figure (4.14): The Distribution Of Entering And Exiting Vehicles For Students Parking Areas



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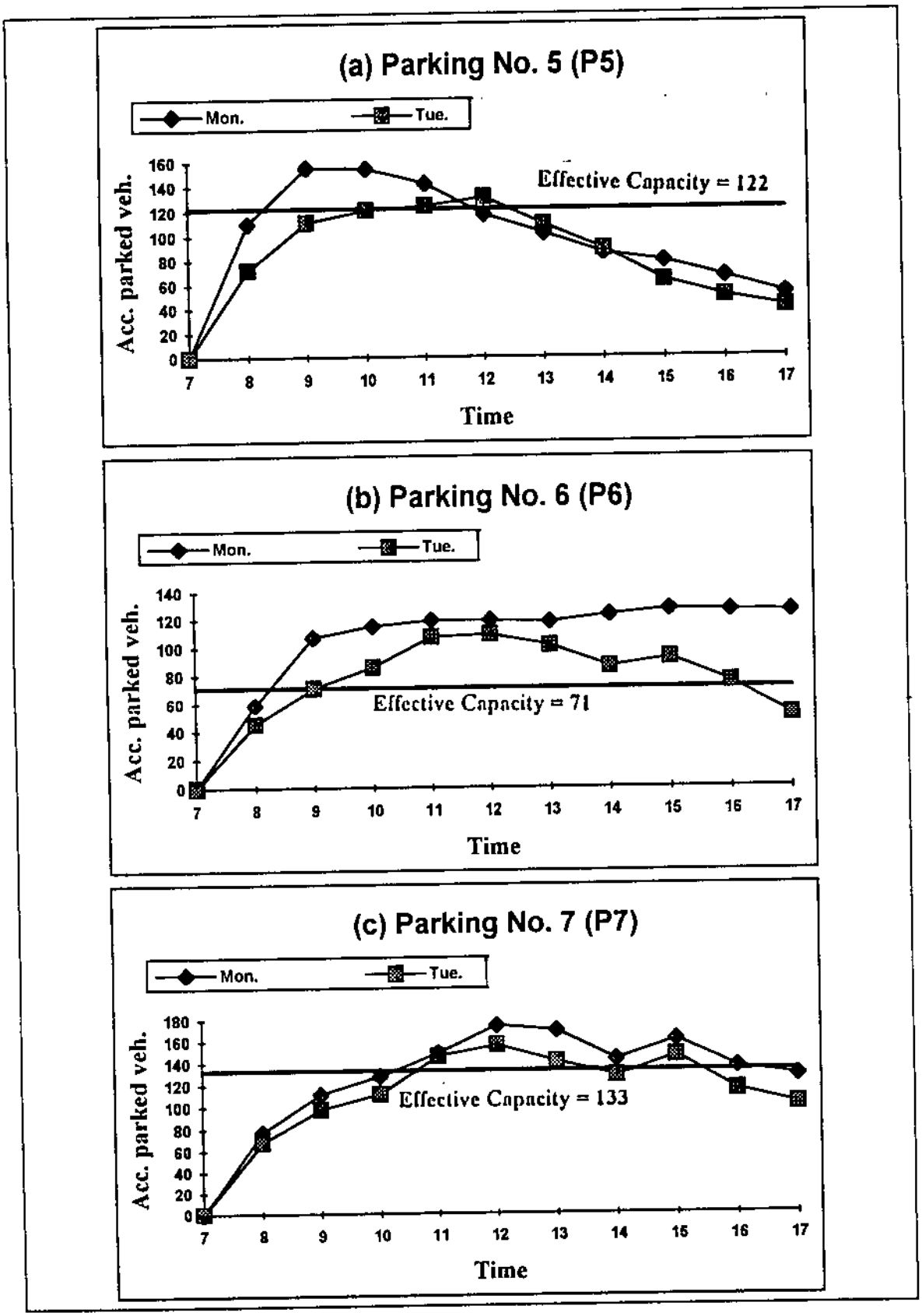
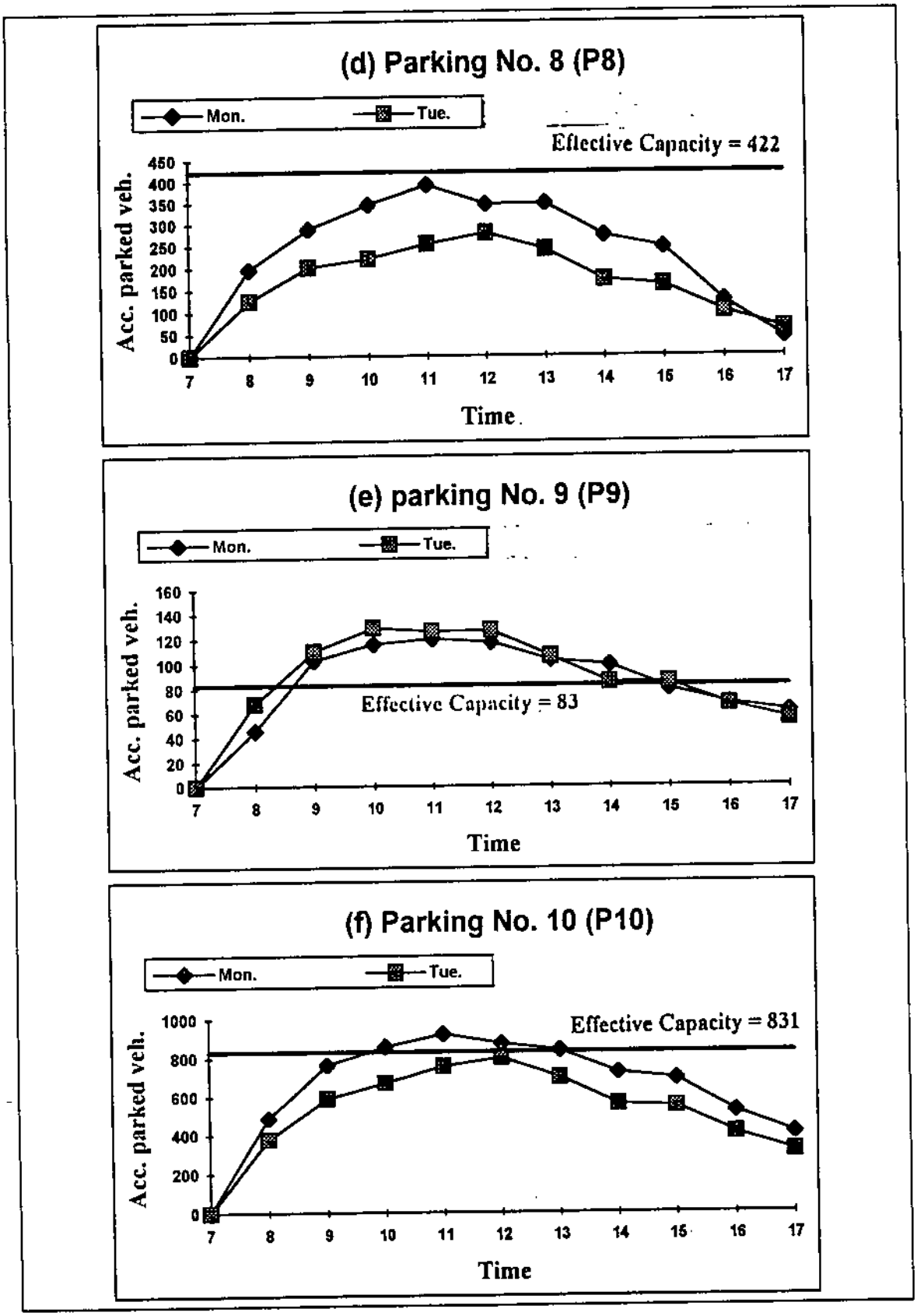


Figure (4.15): The Parking Accumulation Of Students Parking Areas



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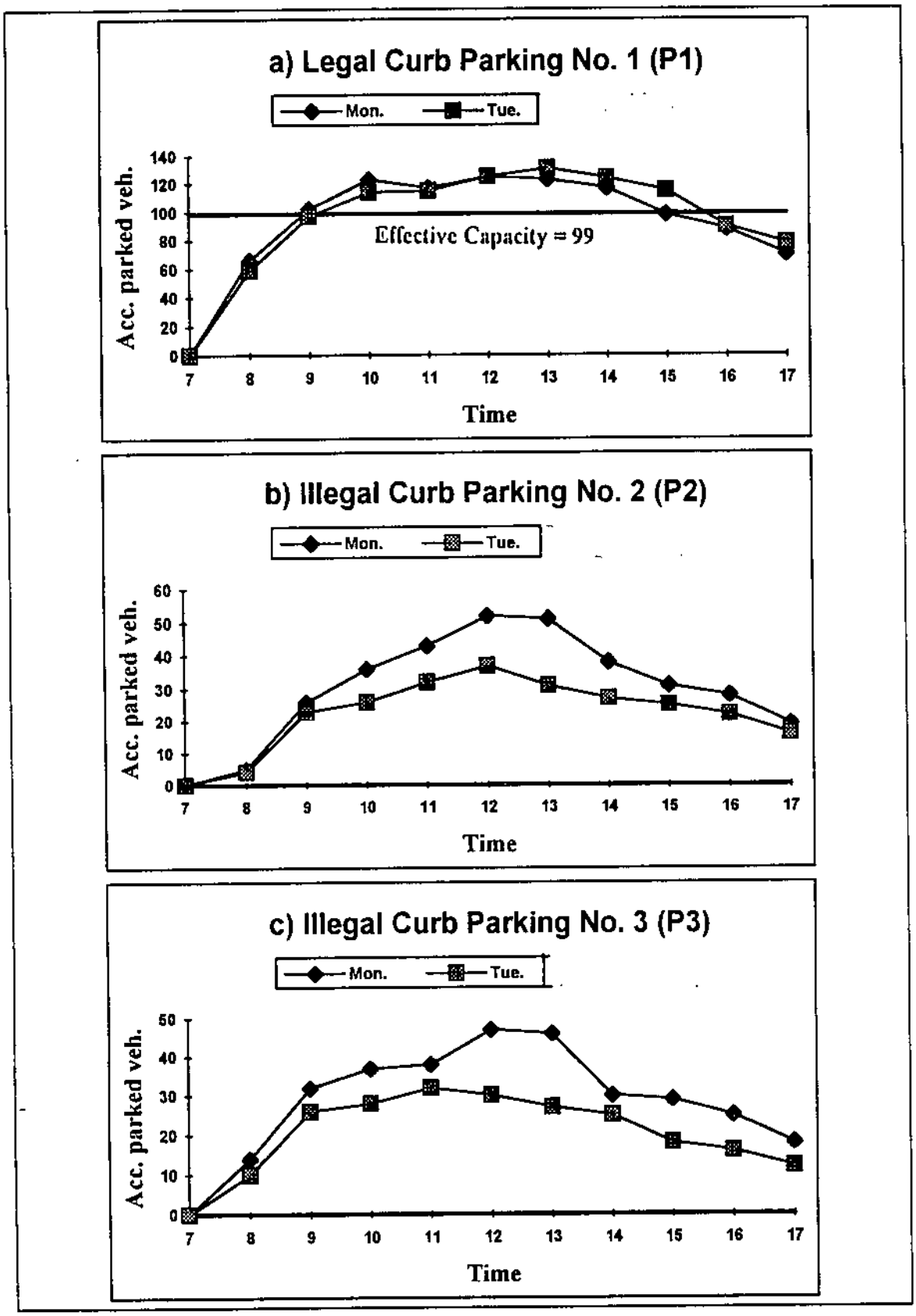
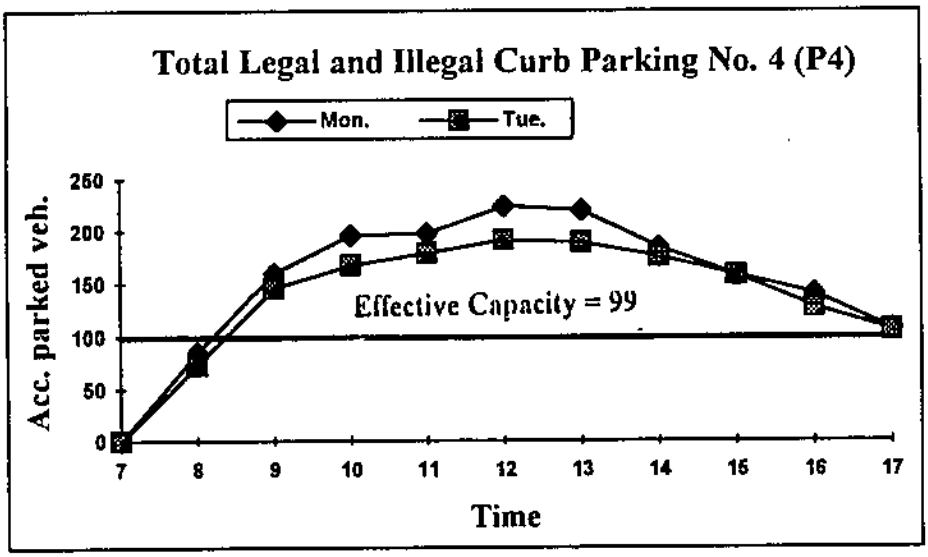


Figure (4.16): The Parking Accumulation Of Legal And Illegal Curb Parking Of Students Parking Areas



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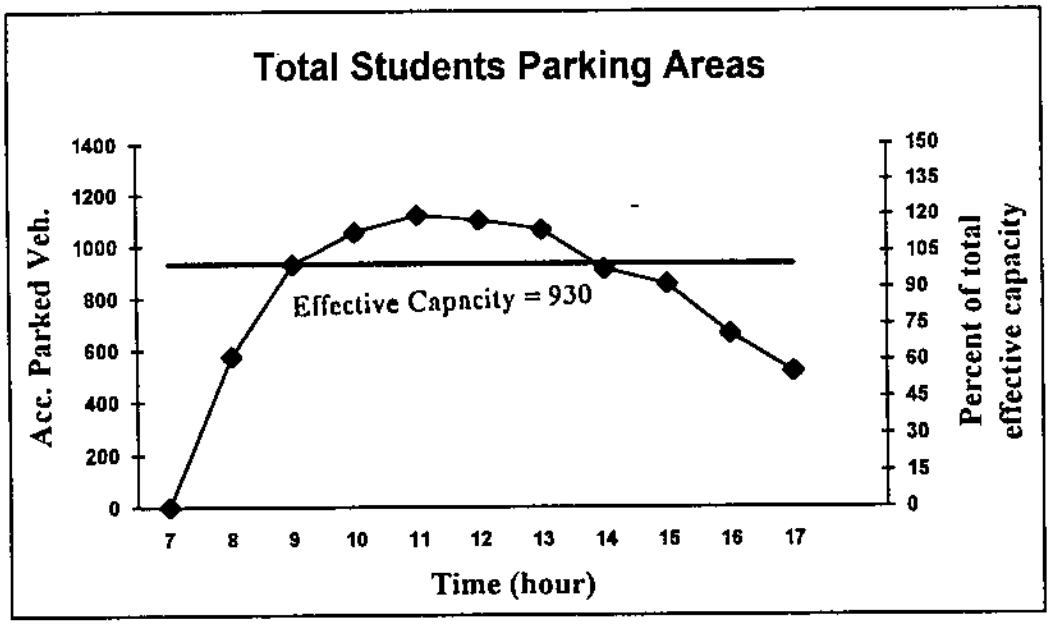


Figure (4.17): The Parking Accumulation And The Percent of Total Effective Capacity For Total Student Parked Vehicles

The parking demand for the total university parking areas for faculty, staff, students and visitors was less than its effective capacity with a degree of utilization of 93.2 percent during the peak hour between (10.00-11.00) a.m.. The trend decreased after the peak hour as shown in Figure (4.18).

This Figure also illustrate the percent of effective capacity utilized by the accumulated parked vehicles.

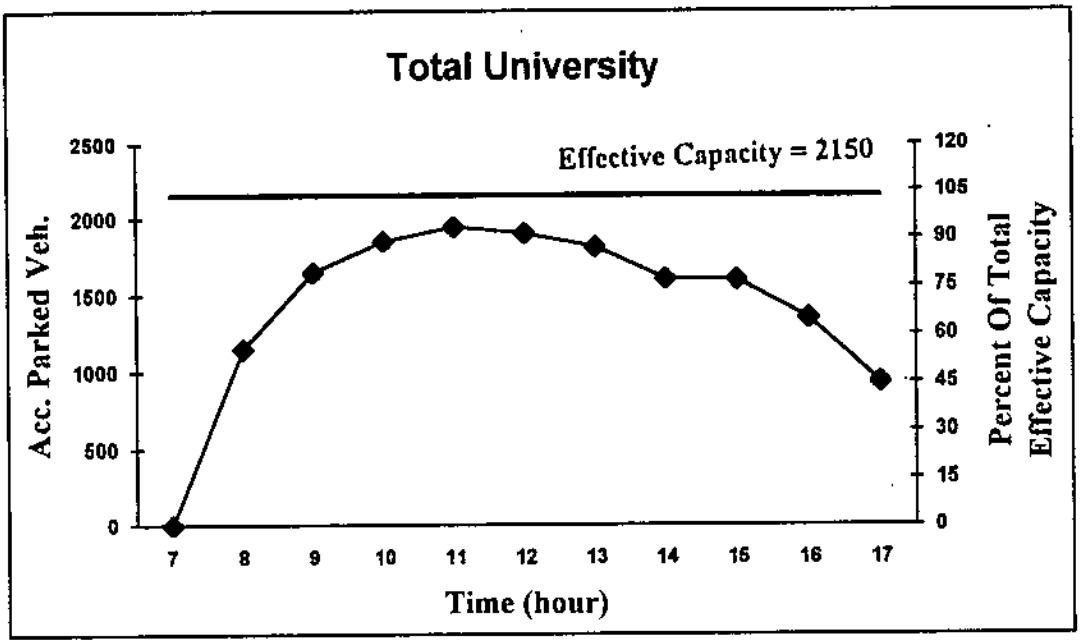


Figure (4.18): The Parking Accumulation And The Percent Of Total Effective Capacity For Total University Parked Vehicles

4.4.3 Walking Distance

The average walking distance of parkers can be used as a good indication of the proper location of the new or proposed parking lot. Table (4.7) shows the average walking distance in each sector which was determined by measuring the distances from the center of each parking area in each sector to the nearset building gate in that sector. The Table shows that sector seven has a highest average walking distance equal 63 meters, while the average walking distance of all university sectors was 49 meters.

Table (4.7): Average Walking Distances At University Sectors

Sector No	Average walking Distance (m)
1	29
2	40
3	31
4	38
5	55
6	48
7	63
8	55
9	42
Average	**49**

Table (4.8) shows the walking distance of student parking areas to each sector which was found by determining the center of each parking area then measured the shortest walking distance to the center of each sector. The average walking distance from parking one (P1) to sectors three, four and five was less than 400 meters, in addition sector five is the nearest one to the parking two (P2), while sector six and one are the nearset one to the parking three (P3) and sector one is nearest to parking five (P5).

Table (4.8): Average Walking Distance (Meters) From Students Parking Areas To Each Sector

Sector No. / Parking No.	1	2	3	4	5	6	7	8	9	Avg.
P1	470	570	300	223	354	-	-	-	-	-
P2	1045	725	915	740	490	1165	895	990	910	-
P3	679	749	-	-	-	575	-	-	-	-
P5	360	695	565	930	900	740	1360	1340	1260	446
P6	1315	1160	925	355	490	1665	535	555	435	702
P7	-	-	-	-	-	-	530	340	130	252
P8	1450	1310	1070	770	840	1550	390	320	510	384
P9	810	490	680	505	255	930	660	755	675	469

Parking six (P6) is near to the sector four with a walking distance of 355 meters, also the walking distance from this parking area to the sectors five, seven, eight and nine is ranged between (400-600) meter. The walking distance between parking seven (P7) and the nearset sector (nine) is 130 meter.

The nearest sectors to the parking garage (P8) are seven and eight, the walking distance from these sectors to P8 are 390 and 320 meters respectively. The location of parking nine (P9) is near to the sectors two and five which their walking distances are 490 and 255 meters respectively.

4.4.4 Parking Duration

The average parking duration for each sector was estimated from the parking survey and questionnaire survey as shown in Table (4.9). The average parking duration obtained from the parking survey is more accurate because the licence plate number of each parked vehicles was recorded hour by hour in each sector. Moreover, since there are few classes finished after 5:00 p.m. and the parking survey was carried out till 5:00 p.m., the study considered the maximum parking duration to be 10 hours and 30 minutes to cover vehicles parked from the morning hours and stayed parked after 5:00 p.m. (parked more than nine hours). As a result of that, there is a difference appeared between the average parking duration obtained from the parking survey and questionnaire survey.

The maximum average parking duration was occured in sector six and was found to be equal to six hours and 30 minutes. The higher value of parking duration reflects the nature of maintenance works existed at sector six. The average parking durations for other sectors were ranged between 4 hours-12 minutes and 5 hours-12 minutes while the average parking duration for all university campus sectors was 4 hours and 42 minutes. Figures (4.19 and 4.20) shows the percent of cummulative parkers and the parking

duration at the university and at each university sectors through mondays respectively. The maximum percent of cumulative parkers of two or less than two hours parking duration was 28.8 percent for all university sectors while for sector four was 39.4 percent where the place of sport activity building, library, students affairs of deanship, admission and registration office and stadium. Sector six has a minimum percent of cumulative parkers for the parking duration of two or less than two hours which was 14.4 percent.

Table (4.9): Average Parking Duration In Each Sector

Sector No.	Average Parking Duration (hour)	
	By Parking Survey (hour)	By Questionnaire Survey (hour)
1	4.3	5.3
2	4.5	4.2
3	5.2	4.6
4	4.5	6.0
5	4.7	4.9
6	6.5	4.6
7	4.2	4.7
8	4.9	3.8
9	5.2	5.0
Average	4.7	4.2
Unknown		1.4

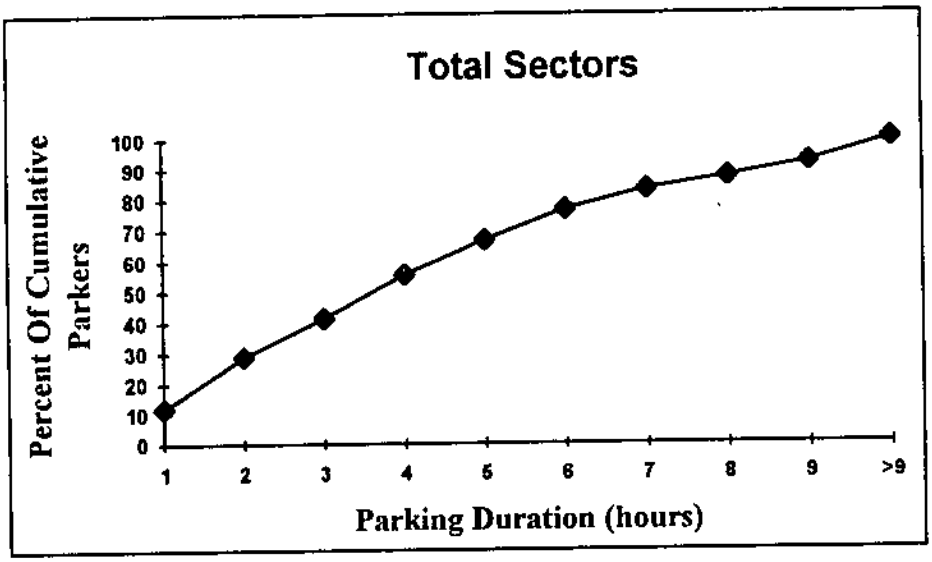


Figure (4.19): The Percent Of Cumulative Parkers and Parking Duration for total University Sectors

The number of parked vehicles in each parking duration for the sectors of university of Jordan is shown in Figure (4.21). However, for each sector is shown in Figure (4.22). For the all university sectors, the parking duration of maximum number of parked vehicles was two hours. While the maximum number of parkers were parked their vehicles at the sectors of university between (two-five) hours except in sector six and nine, where the maximum number of parkers were parked their vehicles for more than nine hour and for one hour respectively.

The average parking duration of students parking areas was calculated by using the data obtained from the parking survey as shown in Table (4.10). The maximum average parking duration was 5 hours and 12 minutes occured at the illegal curb parking (P2) at the back street of the university of Jordan. While the minimum average parking duration was 3 hours and 12 minutes occured at the parking lot (P7) near the consulting center and the university administration and the parking garage P(8). Also, the average parking duration for all legall and illegal curb parking (P4) was greater than the average parking duration of all parking lots and parking garage (P10). In

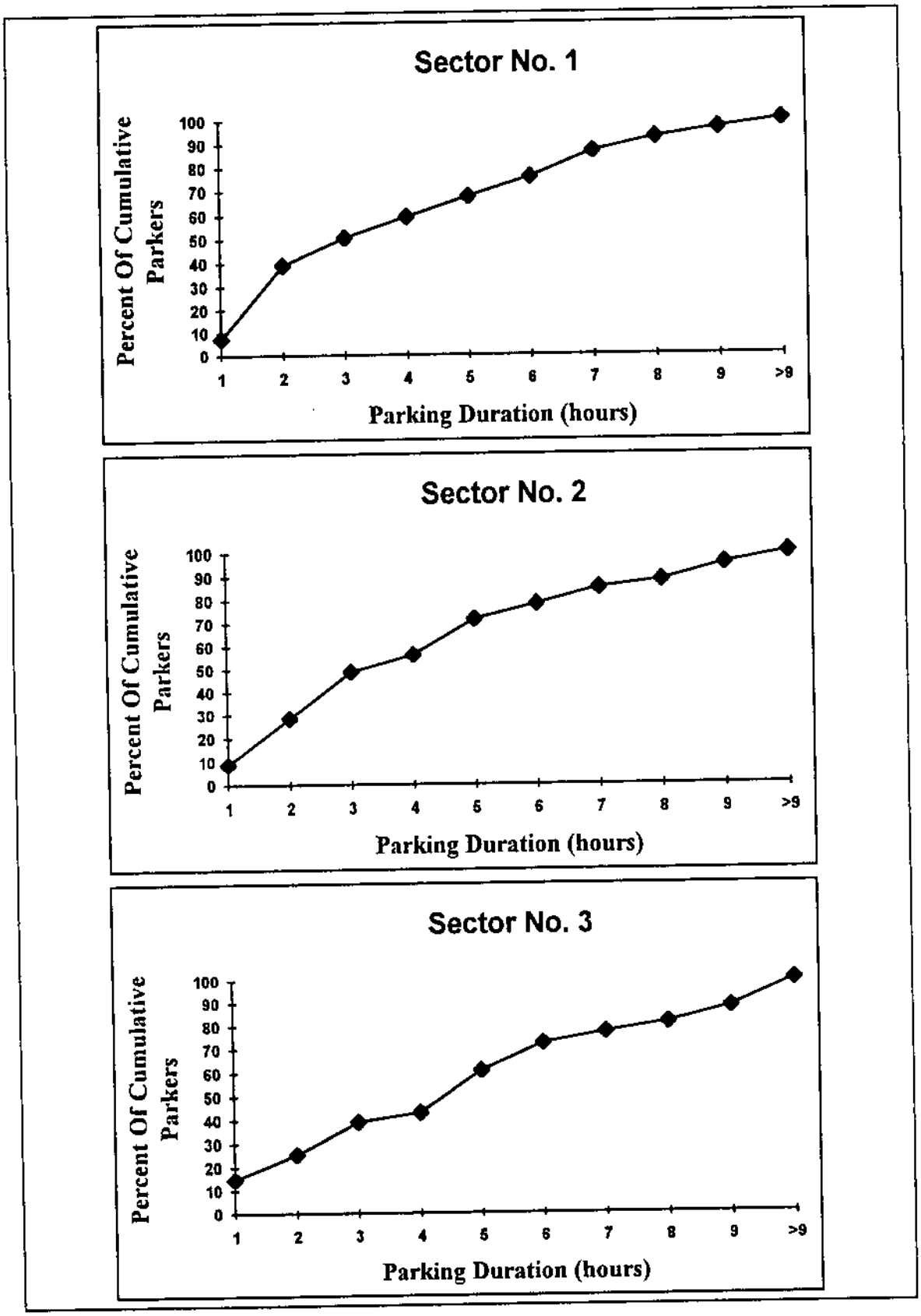
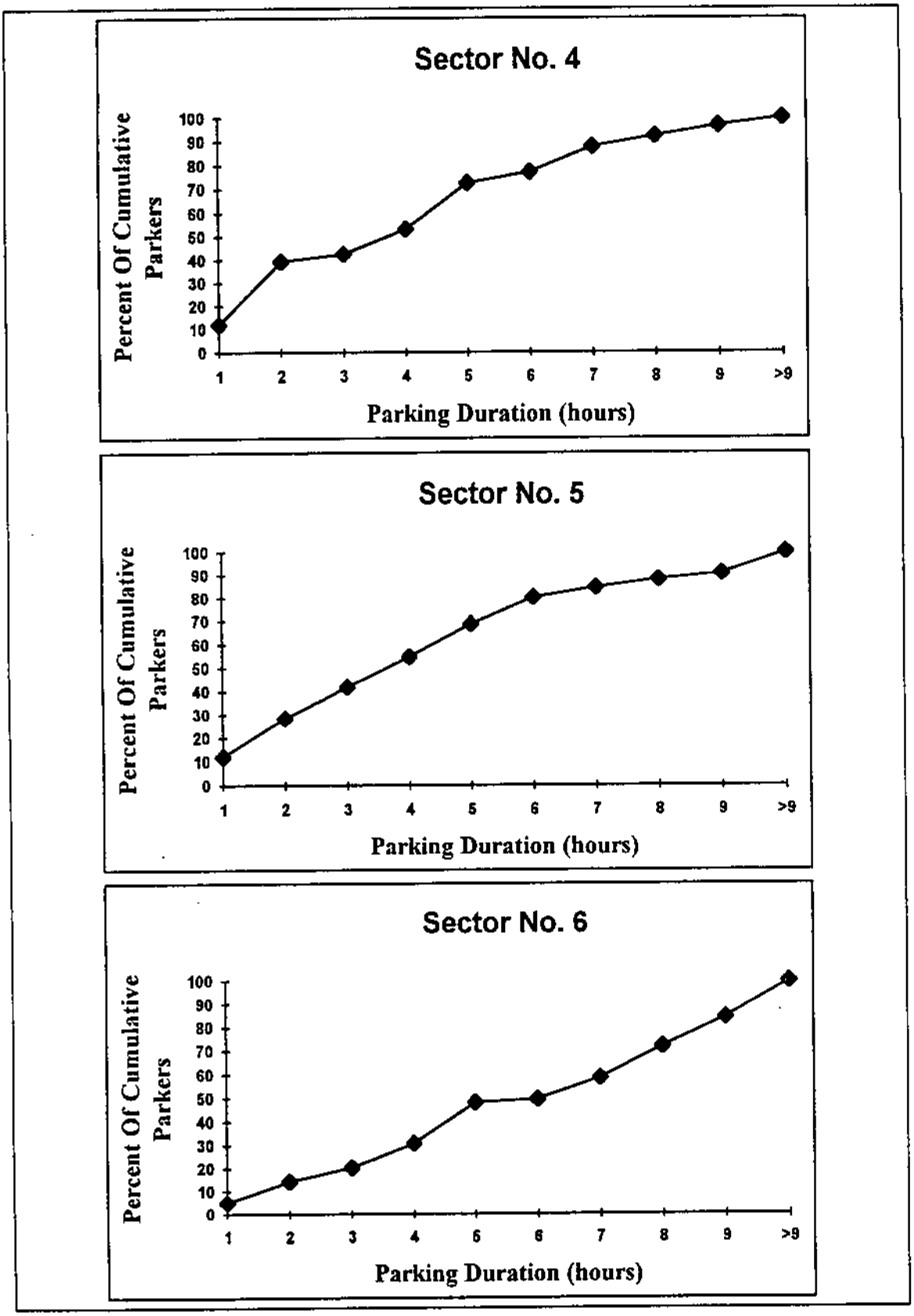


Figure (4.20): The Percent Of Cumulative Parkers And Parking Duration In Each Sector



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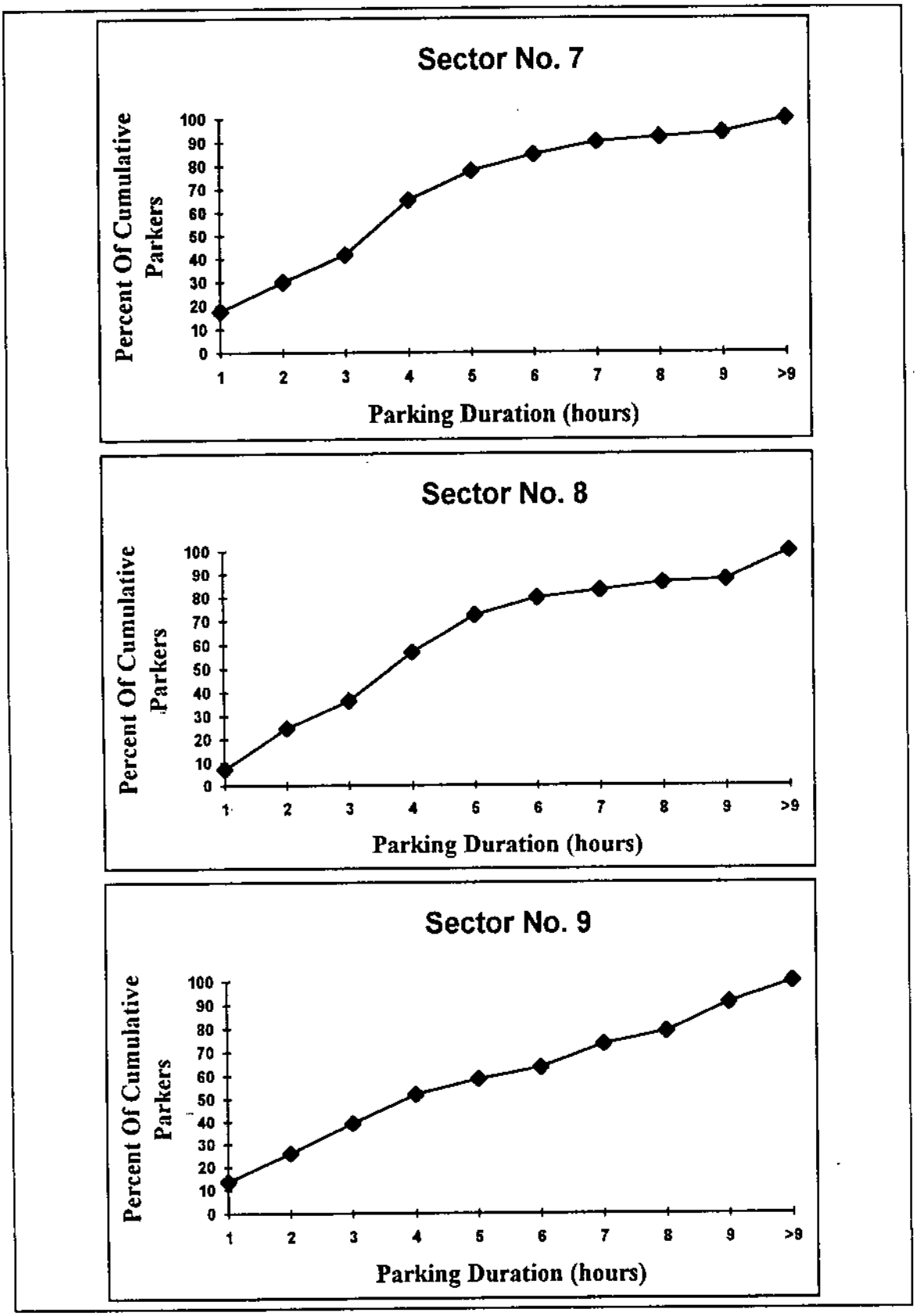

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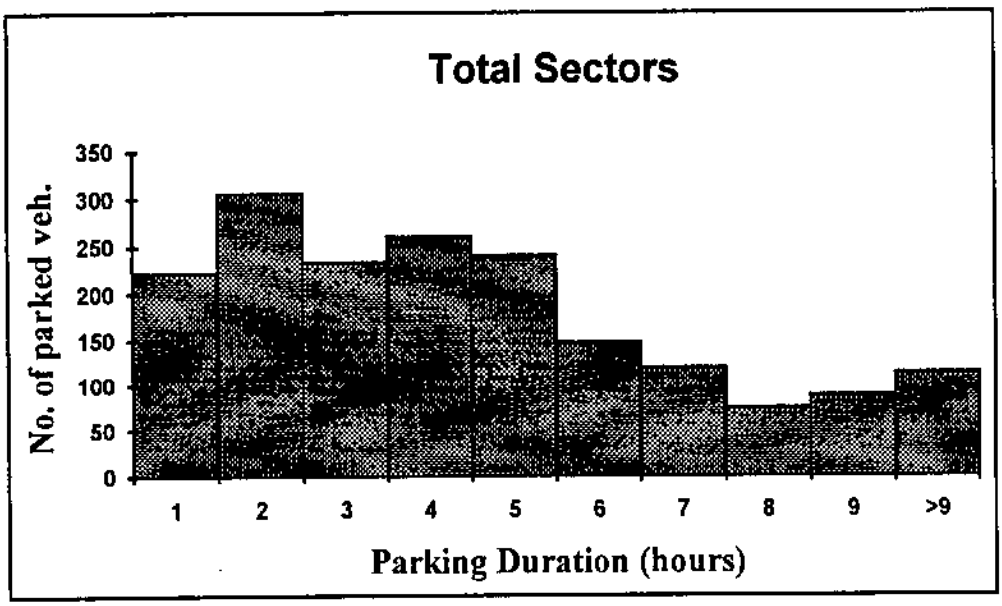


Figure (4.21): Parking Duration Of Parked Vehicles For Total University Sectors

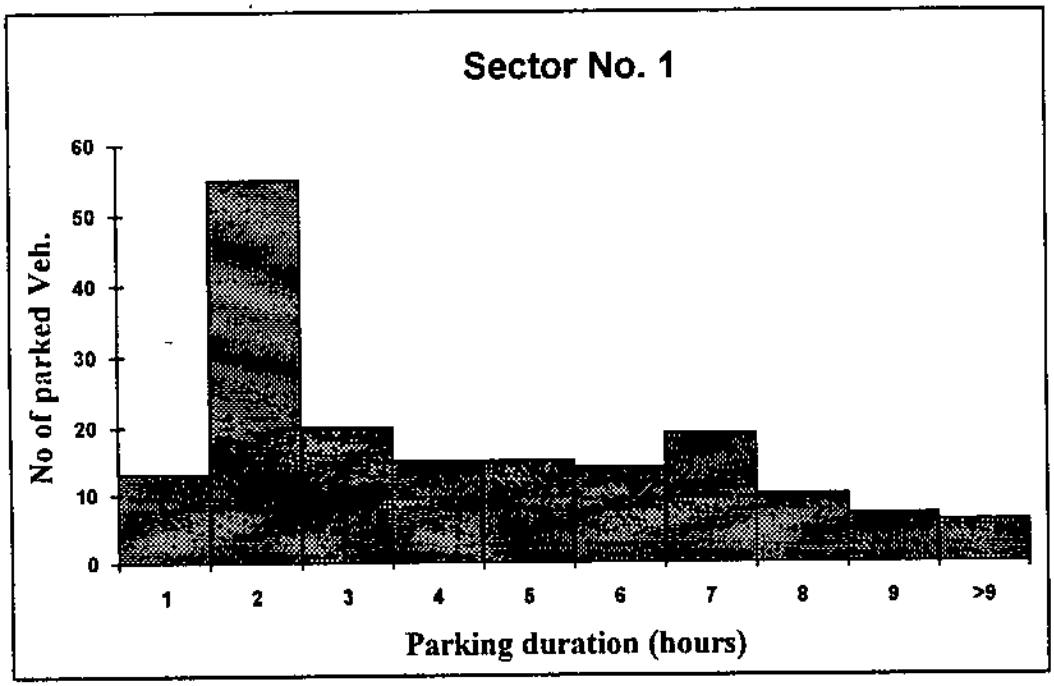
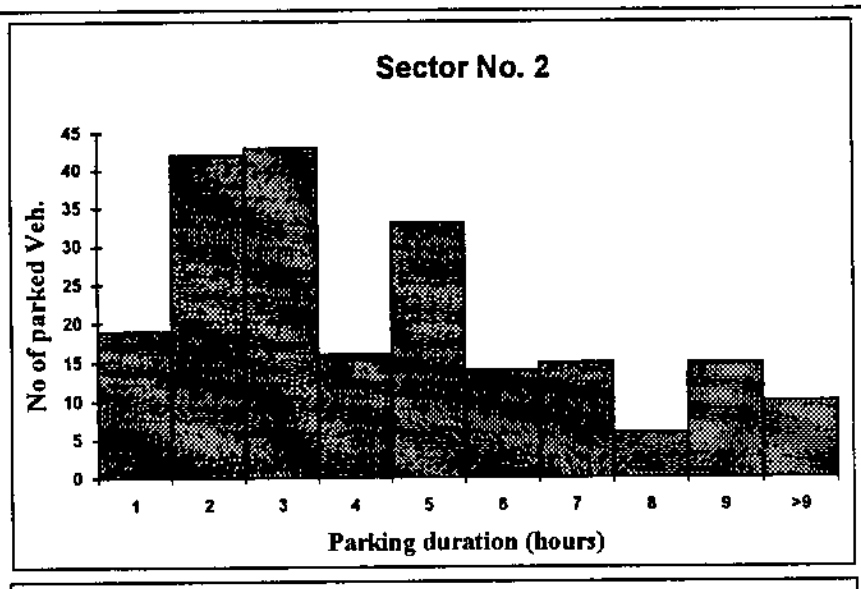
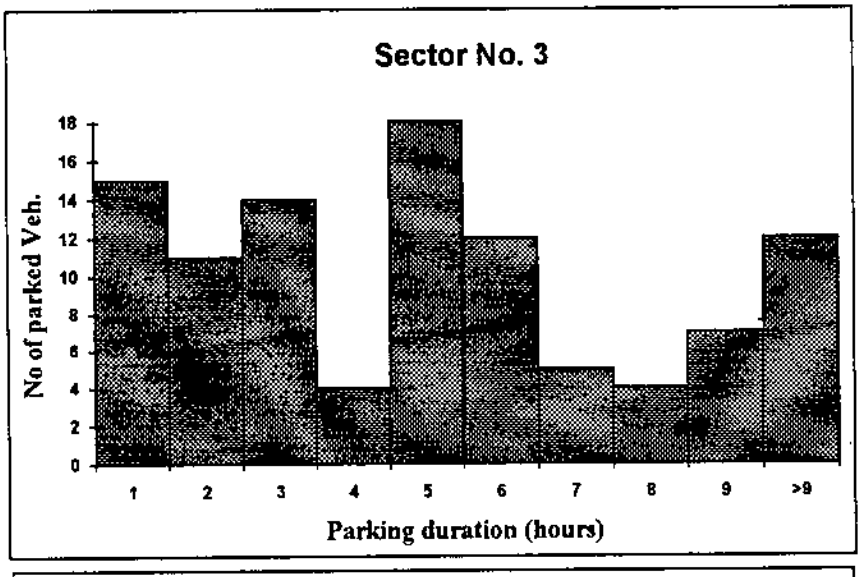
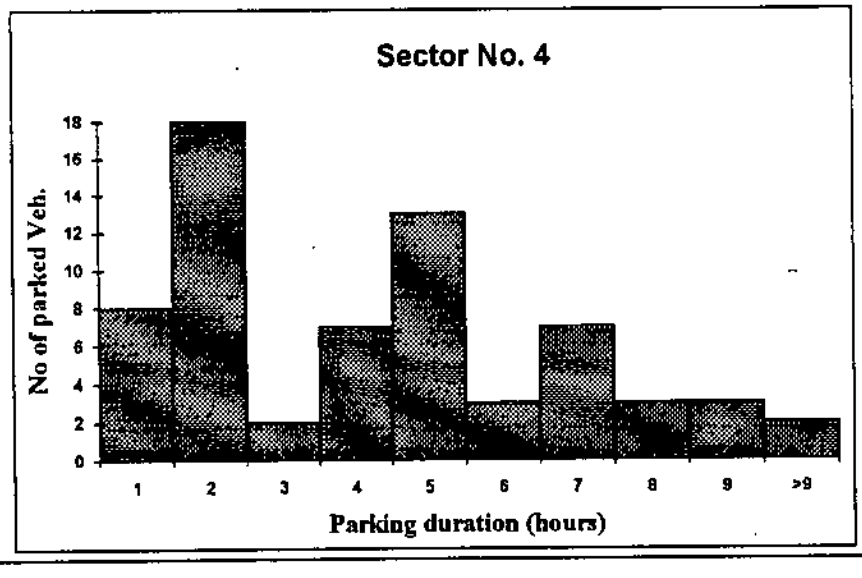


Figure (4.22): Parking Duration Of Parked Vehicles For Each Sector







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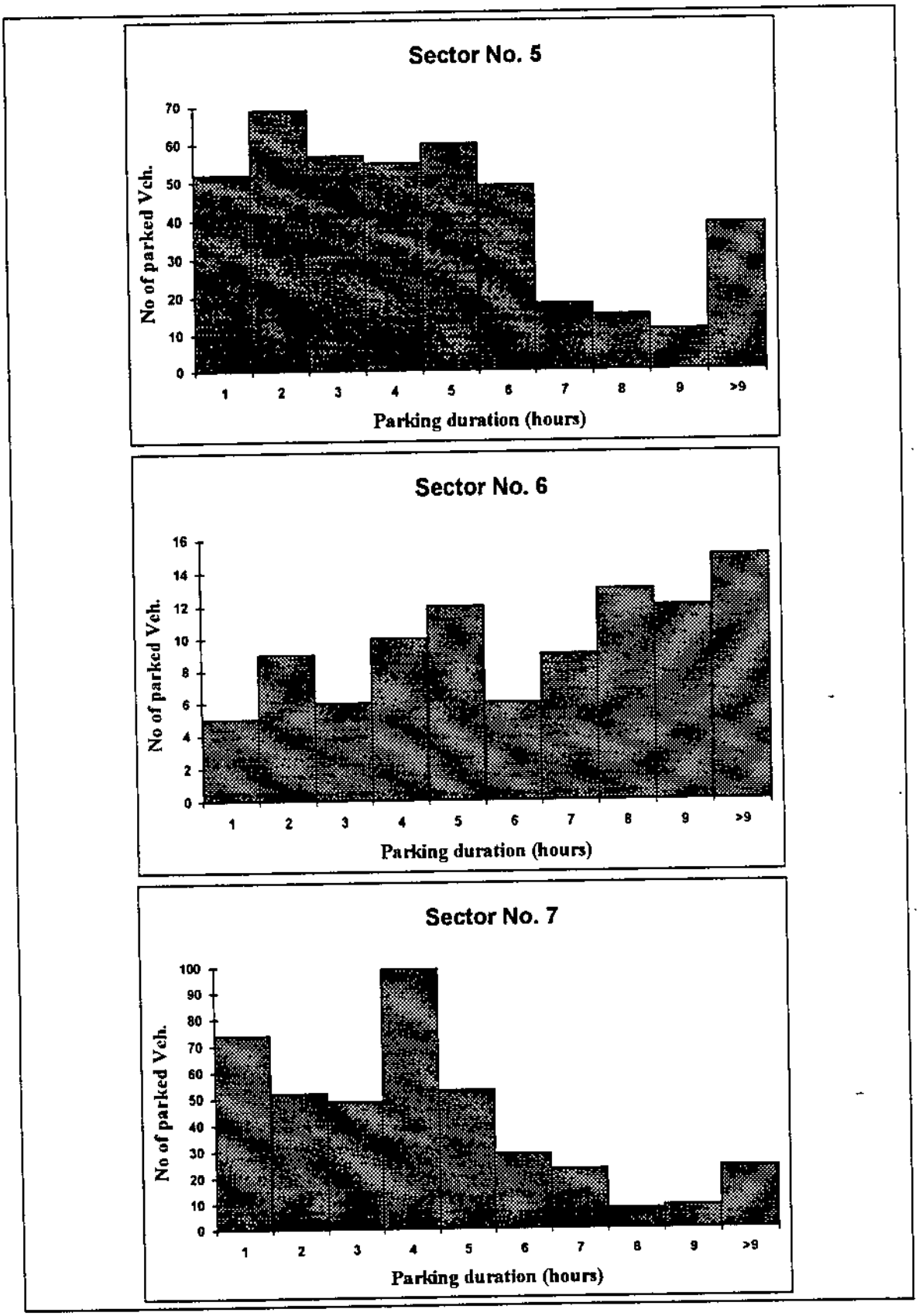

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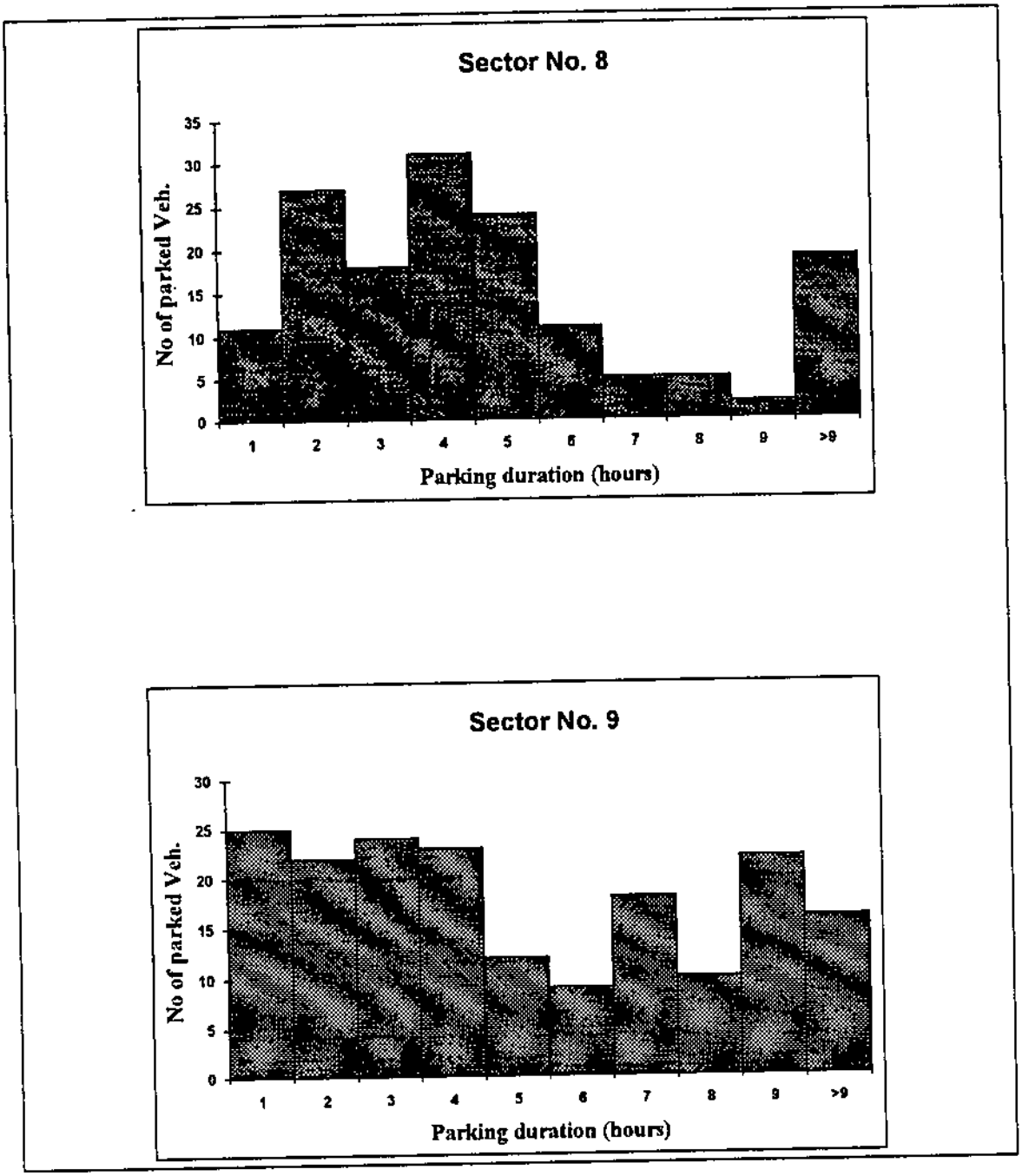


Figure (4.22): Continued.

addition the average parking duration for all students parking areas (P4+P10) was 3 hours and 48 minutes which was close to the average parking duration of students parking lots and parking garage (3 hours and 42 minutes).

Table (4.10): Average Students Parking Duration

Parking Number		Average Parking Duration (Hour)
	P1	3.63
	P2	5.21
	P3	4.91
Subtotal	(P4)	4.09
	P5	4.82
	P6	4.59
	P7	3.22
	P8	3.23
	P9	4.75
Subtotal	(P10)	3.73
	Average	3.79

The maximum parking duration is considered more than six hours since the last lecture was scheduled between (7:00-8:30) p.m. as a result of that, the maximum parking duration of student parking areas was decided to be 7 hours and 30 minutes for vehicles which parked more than six hours. Figure (4.23 and 4.24) show the percent of cumulative parkers and the parking duration of students parking areas and for each parking lot and garage respectively. The percent of cumulative parkers of all students parking areas which parked their vehicles for one hour or less was 15.6 percent while the maximum percent of cumulative parkers which parked

their vehicles for one hour or less was equal 21.8 percent occured at the parking garage (P8). Moreover, the percent of cumulative parkers for the parking duration of one hour or less of the legal and illegal curb parking (P4) was 10.5 percent which is less than the percent of cumulative parkers of the parking lots and parking garage (P10) which is 16.6 percent.

The number of parked vehicles and the parking duration for all students parking areas and for each students parking area are shown in Figure (4.25 and 4.26) respectively. Most of the parkers of all students parking areas were parked their vehicles between (two-four) hours. While other students parking areas, their parkers were stayed between (four-six) hours as P1, P7 and P8 or stayed more than six hours as P3, P5, P6 and P9.

Finally, the average parking duration for the whole university was 4 hours and 12 minutes.

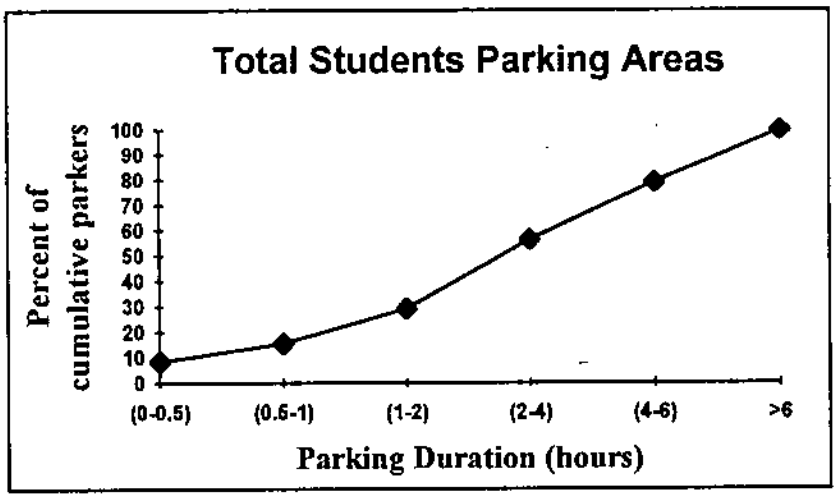


Figure (4.23): The Percent Of Cumulative Parkers And The Parking Duration Of Students Parking Areas.

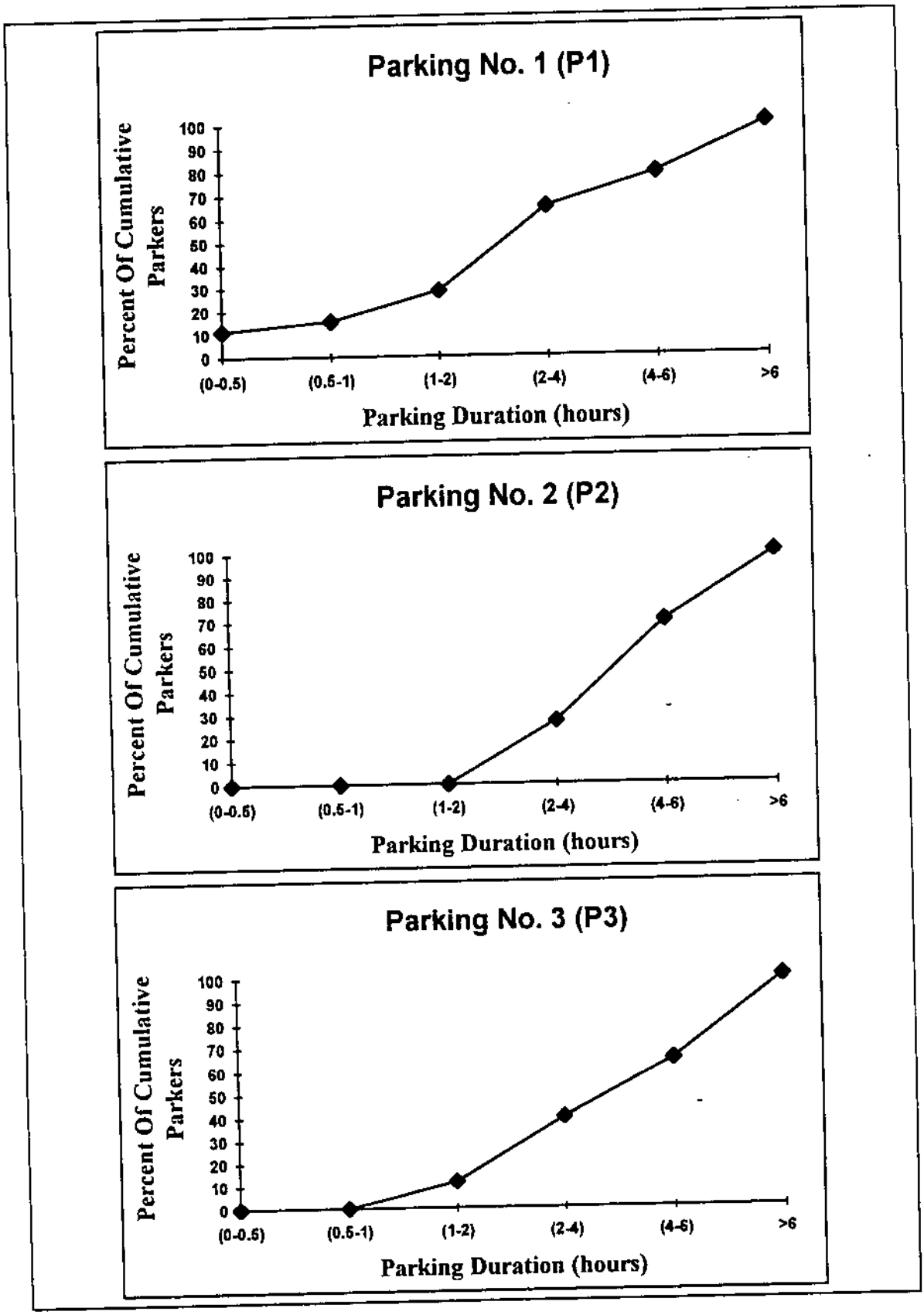
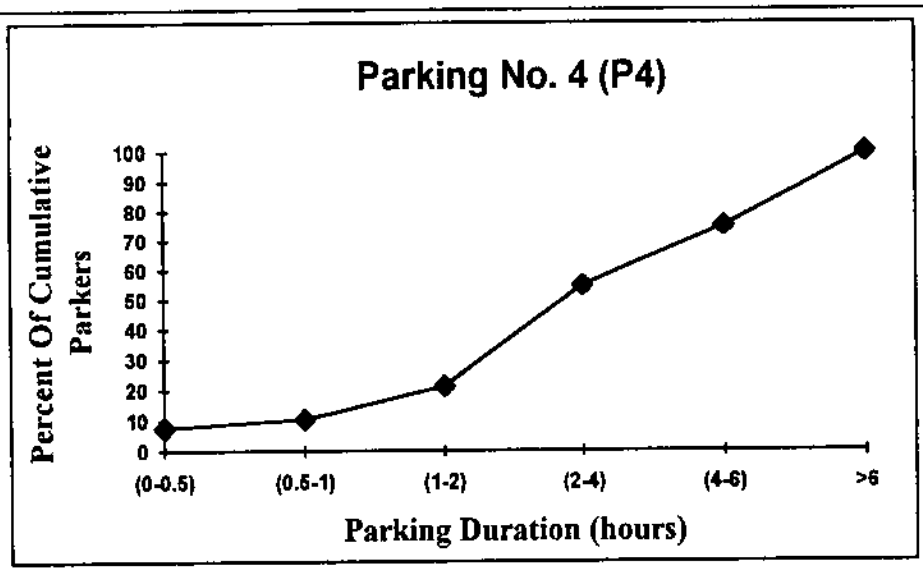
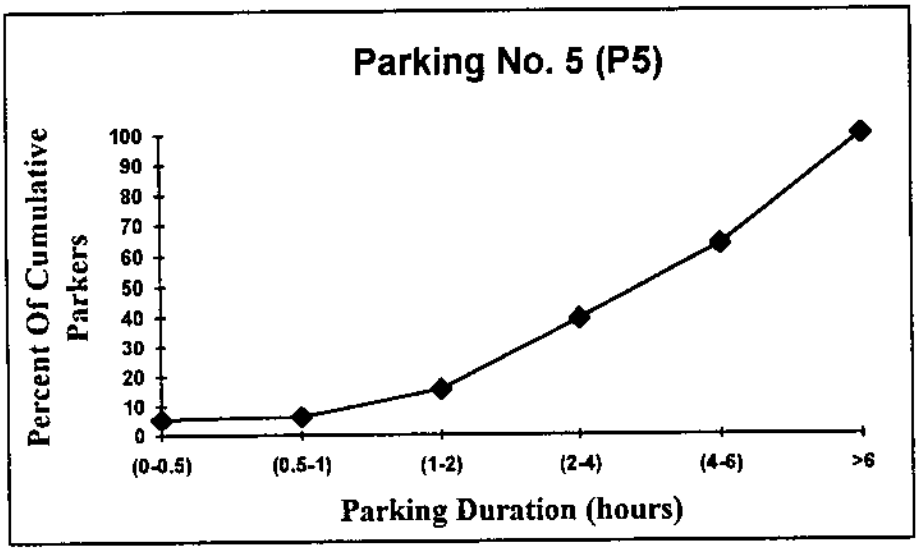
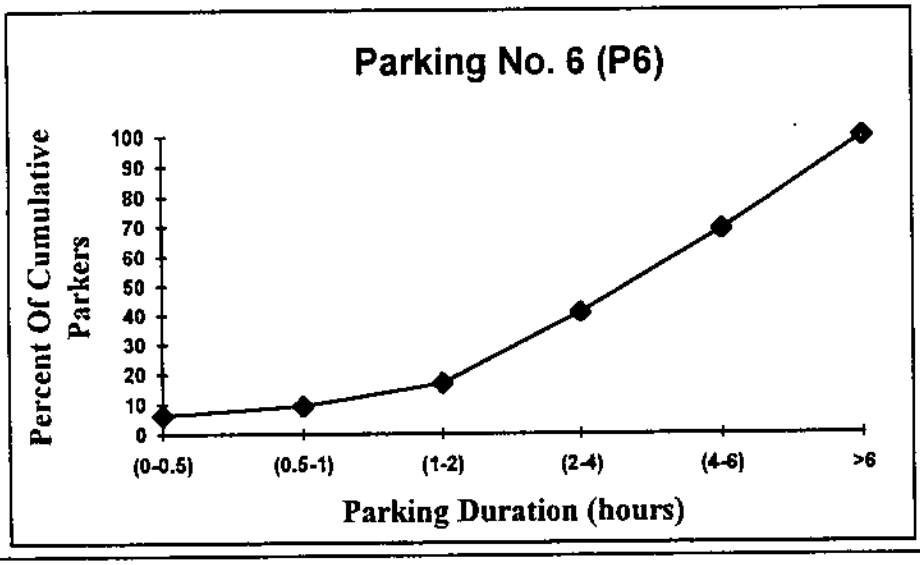


Figure (4.24): **The percent Of Cumulative Parkers And Parking Duration At Each Student Parking Lot And Garage**







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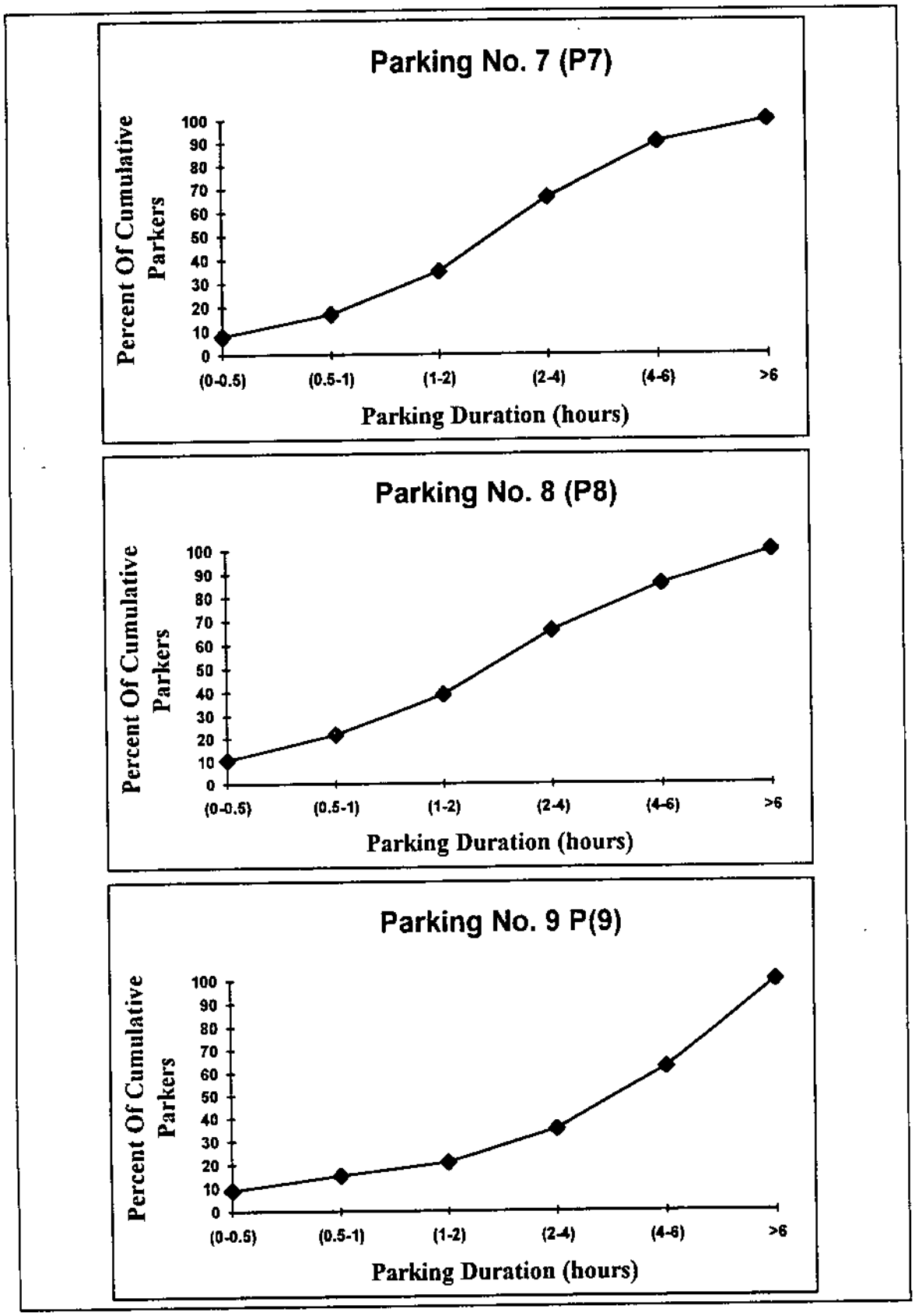

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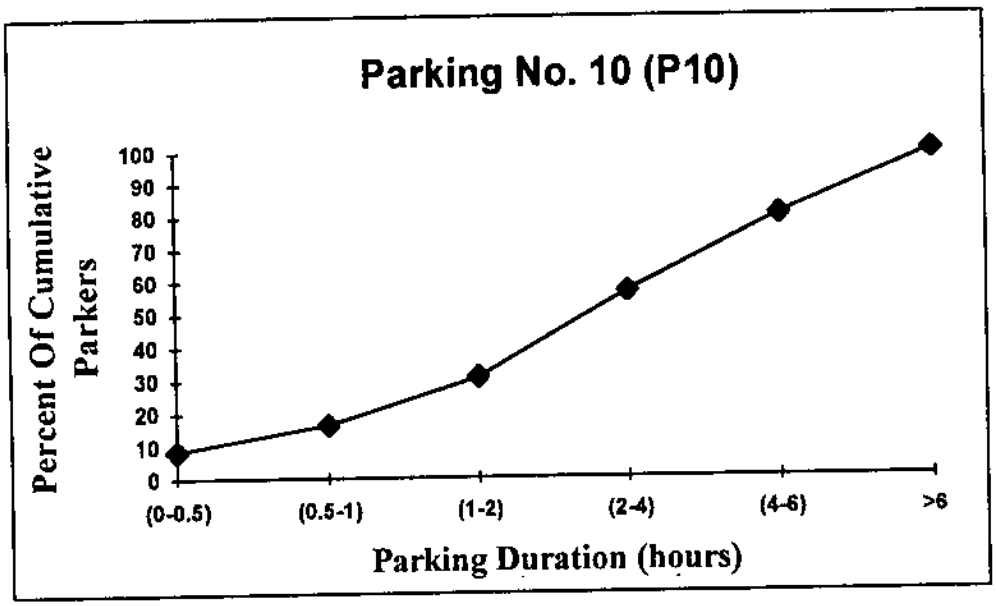

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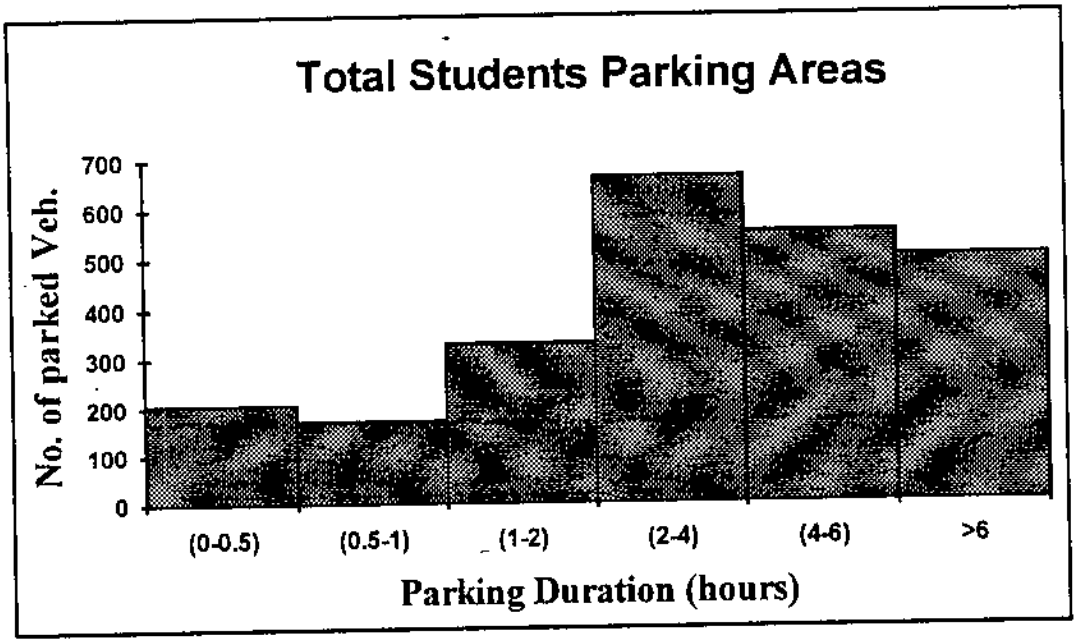


Figure (4.25): Number Of Parked Vehicles In Each Parking Duration Of All Students Parking Areas.

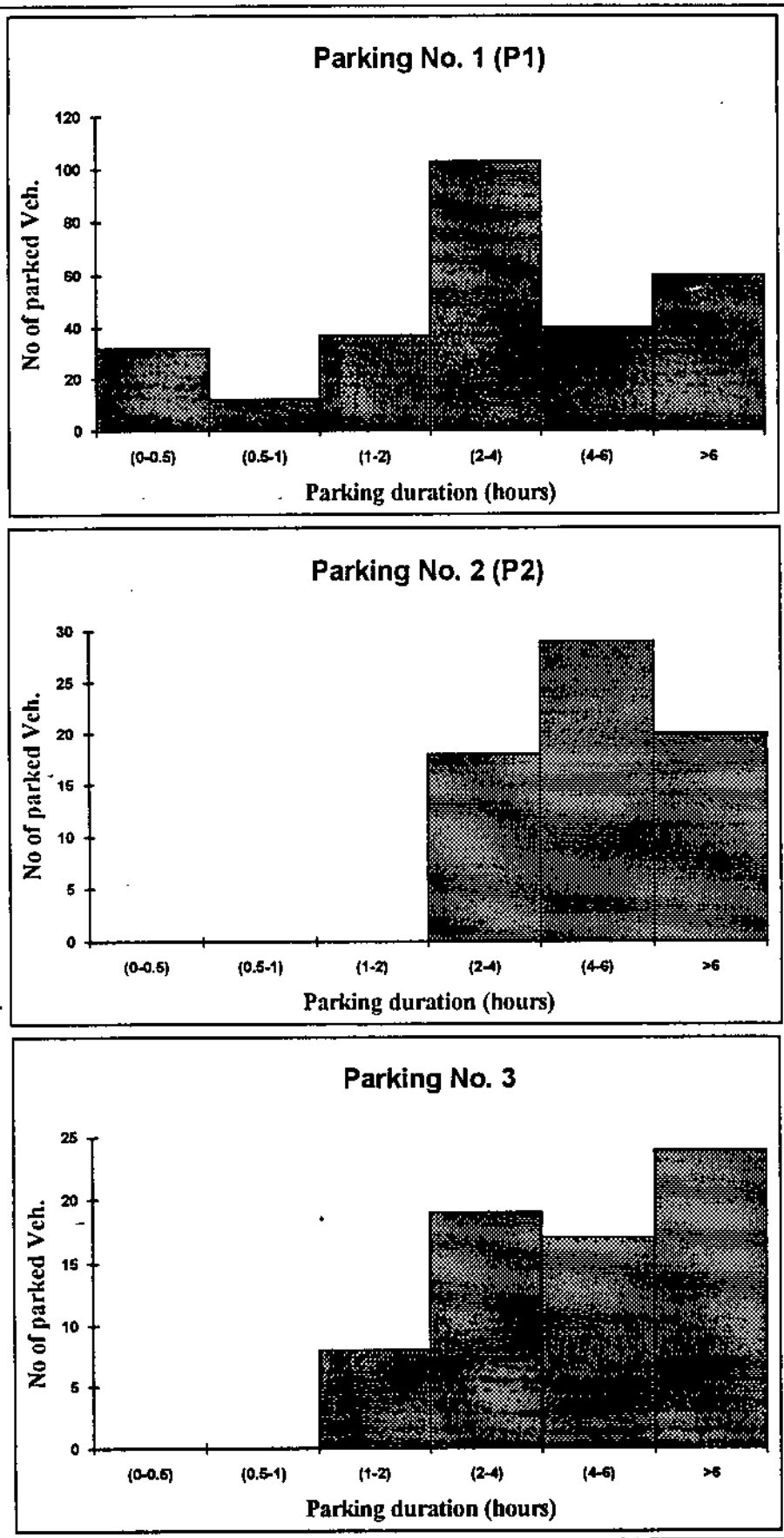
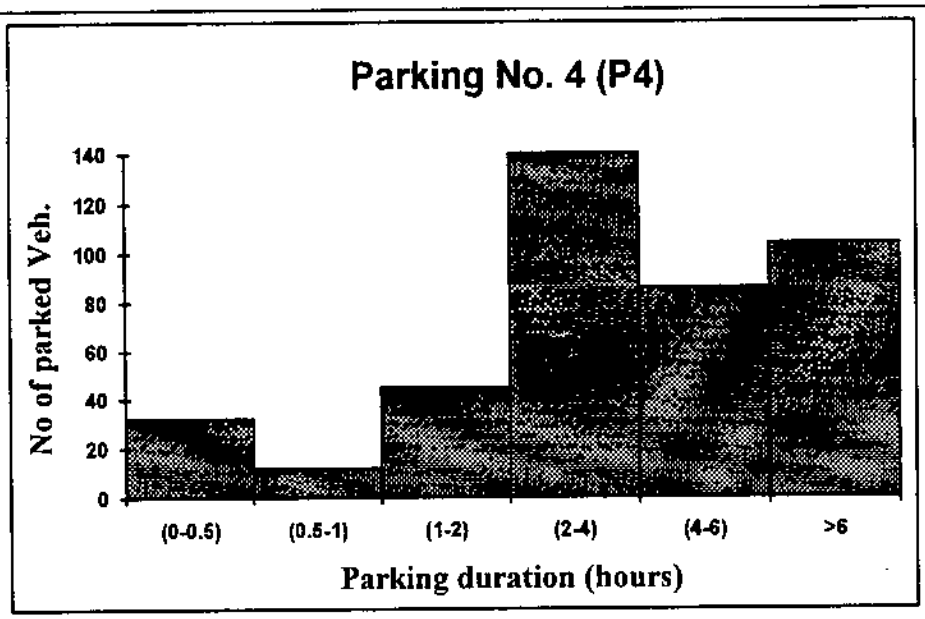
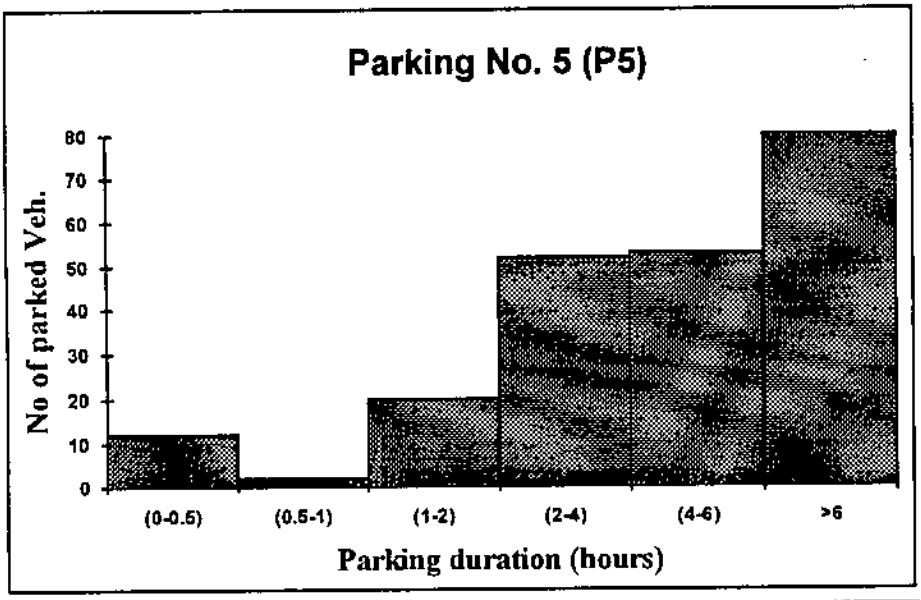
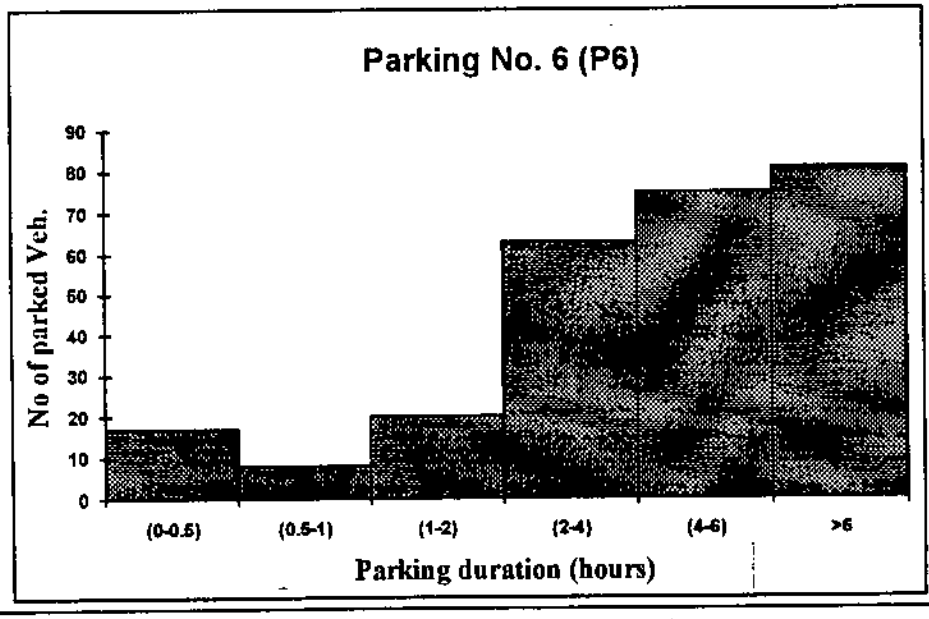


Figure (2.26): Number Of Parked Vehicles In Each Parking Duration Of Each Student Parking Area







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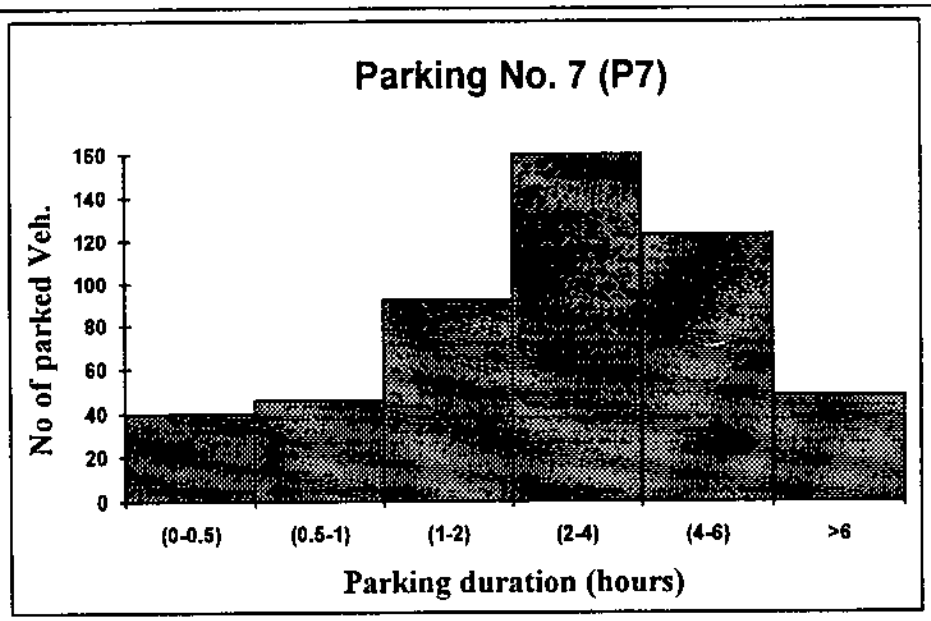

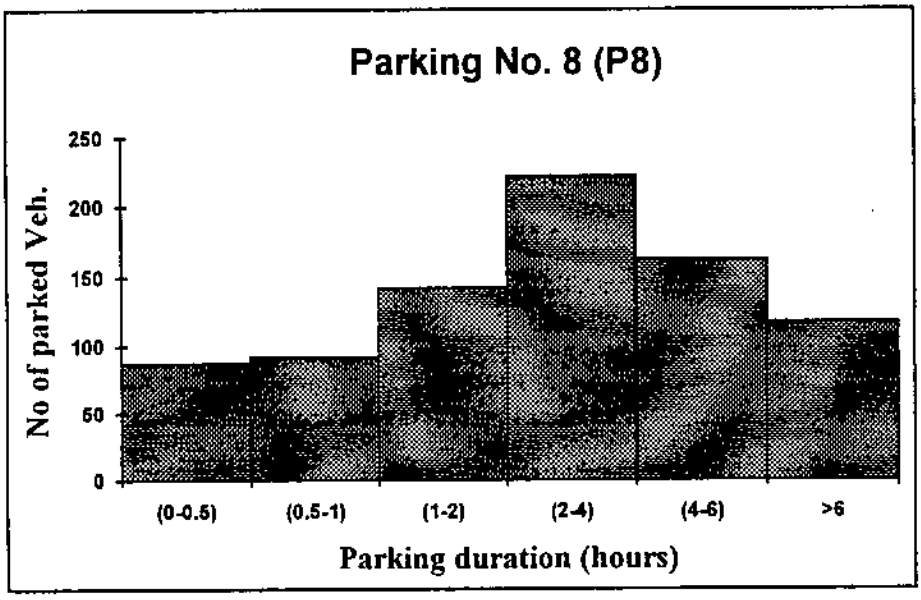

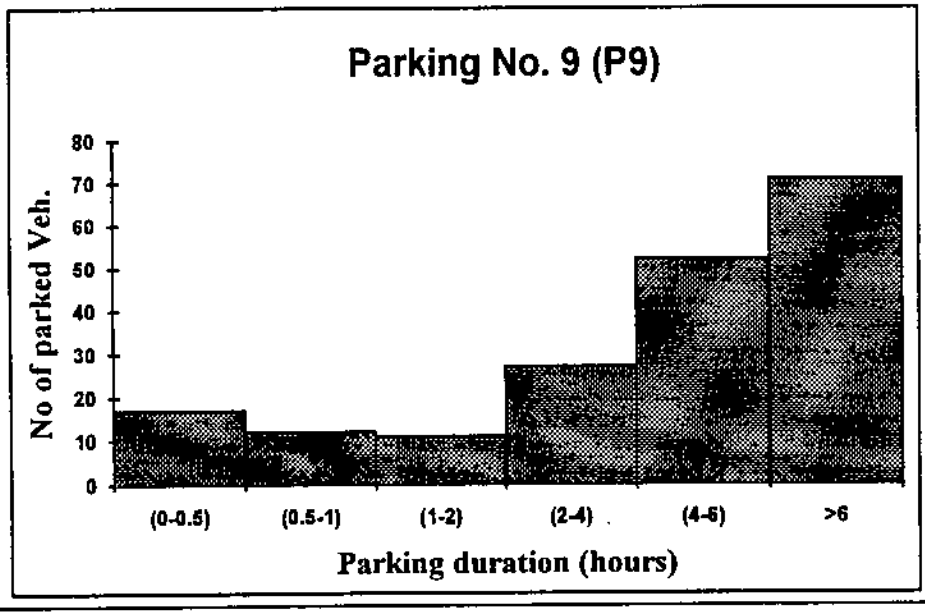

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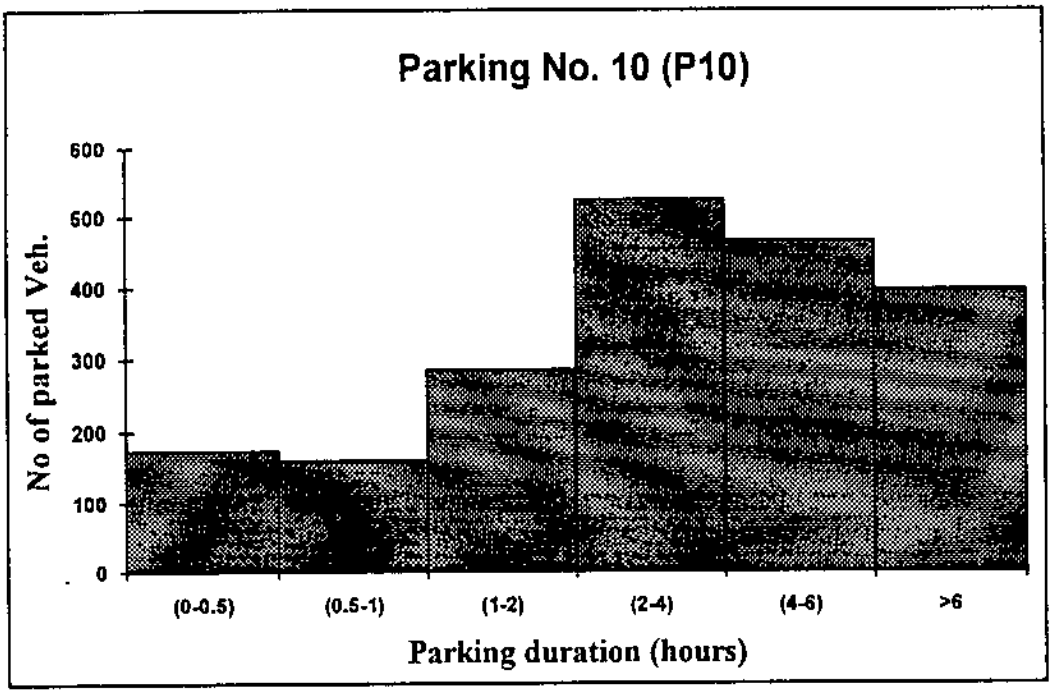

Figure (4.26): Continued

4.4.5 Parking Turnover

The utilization of a parking space is measured by a parking turnover which can be determined by dividing total number of parked vehicles during a specific time period (7:00-17:00) over total available parking spaces.

The turnover of the parking areas for all university sectors is shown in Table (4.11). The average turnover for all sectors was 1.29. The average turnover for university sectors as indicated in Table (4.11) ranging between 0.6 and 1.73 parked vehicles per space per day (7.00-17.00). It was observed from the table that the highest turnover was in sector seven where the turnover was ranging from 0.83 at P7-1 to 2.25 at P7-2, while the lowest turnover was equal 0.6 occured in sector four. The turnover of other sectors has ranged from 0.86 at sector three to 1.65 at sector nine.

In addition the study estimated the average turnover of all students parking areas as shown in table (4.12). The average turnover for legal and illegal curb parking areas was 3.81, while the average turnover for the parking lots and parking garage was 2.05. The highest turnover was 6.06

occured at P7 near to the consulting center and university administration, while the lowest turnover was 1.52 occured at P5. The turnover of other parking areas ranged from 1.66 at the parking garage (P8) to 1.94 at P9.

The Study found that the average turnover for all student parking areas was 2.22 which is greater than the average turnover for all university sectors (1.29).

Finally, the average turnover for the whole university parking areas was 1.7 vehicles/space.

Table (4.11): Turnover Of Parking Areas Of All University Sectors

Parking No.	No. Of Spaces	No. Of Parkers	Turnover
P1-1	60	46	0.77
P1-2	52	100	1.92
P1-3	22	28	1.27
P1-T	**134**	**174**	**1.3**
P2-1	81	34	0.42
P2-2	49	40	0.82
P2-3	60	139	2.3
P2-T	**190**	**213**	**1.12**
P3-1	82	93	1.13
P3-2	86	9	0.11
P3-T	**118**	**102**	**0.86**
P4-1	39	11	0.28
P4-2	71	55	0.78
P4-T	**110**	**66**	**0.6**
P5-1	26	40	1.54
P5-2	25	25	1.00
P5-3	63	43	0.68
P5-4	98	197	2.01
P5-5	22	18	0.82
P5-6	25	21	0.84
P5-7	66	81	1.23
P5-T	**325**	**425**	**1.31**
P6-1	42	65	1.55
P6-2	44	32	0.73
P6-T	**86**	**97**	**1.13**
P7-1	18	15	0.83
P7-2	16	36	2.25
P7-3	32	70	2.19
P7-4	37	74	2.00
P7-5	35	42	1.2
P7-6	64	99	1.55
P7-7	41	84	2.05
P7-T	**243**	**420**	**1.73**
P8-1	75	140	1.87
P8-2	29	13	0.45
P8-T	**104**	**153**	**1.47**
P9-1	67	103	1.54
P9-2	43	78	1.81
P9-T	**110**	**181**	**1.65**
All Sectors (Avg.)	**1420**	**1831**	**1.29**

Table (4.12): Turnover Of All Students Parking Areas

Parking No.	No. Of Spaces	No. Of Parkers	Turnover
P1	110	284	2.58
P2	0	67	0
P3	0	68	0
Subtotal (P4)	110	419	3.81
P5	144	219	1.52
P6	157	264	1.68
P7	84	509	6.06
P8	496	822	1.66
P9	98	190	1.94
Subtotal (P10)	979	2004	2.05
P_{avg} (students)	1089	2423	2.22
P_{avg} (university)	2509	4254	1.7

4.4.6 Car Occupancy And Trip Destination of Students Parking Areas

Most of parked vehicles in each of the five students parking areas P(5-9) had one person occupant with 75 percent of total parked vehicles, while 21 percent of total parked vehicles had two persons occupant as shown in Table (4.13).

Table (4.13): Car Occupancy In Each Student Parking Area

Parking No.	1	2	3	4	5	6	Total
P5	158	47	10	3	1	-	219
P6	191	57	11	3	2	-	264
P7	350	138	15	6	0	-	509
P8	670	134	14	4	0	-	822
P9	134	45	9	1	1	-	190
Total P(5-9)	1503	421	59	17	4	-	2004

The sector number of a student trip destination of parked vehicles in each of the five students parking areas is shown in Table (4.14). From this Table it can concluded that most vehicles were parked near their colleges

destination. This Table shows that the destination of 82.2 percent of total parked vehicles in the parking area five (P5) was sector one because it is the nearest sector to this parking area.

Table (4.14): Trip Destination Of Parked Vehicles In Each Student Parking Area

Parking No.	Sector Number									Total
	1	2	3	4	5	6	7	8	9	
P5	180	22	4	3	3	-	7	-	-	219
P6	5	43	44	8	58	-	98	8	-	264
P7*	-	-	-	-	-	-	71	141	265	509
P8	-	-	-	-	6	-	705	111	-	822
P9	6	130	12	-	38	-	3	1	-	190

* Outside university sectors was equal 32 parked vehicles

The destination of 59.1 percent of total parked vehicles in the parking area P6 was sector seven and five, while the destination of 33 percent of total parked vehicles in this parking area was sectors two and three.

In the parking area seven (P7); the destination of 52.1 percent of the total parked vehicles was sector nine near the place of consulting center and university administration.

In the parking area eight; the destination of 85.8 percent was sector seven, while the destination of 68.4 percent of total parked vehicles in the parking area nine was sector two.

The study found that the destination of parked vehicles in each student parking area was not the same for all the sectors because most vehicles were parked near their colleges destination. Moreover, each parking area would serve some of university sectors within an acceptable walking distance and would not serve the other far sectors.

4.4.7 Parking Usage

Most of the parkers inside the campus parking areas used the parking once a day which represent 38.2 percent determined from the questionnaire survey, while 31.6 percent and 14.4 percent used the campus parking areas twice and more than twice respectively during one day as shown in Figure (4.27). In addition the frequency of 15.8 percent of using the campus parking areas was unknown. The percentage of parkers which used the campus parking areas for five days a week are 69.9 percent of total parkers. While the percentage of parkers which used the campus parking areas for six and seven days a week are (3.5) percent and (0.5) percent of total parkers respectively as shown in Figure (4.28). Although thursdays and fridays are the weekend holidays, some of university staff comes to the university during the weekend since some of the staff especially in engineering departments comes to follow existing university projects, in addition to the university security and the library staffs.

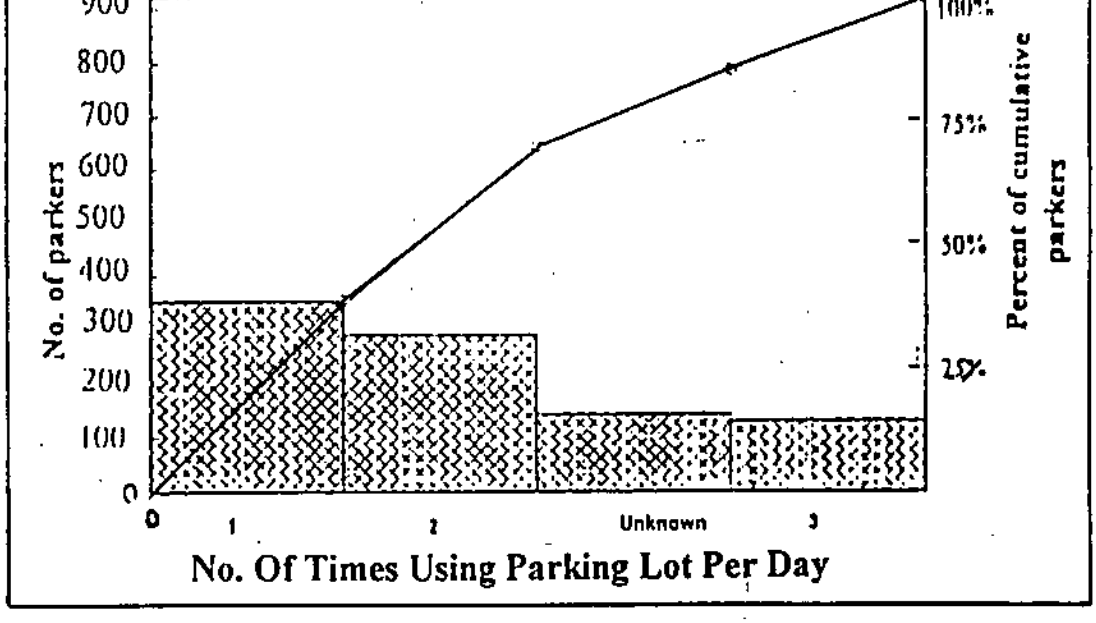

Figure (4.27): The Frequency Of Using The Campus Parking Areas

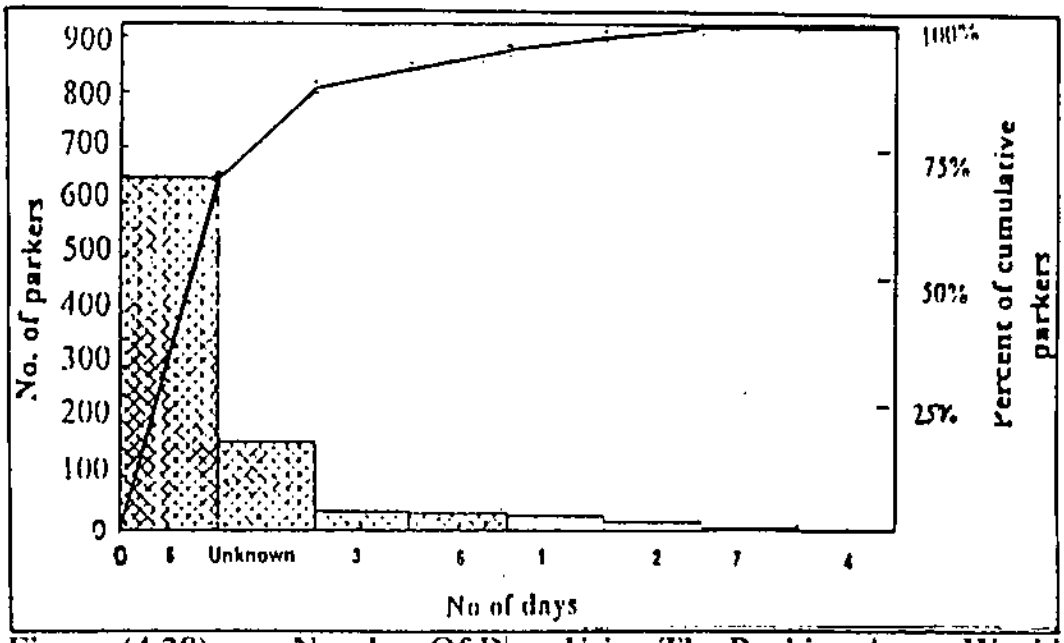

Figure (4.28): Number Of Days Using The Parking Areas Weekly

4.5 Parking Generation Rate

The parking generation rate was calculated in each sector at the university of Jordan by using the ratio of (space/1000m^2) as shown in Table (4.15). This table shows the ratios which were ranged from 1.10 at sector six to 4.66 at sector nine.

Table (4.15): The Parking Generation Rate For University Sectors.

Sector No.	Parks Space/1000m^2
1	3.06
2	2.69
3	2.61
4	1.35
5	3.00
6	1.10
7	2.15
8	1.94
9	4.66

The parking generation rate for the whole university parking areas was equal 2.19 space/1000 m^2. However, the ratio of parking space per 1000 square meters at the time of developing new university would not be

varied in terms of its parking demand since some areas are not utilized fully at the early years of its commencement as an example of that the University of Science and Technology in Irbid city.

The ratio of parking space per 1000 square meters at the University of Jordan could be taken as a guidelines because the University was established for more than thirty years.

The parking generation rate for the students parking areas was equal 4.9 space/100 student.

4.6 CAMPUS PARKING DEMAND AND SUPPLY

4.6.1 Parking Demand And Supply For Faculty And Staff

The total legal parking spaces available at all campus sectors were 1420 spaces, including 1222 spaces at parking lots and 198 spaces at permitted curb parking. The total adjusted parking supply yields a practical (effective) parking capacity equal 1220 spaces.

The existing ratio of parking space per university population of faculty and staff was 0.48 space per person but the ratio of parking space per registered vehicle (permitted vehicle) was 0.79 space per registered vehicle.

The existing parking demands are a necessary element in the estimation and evaluation of the campus parking program for the coming ten years. When parking demands, generated by the number of parkers destined to a particular sector are compared with available supply in that sector, surpluses or deficiencies are determined as shown in Table (4.16) during the peak hour. Also, the total parking demand in the Table represent the maximum number of vehicles that destined to each sector during the surveying day between (7:00-17:00). While the peak hourly parking demand is the maximum number of parked vehicles during one hour through the survey time which was occured at all university sectors between (10.00-11.00)a.m.. The peek hourly parking demand was equal to 885 vehicles, however there is a surplus of 335 parking spaces.

Table (4.16) shows that there was a surplus in each sector at the University of Jordan except sector nine where a deficiency of only seven parking spaces was existed. Therefore, the parkers which couldn't park their vehicles in sector nine will use the parking areas in sector eight because it is the nearest one to sector nine which have a surplus of 14 parking spaces.

Table (4.16): The Existing Parking Demand And Supply At Each Sector In 1994.

Sector No.	Total Parking Demand (7-17)	Peak Parking Demand (1) (10-11) a.m	Supply	Effective Supply (2)	Peak hour Paking Condition (2) - (1)
1	150	92	134	115	+23*
2	187	108	190	162	+54
3	82	53	118	101	+48
4	52	26	110	93	+67
5	368	186	325	278	+92
6	78	71	86	76	+5
7	375	169	243	208	+39
8	139	79	104	93	+14
9	170	101	110	94	-7**
Total	**1601**	**885**	**1420**	**1220**	**+335**

* (+) means surplus

** (-) means defficiency

4.6.2 Forecasting Demand for Faculty and Staff

The total and peak parking demands were predicted for the coming ten years using two methods described in chapter three. Table (4.17) shows the predicted values of the total and peak parking demands using both methods. The surpluses and deficiencies for the coming ten years are determined in each parking area for all university sectors as shown in Table (4.18) using method two. Moreover the prediction of the peak value for the Parking areas in each sector was found by the existing ratio of the peak value for the parking area to the total peak value for that sector multiplying

by the prediction of the total peak value for the same sector. Also the future supply of parking spaces are assumed to be unchanged and equal the same as the existing supply including additional spaces at some parking areas which was improved by the university earlier. It may also decrease the number of parking spaces. There was a deficiency of 14 parking spaces at P1-2 in sector one show in Table (4.18) which could be covered by the surplus of 18 parking spaces at P1-1, also the forecasted peak will be equal to the future supply at the curb parking P1-3.

The deficiency of 34 parking spaces was occured at P2-3 in sector two which was mostly preferable by the parkers could be covered the surplus of 38 parking spaces at P2-1, therefore the parkers of civil engineering department and visitors must be prohibited to park at P2-3 and allow them to park at P2-1. In addition there was a surplus of 10 parking spaces at P2-2.

In sector three, there was a surplus of 27 parking spaces distributed as a deficiency of six parking spaces at P3-1 and surplus of 33 parking spaces at P3-2. The deficiency which was occured at P3-1 could be covered by the surpluses parking spaces at P3-2 and P5-5.

Table (4.17): Predicted Distribution Of The Total And Peak Parking Demand At Each Sector For The Academic Year 2003/2004 By Methods 1 And 2

Sector No.	First Method		Second Method	
	Total Parking Demand	Peak Parking Demand	Total Parking Demand	Peak Parking Demand
1	236	144	204	125
2	293	169	270	156
3	128	83	121	78
4	80	40	88	44
5	577	291	593	300
6	123	111	137	125
7	586	265	668	301
8	218	125	185	105
9	266	158	296	176
Total	**2507**	**1386**	**2562**	**1410**

Table (4.18): The Forecasted Peak Parking Demand In Each Parking Area At All University Sectors

Parking No.	Supply	Effective Supply (1)	Peak Hour Demand (2)	Peak Hour Condition (1) - (2)**
P1-1	65	55	37	+18
P1-2	63	54	68	-14
P1-3	22	20	20	0
P1-T*	**150**	**129**	**125**	**+4**
P2-1	71	60	22	+38
P2-2	51	43	33	+10
P2-3	79	67	101	-34
P2-T	**201**	**170**	**156**	**+14**
P3-1	77	65	71	-6
P3-2	47	40	7	+33
P3-T	**124**	**105**	**78**	**+27**
P4-1	37	31	7	+24
P4-2	66	56	37	+19
P4-T	103	**87**	**44**	**+43**
P5-1	27	23	29	-6
P5-2	21	18	23	-5
P5-3	63	54	27	+27
P5-4	101	86	132	-46
P5-5	25	21	18	+3
P5-6	25	23	15	+8
P5-7	67	57	56	+1
P5-T	**329**	**282**	**300**	**-18**
P6-1	36	31	77	-46
P6-2	61	55	48	+7
P6-T	97	**86**	**125**	**-39**
P7-1	18	15	23	-8
P7-2	17	15	27	-12
P7-3	14	13	48	-35
P7-4	39	33	59	-26
P7-5	39	33	25	+8
P7-6	67	57	59	-2
P7-7	43	37	60	-23
P7-T	237	**203**	**301**	**-98**
P8-1	79	71	100	-29
P8-2	72	61	5	+56
P8-T	**151**	**132**	**105**	**+27**
P9-1	62	53	122	-69
P9-2	83	71	54	+17
P9-T	**145**	**124**	**176**	**-52**
Total	**1537**	**1318**	**1410**	**-92**

* Total of sector no. 1

** (t) indicates surplus and (-) indicates deficiency

There was a surplus of 43 parking spaces at sector four due to the surplus of 24 and 19 parking spaces occured at P4-1 and P4-2 respectively.

There was a deficiency of 18 parking spaces in sector five. The deficiency of spaces existed at P5-1 and P5-2 would be coverd by the surplus of parking spaces at P5-3 within an acceptable walking distance. While the deficiency of parking spaces at P5-4 which was 46 space could be covered by the surplus of parking spaces at P5-6 and prepared a new parking area near to P5-4 which will provide an acceptable walking distance.

In sector six, there will be a deficiency of 39 parking spaces for private vehicles which could be covered by developing new parking area for university vehicles as shown in Figure (5.1) of the next chapter.

In sector seven; there was a deficiency of 98 parking spaces. These deficiency would be reduced after transfering the college of education sciences to their new buildings at sector ten which have 60 parking spaces.

There was a deficiency of 29 parking spaces at the curb parking P8-1 in sector eight which could be covered by the surplus of 56 parking spaces at the parking lot P8-2.

In sector nine; there was a deficiency of 52 parking spaces due to the deficiency of 69 parking spaces at P9-1 and surplus of 17 parking spaces at P9-2. A new parking area will be need to satisfy the deficiency ocured at this sector.

Table (4.19) shows the prediction peaks of parking demand according to the campus population groups of faculty, staff and visitors which was estimated by using the percentage of vehicles with stickers or without stickers as mentioned in Table (4.6). The total peak demand is 1410, parkers including 964 faculty and staff and 446 visitors.

The predicted peak value of parking demand of total vehicles in each sector will be used in the design of future parking areas according to the surpluses and deficiencies, when compared to the future effective supply.

Table (4.19): The Forecasting Peaks Of Parking Demand According To The Campus Population Groups (2004)

Sector No.	Faculty and Staff	Visitor	Total
1	77 (61.9%)	48 (38.1%)	125
2	114 (73.4%)	42 (26.6%)	156
3	58 (74.6%)	20 (25.4%)	178
4	24 (55.6%)	20 (44.4%)	44
5	207 (69.2%)	93 (30.8%)	300
6	84 (67.3%)	41 (32.7%)	125
7	203 (67.5%)	98 (32.5%)	301
8	80 (76.8%)	25 (23.2%)	105
9	117 (67%)	59 (33%)	176
Total	**964 (68.4%)**	**446 (31.6%)**	**1410**

4.6.3 Parking Demand And Supply For University Students

The total available parking spaces of students and the whole university as well were 1089 and 2509 spaces respectively. While the practical (effective capacity) was 930 parking spaces for students parking areas and 2150 parking spaces for the whole university. The existing ratio of parking space is 4.9 space/100 students while the ratio of parking space for the whole campus population is 9.9 space/100 university pop.

The surpluses and defficiencies of students parking areas were calculated by comparing the existing peak with the existing effective capacity as illustrates in Table (4-20). In addition the table shows the existing total parked vehicles which parked a day.

Also the peak demand was taken between (10:00-11:00) for students parking areas as well as the whole university student parke lots. The study found that there was a deficiency of 99 parking spaces at the existing curb parking (P4) and there was a deficiency of 91 parking spaces at the student parking lots and garage (P10). Also the parking areas five, six, seven and nine had a defecieincy of 20, 48, 16 and 37 parking spaces respectively, while the parking area eight (P8) had a surpluse of 30 parking spaces.

The existing peak of the whole university was 2005 parked vehicles with a surplus of 145 parking spaces.

Table (4.20): The Existing Total And Peak Parking Demand Of Student Parking Areas In 1994

Parking No.	Total Parking Demand	Peak Parking Demand (1)	Supply	Effective supply (2)	Peak Hour Condition (2) - (1) *
P1	276	117	110	99	-18
P2	65	43	0	0	-43
P3	68	36	0	0	-38
Subtotal (P4)	409	198	110	99	-99
P5	214	142	144	122	-20
P6	258	119	84	71	-48
P7	495	149	157	133	-16
P8	797	392	496	422	+30
P9	185	120	98	83	-37
Subtotal (P10)	1949	922	979	831	-91
Total	**2358**	**1120**	**1089**	**930**	**-190**

* (+) Means surplus and (-) Means deficiency

4.6.4 Forecasting Demand For University Students

The total and peak students parking demands are predicted for the academic year 2003/2004 by using the method described in chapter three. These values are shown in Table (4.21). In addition the surplus and deficiency were calculated by comparing the future peaks with the future

effective supply which was assumed to be unchange and equal the existing supply except the capacity of parking area seven (P7) which was decreased by the university to improve the parking area (P9-2) in sector nine because of the nearest distance to P7. The table shows that for all students parking areas there are deficiencies in the parking spaces. Therefore new parking areas should be prepared at P1, P2 and P3. In addition to satisfy the deficiency of 112, 125, 146, 224 and 115 parking spaces at P5, P6, P7, P8 and P9 respectively a new parking areas should be prepared. The forecasting peak of the whole university is 3255 parked vehicles and the future effective capacity is 2215 parking spaces with a deficiency of 1040 parking spaces.

Table (4.21): The Predicted Total And Peak Parking Demand Of Students Parking Areas In 2004

Parking No.	Total Parking Demand	Peak Parking Demand (1)	Supply	Effective supply (2)	Peak Hour Condition * (2) - (1)
P1	454	192	110	99	-93
P2	107	71	0	0	-71
P3	111	62	0	0	-62
Subtotal (P4)	672	325	110	99	-226
P5	353	234	144	122	-112
P6	424	196	84	71	-125
P7	816	246	117	100	-146
P8	1314	646	496	422	-224
P9	305	198	98	83	-115
Subtotal (P10)	3212	1520	939	798	-722
Total (P4+P10)	**3884**	**1845**	**1049**	**897**	**-948**

* (+) Means surplus and (-) Means deficiency

CHAPTER FIVE
RECOMMENDED PARKING AND TRAFFIC PROGRAM

CHAPTER FIVE
RECOMMENDED PARKING AND TRAFFIC PROGRAM

A ten-years developed parking and traffic program has been recommended to overcome main campus needs and students parking areas in year 2003/2004. However, the effective parking and traffic program was initiated to meet the parking demands and traffic generated by both existing and predicted campus activities.

This chapter presents a realistic program to improve services to traffic and parking users, also it should be adapted by university administrators to formulate policies and to issue new regulations in order to achieve technical decisions regarding campus improvement and development.

5.1 ADMINISTRATION

The responsibility of planning and administrating the traffic and parking program in the main campus may be delegated to a separate department at the university main office which may be called traffic and parking service department [TPSD]. A TPSD is a service organization which operate and maintains the campus traffic and parking functions and facilities. It should be responsible for supervision, regulations, policies, trafficlaw, enforcements, registration and parking programs.

5.1.1 Registration and Type of Modiefied Campus Badges

The owner of the vehicles which are faculty and staff utilizing campus traffic and parking facilities permanently must have a campus badge which is obtained by registering the vehicles at the TPSD.

The following points describe the rules regarding the use of the campus badges:

1- There are two types campus badges: Permanent and temporary badges. The permanent badges are issued to vehicles owned by faculty and staff while temporary badges are issued to vehicles whose owners are not the faculty and staff but they use their vehicles inside the university, also are given to the faculty and staff vehicles who are working for a limited period of time. Temporary badges may also be issued to the companies and institutions which have works inside the university of Jordan for a limited period. Moreover, there is a temporary card which is given at the gates to visitors while entering the University. This card is used once every day.

2- The badges should not transfer to any other vehicle.

3- Permanent badges have adhesive coating on one side and place it at driver's front windowpan in the upper right hand corner. While temporary badges have less adhesive coating on one side and place it on the same place as permanent badges.

4- All outdate badges must be removed completely. The owner is responsible for the badge issued to his or her vehicle. If such vehicle is sold, the badge must be removed or the owner will be responsible for any citations received on the vehicle.

5- All badges remain as property of University of Jordan and may be reclaimed at any time.

6- The permanent badge will be valid for one academic year starting from the 1 st of September through 31 August. While the temporary badge will be valid for one month to less than a year.

Badges may be color coded according to their types to provide controlled entering operations. Therefore, the TPSD provides four types of campus badges as follows:

1- Red badges: issued for authorized university persons such as university president and V.president and dean of each college.
2- Green badge (permanent badge) for faculty and staff members
3- Blue badge (temporary badge) for faculty, staff, institutions and companies which have works inside the university for a limited period.
4- Orange card for visitors to enter the university for only one time.

5.2 PARKING IMPROVEMENTS

The outputs resulting from the analysis of data were necessary to determine the parking demand and locations which have surpluses or deficiencies. Moreover, any parking program should cover the needs and demands in the study area.

The proposed Parking improvements may be summarized as follows:

1- Adding more spaces where the deficiencies occur by selecting new parking areas or using the surpluse spaces by other adjacent parking areas within an acceptable walking distance.
2- Designing the parking entrances and exits to provide suitable contact point with the surrounding areas and to decrease hazardous points.
3- Up-grading and surfacing of the parking facilities with good pavement conditions. The facilities should be regularly maintained.
4- Signing at the entrances and exits and markings should be used to aid motorists to park their vehicles with greater safety and convenience.
5- Lighting the parking areas especially if the parking facilities are expected to be used at night.

5.2.1 Campus Parking Improvements

Location consideration should insure the most efficient use of existing facilities from the standpoint of convenience. The hypothesis for the parking design is based on the assumption that will accept resonable walking distance not more than 100 meters. This Figure is considered acceptable by many staffs, visitors, and others. The following improvements are suggested as illustrated in Figure (5.1):

Sector One:

There is a deficiency of 14 parking spaces at P1-2 which would be covered by the surplus of 18 parking spaces at P1-1.

Moreover, the study suggests a 28 and 20 parking spaces at P1-1 and P1-2 respectively for parked vehicles of visitors and temporary badges.

Sector Two:

There is a deficiency of 34 parking spaces at P2-3 which could be covered by the surplus of 38 parking spaces at P2-1, also the vehicles of visitors and temporary badges will be prohibited to park at P2-3 and allow them to park at P2-1 in the lower level of civil engineering department. In addition the parking area P2-1 will serve the faculty and staff of civil engineering department.

However, the trees along the street to the parking area P2-1 must be removed to decrease the hazards which result from the inadequate sight distance.

Sector Three:

The deficiency in the parking area P3-1 can be served by the excessive supply available in P3-2 and P5-5. In addition, the number of parking spaces will be provided for the vehicles of visitors and temporary badges are equal 20 space for both P3-1 and P3-2.

The study found that it is necessary to close one of the exit and entrance at P3-1 and use the road between the graduate and agriculture college in order to provide a safe road for high number of pedestrians in front of agriculture college. However, this will need to increase the width of pavement of the road between the graduate and agriculture college as shown in Figure (5.1).

The illegal curb parking along the street between the chemistry and agriculture building will be prohibited by allocating signs.

Sector Four:

There is no problem of parking spaces because the future supply is greater than the future demand. In addition, the vehicles of visitors and temporary badges can be parked at P4-1 and P4-2 with 10 parking spaces for each.

The illegal curb parking along the street in front of students affairs of deanship will be prohibited by placing signs.

Sector Five:

The deficiency of six and five parking spaces at P5-1 and P5-2 respectively can be covered by the surplus of 27 parking spaces at P5-3.

While the deficiency of 46 parking spaces at P5-4 will be satisfied by preparing a new parking site [A] within an acceptable walking distance which has an area of 900 square meters and yields a practical ssupply of 38 parking spaces, in addition to the surplus of eight parking spaces at P5-6.

The vehicles of visitors and temporary badges will be distributed as 5, 5, 5, 50, 5, 10 and 13 at the parking areas P5-1, P5-2, P5-3, P5-4, P5-5, P5-6 and P5-7 respectively.

The study suggests to close one of the exit and entrance of the parking area P5-4 which is located at the intersection, therefore the obstacles which

closed the roadway leading to the admission and registration office will be opened and controled by the guard.

Sector Six:

There are a deficiency of 46 parking spaces at P6-1 which can be satisfied by the 58 parking spaces available for parked university vehicles after transferring these vehicles to a new site [B] which has an area 3250 square meters and yields a practical supply of 138 parking spaces as shown in Figure (5.1).

The vehicles of visitors and temporary badges can be parked at the previous parking area university vehicles.

Sector Seven:

The deficiency of parking spaces at P7-2, P7-3, P7-4, P7-6 and P7-7 can be covered after transferring the education sciences college to the new buildings. While the deficiency of eight parking spaces at P7-1 will be satisfied by adding 10 parking spaces at site [c] which has an area 235 square meters within an acceptable walking distance as shown in Figure (5.1).

Sector Eight:

The deficiency of 29 parking spaces at the curb parking P8-1 can be served by the excessive supply of 56 parking spaces at the parking lot P8-2. Also, the vehicles of visitors and temporary badges will be parked at P8-2 of 25 parking spaces.

Sector Nine:

The deficiency of 69 parking spaces can be satisfied by the surplus of 17 parking spaces at P9-2 and developing a new parking garage at site [D] which has an area 3000 square meters and yields a practical supply of 545

parking spaces and five-levels. The lower level will be served only the faculty, staff and visitors entered to it from inside and outside university while the upper levels will be served by the students entered to it from outside university only.

The vehicles of visitors and temporary badges will be allowed to park at the lower level of the new parking garage of 59 parking spaces.

The illegal curb parking along the street beside the consultation center will be prohibited by placing necessary signs.

Sector Ten:

Consists of the new buildings of education sciences college which will start to educate next year, therefore it is need to study later the parking areas in this sector.

5.2.1.1 Parking Policy :

Parking policy is an extremely important part of any transportation plan. However, public policies on parking development should be based on how a parking program can best be developed and administered rather than on who has the responsibility for providing and operating the parking facilities.

The parking policy of this study are the following points:

A- Providing additional parking spaces and the parking areas should be identified by the sector and parking number as shown in Figure (5-2) while the parking spaces should be identified by a letter corresponding to the type of campus badges as shown below:

1- Parking space Type [A] corresponding to faculty members with red badges.

2- Parking space Type [B] corresponding to faculty and staff members with green badges.

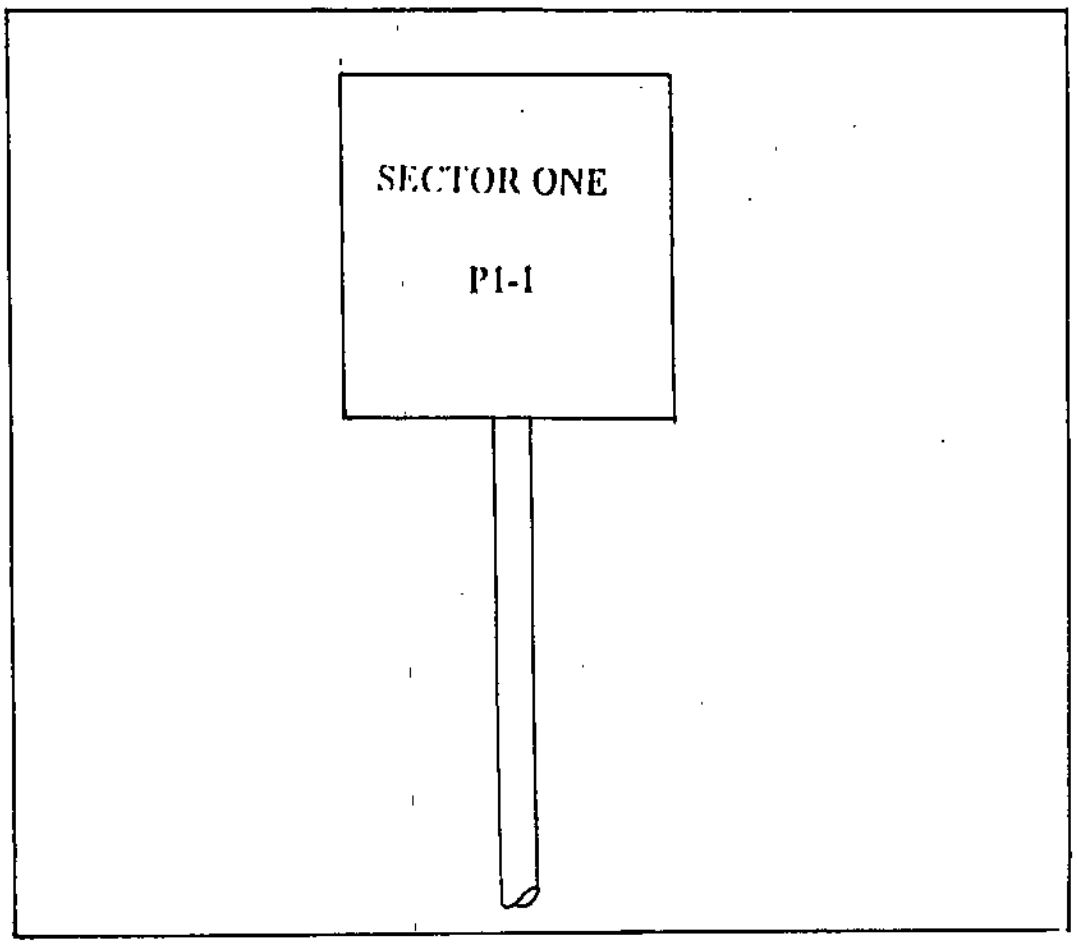

Figure (5.2): Typical Parking Signs Proposed For University Main Campus

3- Parking space Type [C] corresponding to the vehicles with blue temporary badges and orange temporary card.

B- Encouraging the ride sharing program in general by increasing the fees of parking areas, restricting the parking spaces and improving the mass transportation. However, this policy is not analyzed in the study.

5.2.1.2. Parking Regulations:

1- Vehicles should park only in spaces that are marked by signs to match their type of badges. Moreover, type A can be parked in any parking spaces (A,B and C) while type B can be parked in the parking spaces B and C at their sectors where they work. However, type C can park only in the C parking spaces.

2- Many faculty members have lectures in more than one place on campus or they visit other sectors for such a purpose, they are permitted to park within any other parking area on the campus, i.e. parking space type c, but they are not allowed to park in A and B.

3- The following practices should be specifically prohibited:
   a- Double parking
   b- Parking in front of driveways, building entrances or in any location which may cause hazard to other vehicles or pedestrians.
   c- Parking on lawns, landscaped areas, sidewalk, or other areas not designated for parking.

4- The Parking violations include the followings:
   a- When a parked vehicle creates hazard to other traffic or obstructs a street or parking area.
   b- The vehicle is illegally parked in any area on campus.
   c- When the vehicle is parked in violation to the lot posted signs which limit parking to specific badges.
   d- Fraudulent use of the badge.

e- Disregarding instructions and posted signs.

f- Driving too fast along the campus streets and parking.

The type and number of badge may be used as a good indication to record any violation, and to identify the drivers violating campus regulations. Finally, all drivers should held responsible for any vehicle operated inside the campus which is registered to them they operate. Therefore, the type of badges A and B and temporary badges of type C must be numbered while the licence plate number of temporary card type C must be recorded and cooperated with security department for getting the violations of visitors vehicles.

5.2.1.3 Parking Enforcement

Parking enforcement means providing a service to the faculty, staff and visitors. Enforcement should provide a service to those who have followed the parking regulations established by TPSD to maximize the benefits to the authorized user as developed over number of years. The following principles should be considered:

1- The violater of the parking regulations should be charged by the university or TPSD.
2- The TPSD reserve the right to have the vehicle of any violater physically removed [towed] from the campus.
3- The TPSD reserve the right to revoke campus badges to any individual who fails to comply with parking regulation.

The persons who would record and monitor the traffic and parking violations should be employed by the TPSD and they should be trained efficiently to understand their duties.

5.2.2 Students Parking Improvements:

The students parking areas are improved to satisfy the current and projected 10-years parking demands. The location of proposed sites are shown in Figure (5.1) and their characteristics are described below:

1- The future deficiency of 93 parking spaces along the legal curb parking of service road (P1) can be served by opening the closed service road which is parallel to the existing one and provides 36 of curb parking spaces. Also, the study suggests a new parking site [E] which has an area 3525 square meters and yields a practical supply of 150 parking spaces which can be served the deficiency of 38 and 112 parking spaces at the parking areas one (P1) and five (P5) respectively. The proposed site is located in a trees land and free of any construction.

2- The future peak of 71 vehicles at the illegal curb parking (P2) and the future deficincy of 115 parking spaces at the parking lot (P9) can be satisfied by developing a new parking garage at site [F] which has an area 3600 square meters and yields a practical supply of 393 parking spaces with three levels. The location of proposed site is free of any construction.

3- The future peak of 62 vehicles at the illegal curb parking (P3) can be served by proposing a new parking lot at site [G] which has an area 1750 square meters and provides a practical supply of 75 parking spaces. The proposed site is located in trees land and free of any construction.

4- The future peak of 196 vehicles at the parking lot five (P5) can be served by the new parking garage with five levels at site [D] which has an area 3000 square meters and yields aspractical supply of 545 parking spaces. The new parking garage will be covered the future peak of 246 vehicles at the parking lot seven (P7). However, the upper four levels will be used by vehicles of students entered to it from the service road. The proposed site is located over the existing parking lot seven (P7).

The study found that it is necessary to cancel the parking lot six (P6) for the following reasons :

a- To decrease the congestion and delay time at the conflict area of the exit and entrance of P6 with the service road, Moreover the buses were parked near to P7.

b- To decreace the conflict between the pedestrians and vehicles because of existing pedestrian tunnel near to the exit of P7.

5- The deficiency of 224 parking spaces at the parking garage eight (P8) can be satisfied by the higher level with available supply of 108 parking spaces. In addition, a new parking lot at site [H] will be prepared near to P8 which has an area 3055 square meters and yields a practical supply of 130 parking spaces. The location of the new parking area is free of any construction and trees.

5.3 CAMPUS TRAFFIC IMPROVEMENTS

5.3.1 Entrance and Exit Gates

The entering and exiting vehicles which are destined inside the university to sectors two and five could enter from khaleel Al-Sakit street (back street of university) by constructing a new gate G6 at this location to serve those vehicles as shown in Figure (5.1). The new gate will decrease the traffic entered from gate G2 due to the lower travel time results from the near distances between G6 and sectors two and five.

The Gates G1 and G2 will be redesigned as shown in Figure (5.1) to provide safety and decrease the congestion and delay time.

The following consideration should be taken in order to simplify traffic control and to insure efficient, safety and convenient travel movements at campus gates:

1- Gates should be attractively designed and clearly defined and adequately supplied with traffic signs and marking.

2- The entering traffic should be separated from the exiting traffic by barries or marking.

5.3.2 Traffic Circulation

1- Two-way traffic movements should be manipulated to achieve simplified circulation and provide maximum convenience.

2- All campus users and visitors, require a clear graphics system plan. Street should be signed with simple, direct, and unconfusing messages. However, the traffic signs and markings should provide drivers informing about regulation and warning while driving in the campus.

3- Speed limit at university main streets should be 40 kilometers per hour and at minor university streets should be 30 kilometers per hour.

4- Adequate maintenance is necessary to provide efficient and safe driving at the campus.

5- The least pavement width of the major and minor campus streets must not be less than 10 and 6 meters respectively.

6- The existing location and characteristics of the intersections may be used as they are, with some improvements to provide safer, more capacity, and efficient vehicles movements as shown in Figure (5.1) including the following improvements:

a- Provide the required traffic signs and markings.

b- Reduce pedestrian-vehicle conflict points and assign pedestrian cross-walks

c- Increase the width of pavement at the intersection.

d- Separate the turning movements with islands or markings.

7- All accidents must be reported and registered at the TPSD.

8- Restricted access drives may be developed. Generally, these should be closed to campus traffic but may be accessable for delivery or emergency vehicles.

5.3.3 Pedestrians Needs:

Pedestrian must have the right of way on the campus street network. Any vehicle should yield for pedestrians while crossing the street at properly marked and posted crosswalks. The sidewalks must be wide enough to accommodate the high pedestrian volume, however, the sidewalk must not be less than two meters.

The street with high pedestrian volume must be considered as a pedestrian street, therefore the vehicles are prohibited to drive throug it.

In addition, the study suggests two medium size buses with seating capacity of 20-25 seats to transfer the pedestrian along the main street between the north and south gates with a little fee to recover the cost of buses operation.

5.4 CAMPUS RECOMMENDED PROCEDURE FOR IMPROVEMENTS IMPLEMENTATION

Recommended previous improvements mentioned in the proceeding sections are affected by several physical, financial, and University policies constraints. These constraints can be very influential to the extent that some of the improvements need to be altered or completely abandoned. The interaction between the desired objectives and improvements and these constraints are illustrated in Figure(5.3).

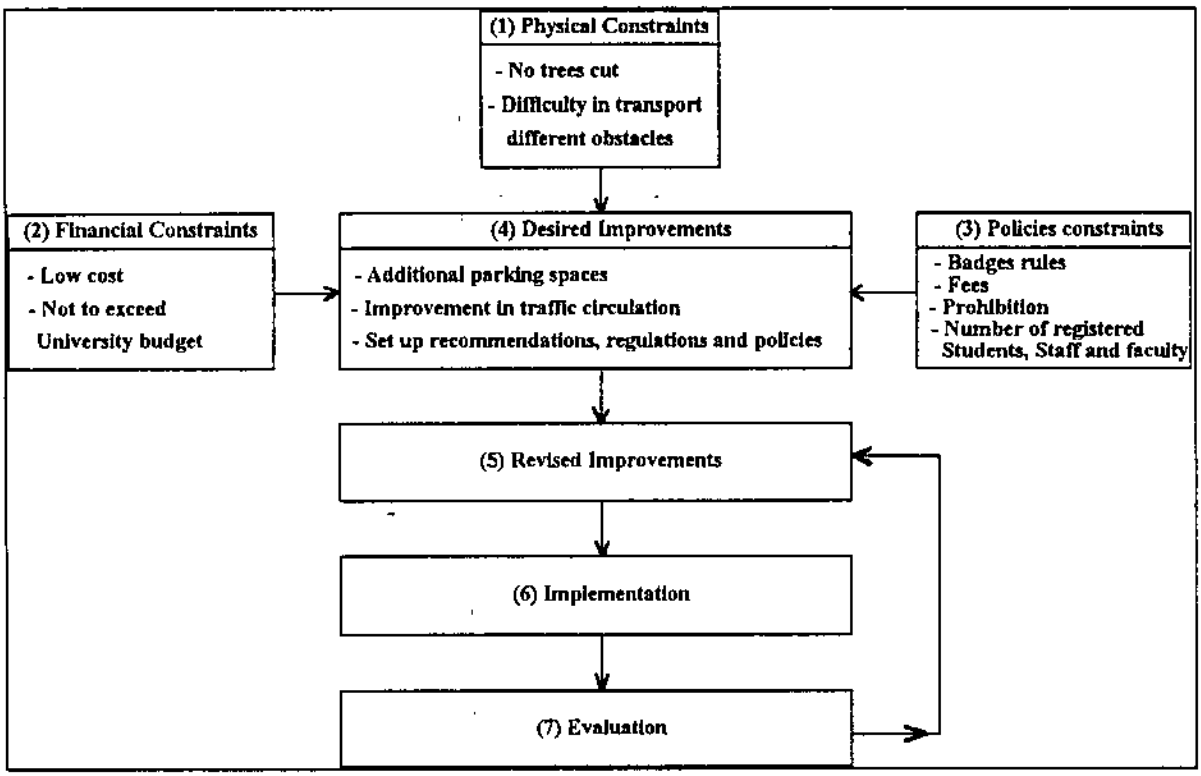

Figure (5.3): Recommended Procedure for Improvements Implementation

CHAPTER SIX
SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

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6.1 SUMMARY OF CONCLUSIONS

The following conclusions and findings were reached for the study results which will summarize the traffic and parking conditions at the campus of University of Jordan :

1- The campus total population of the University of Jordan during the academic year 1993/1994 was 25387 distributed as: 910 faculty members, 2056 staff members, and 22421 students. However, the predicted population in year 2003/2004 was expected to be 30661 distributed as:

1112 faculty members, 2602 staff members, and 26947 students.

2- On a weekday basis, the total number of vehicle entering the campus between 7:00 a.m. to 5:00 p.m. was 3541.

   a- The total vehicles entering from north gate (G1) were 1490 (42.1%) vehicles, from south gate (G2) 1878 (53%) and 173 (4.9%) from other gates (G3, 4 and 5).

   b- The peak hour of entering vehicles to the campus [1070 vehicles] occured between 7:00 to 8:00 a.m.

3- The maximum vehicles accumulation inside the university campus was 915 vehicles which occured between 11:00 a.m. and 12:00 noon.

While the accumulation of parked vehicles at the university was increased after 8:00 a.m. until reach the peak hour between (10:00-11:00) a.m. after that decreased slightly to 1:00 p.m. which would then decrease more between (1:00-2:00) p.m. during the lunch hour then decrease slightly and would decrease more until 5:00 p.m..

4- The existing peak parking demand of the whole university was 2005 vehicles occured between 10:00 to 11:00 a.m., while the existing parking supply was 2150 which results in a surplus of 145 parking spaces distributed as follows:

   a- The existing peak parking demand of university sectors is 885. However the existing effective capacity was 1220 parking spaces which results in a surplus of 335 parking spaces.

   b- The existing peak parking demand of students parking areas was 1120 vehicles and the existing effective capacity was 930 which will result deficiencies of 190 parking spaces.

5- The future peak parking demand of the university will be 3255, and the future practical supply will be 2215 which will result in a defficiency of 1040 parking spaces distributed as follows:

   a- 92 Parking spaces at university sectors according to the differences between the future peak parking demand and effective supply which are equal 1410 and 1318 respectively.

   b- 948 parking spaces at university student parking areas according to the differences between the future peak parking demand and effective supply which are 1845 and 897 respectively.

6- The following ratios were obtained by the study:

   a- The ratio of campus parking per registered vehicles of faculty and staff was found to be 0.79 space/registered vehicle.

   b- The existing ratio of parking space per 100 university population for total university was equal 9.9 spaces/100 population

   c- The existing ratio of parking space per 100 student was equal 4.9 spaces/100 students.

   d- The parking generation rate for total university was equal 2.19 space/1000 square meters.

7- The results of calculated average walking distance, parking duration and turnover are the following:

a- The average walking distance of parkers at the campus was 49 meters while the average walking distance of parkers at the students parking lots and garage was 410 meters.

b- The average parking duration for the whole university was 4 hours and 12 minutes. However, the average parking duration for university sectors was equal 4 hours and 4 minutes and for students parking areas was equal 3 hours and 48 minutes.

c- The average turnover for the total university was equal 1.7 vehicles/ space. The average turnover for all university sectors was equal 1.29 vehicles/space and for students parking areas was equal 2.22 vehicles/space.

6.2 SUMMARY OF RECOMMENDED TRAFFIC AND PARKING PROGRAM

6.2.1 Parking Program

1- The responsibility of planning and administration of traffic and parking program should be delegated to a new office initiated at the university and to be called the traffic and parking service department [TPSD].

2- All faculty and Staff vehicles should be registered in order to get a campus badge to allow them to enter the campus. Four types of colour badges were proposed by the program, which should be issued for authorized university persons, faculty and staff members, companies and institutions which have works inside the university, and visitors who are issued a temporary permit card.

3- Three types of parking spaces are recommended corresponding to the type of badges. These are :

[a] Spaces for authorized persons with red badges.

[b] Spaces for faculty and staff with green badges.

[c] Spaces for vehicles of visitors with orange card and temporary badges with blue badges.

4- Regulatory signs should be located at the parking areas in order to be easily identified by parkers to regulate the locations of parking areas in each sector. Each sign is designed to clasify sector and parking number. The parking spaces are identified by letters according to the type of badges (A, B and C).

5- The program provided clear, direct, and effective parking enforcement measures to regulate traffic movements and parking services in addition to control the violators by the TPSD.

6- The program recommended the most preferable and efficient parking locations and design by establishing a priority system based on relative need and maintaining an acceptable or reasonable walking distance [not exceeding 100 meters].

7- The design of parking areas are carried out at each sector and student parking area to meet the predicted peak parking demand. Therefore, a new parking areas are proposed as shown in Table (6.1).

Table (6.1): Summary of Recommended Sites of Parking Areas

Proposed Parking Sites	Area (m^2)	Capacity Of Proposed Parking Sites (Spaces)	Characteristics Of Proposed Sites	The Location Of Proposed Sites
[A]	900	38 *	parking lot	sector five
[B]	3250	138	parking lot	sector six
[C]	235	10	parking lot	sector seven
[D]	3000	545 **	parking garage	sector nine and parking seven
[E]	3525	150	parking lot	parking five
[F]	3600	393	parking garage	parking nine and two
[G]	1750	75	parking lot	parking three
[H]	3055	130	parking lot	parking eight

* Proposed area of parking spaces = 23.5 m^2/space.

** proposed area of parking spaces for garages = 27.5 m^2/space.

8- The deficiency of parking spaces at P2-3 can be covered by the surpluses of parking spaces at P2-1 and by prohibiting the vehicles of visitors and temporary badges to park at P2-3.

9- The closing service road must be opened and the student parking area six (P6) should be canceled.

10- Adequate fees should be charged by TPSD for each registered vehicle to recover the cost of overall traffic and parking services.

6.2.2 Traffic Program

The traffic program involved many improvements for traffic operations and intersections design in order to improve traffic control and insure safe and convenient driving within the campus. The program considered the following points :

1- A new gate is recommended at the eastern side of the university to serve the vehicles using khaleel Al-Sakit street, and serve the destinations of vehicles at sectors five and two.

2- Redesign the north and south gates.

3- Clear, simple and direct traffic signs and markings were proposed as an active control devices to inform drivers, regulate, and warn vehicles while driving inside the campus.

4- 40 kph and 30 kph speed limit were proposed along the major campus street and minor streets respectively.

5- Pedestrian streets should be seperated from vehicles and new locations for pedestrian crossing were proposed as shown in Figure (5.1).

6- Redesign the main campus intersections as shown in figure (5.1) to provide more safe and efficient driving.

7- The study suggests two medium size buses for transfering the pedestrian along the main road between the north and south gates.

6.3 RECOMMENDATIONS FOR FURTHER STUDIES

Additional research may be conducted to overcome the problems and limitations of the recommended program. These include:

1- Additional research is still needed to study and analyze the pedestrian characteristics at the University of Jordan in terms of building the basic relationships between pedestrian volume, density, speed and space. Interview of pedestrian parkers is needed in order to know their requirements such as acceptable walking distance.

2- Study the parking areas at sectors seven and ten after the college of education sciences is transfered to its new buildings.

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REFERENCES

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APPENDIX A

A:1 REGRESSION EQUATIONS

(1) Dependent Variable : Faculty

Independent Variable	Estimated Coefficient	Standard Error	T-Statistic
One	6.77473e+002	23.91695	28.32605
year	21.70909	3.52636	6.15623

$$Y = 6.77473 * 10^2 + 21.70909x$$

Number Of Observations	11
R-Squared	0.80810
Corrected R-Squared	0.78678
Sum Of Squared Residuals	$1.23109 * 10^4$
Standard Error of the Regression	36.98479
Mean of Dependent Variable	$8.07727 * 10^2$

(2) Dependent Variable : Staff

Independent Variable	Estimated Coefficient	Standard Error	T-Statistic
One	1.53189e+003	27.07938	56.57050
year	52.17549	3.04828	17.11639

$$Y = 1.53189 * 10^3 + 52.17549X$$

Number Of Observations	11
R-Squared	0.96699
Corrected R-Squared	0.96369
Sum Of Squared Residuals	$2.93859 * 10^4$
Standard Error of the Regression	54.20879
Mean of Dependent Variable	$1.91017 * 10^3$

(3) Dependent Variable : Student

Independent Variable	Estimated Coefficient	Standard Error	T-Statistic
One	7.80945e+003	9.55654e+002	8.17183
year	1.69379e+003	2.18673e+002	7.74579
year * year	-35.04808	9.73037	-3.60193

$$Y = 7.80945 * 10^3 + 1.69379 * 10^3 X - 35.04808X^2$$

Number Of Observations	11
R-Squared	0.95784
Corrected R-Squared	0.94847
Sum Of Squared Residuals	$1.32900 * 10^7$
Standard Error of the Regression	$1.21518 * 10^3$
Mean of Dependent Variable	$1.73236 * 10^4$

A:2 SAMPLE OF CALCULATION AT SECTOR ONE

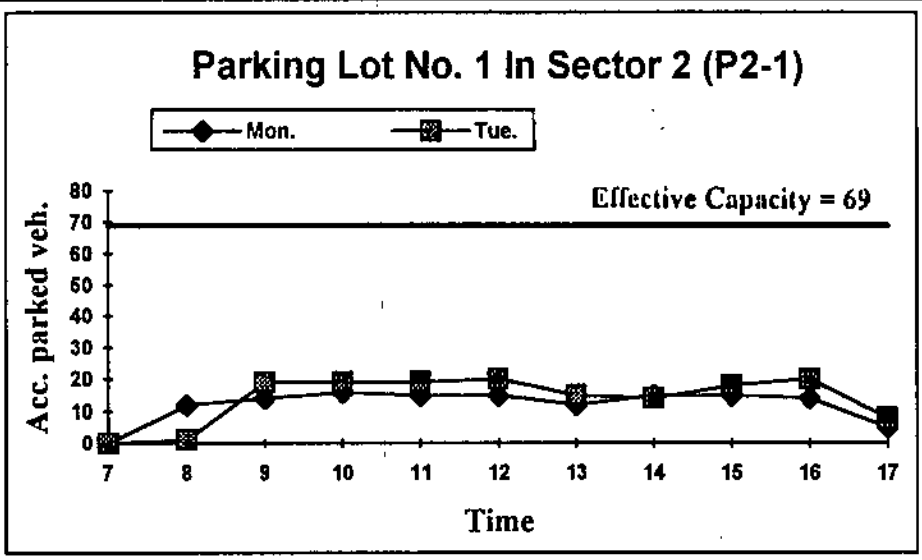
- The existing total parked vehicles = 150 veh.
- The percent of total parked vehicles with stickers = 61.9%
- The existing parked faculty and staff vehicles = 150 * 0.619 = 93 veh.
- The existing percent of (parked faculty and staff vehicles/ faculty and staff car ownership) = $\frac{93}{(208+83)} * 100\% = 32\%$
- The existing parked visitors vehicles = 150-93= 57 veh.
- The existing faculty numbers = 208
- The existing faculty car ownership = 208 faculty - veh.
- The percent of faculty car ownership = $\frac{208}{208} * 100\% = 100\%$
- The growthe factor of faculty car ownership = 1.00
- The existing staff numbers = 150 staff
- The existing staff car ownership = 83 staff-veh.
- The percent of staff car ownership = $\frac{83}{150} * 100\% = 55.3\%$
- The growth factor of staff car ownership = 1.37
- The future faculty numbers = 254 faculty
- The future faculty car ownership= 254*1.00= 254 faculty-veh.
- The future staff numbers = 186 staff
- The future staff car ownership = 186 * 0.553 * 1.37 = 141 staff-veh.
- The future parked faculty and staff vehicles = (254 + 141) * 32% = 126 veh.
- The future total parked vehicles = $\frac{126}{0.619} = 204$veh.

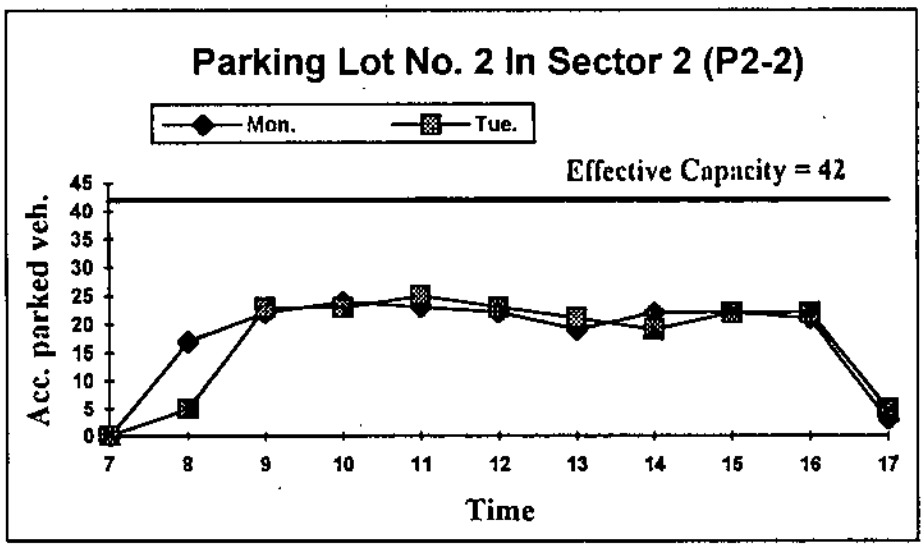
- The existing peak = 92
- The percent of $\left(\frac{\text{existing peak}}{\text{existing total parked vehicles}}\right) =$

$\frac{92}{150} * 100\% = 61.3\%$

- The future peak = 104 * 0.613 = 125 veh.
- The future peak of faculty and staff = 125 * 0.619 = 77
- The future peak of visitors = 125 * 0.381 = 48 veh.

APPENDIX B





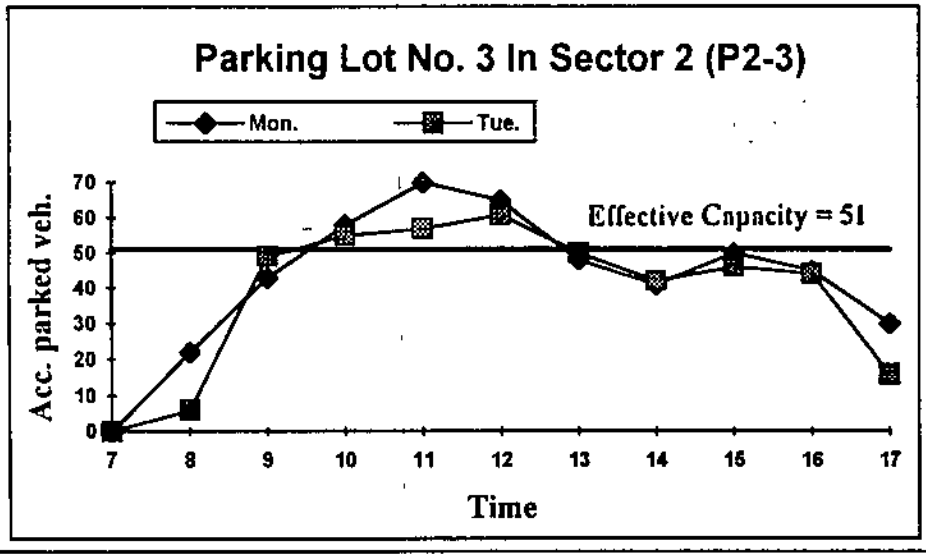
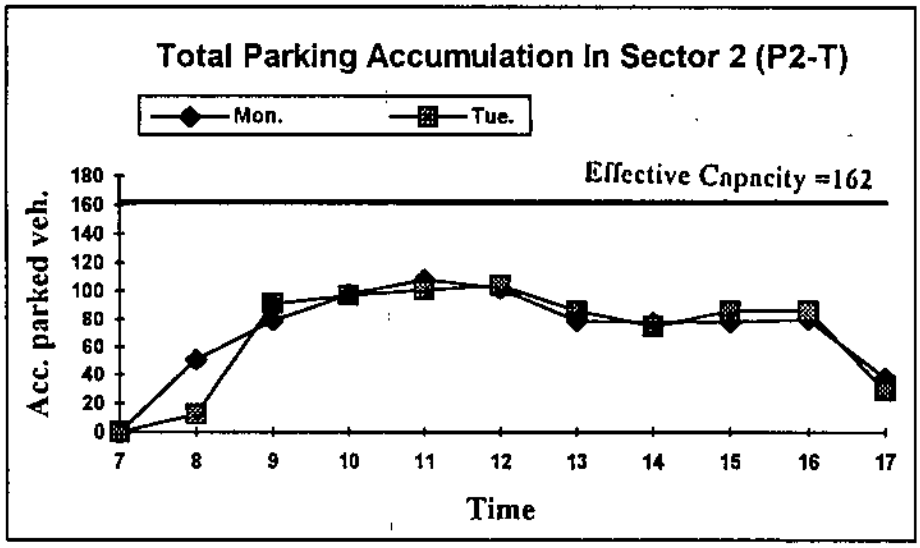


Figure (B-1): The Accumulation Of Parked Vehicles In Sector Two



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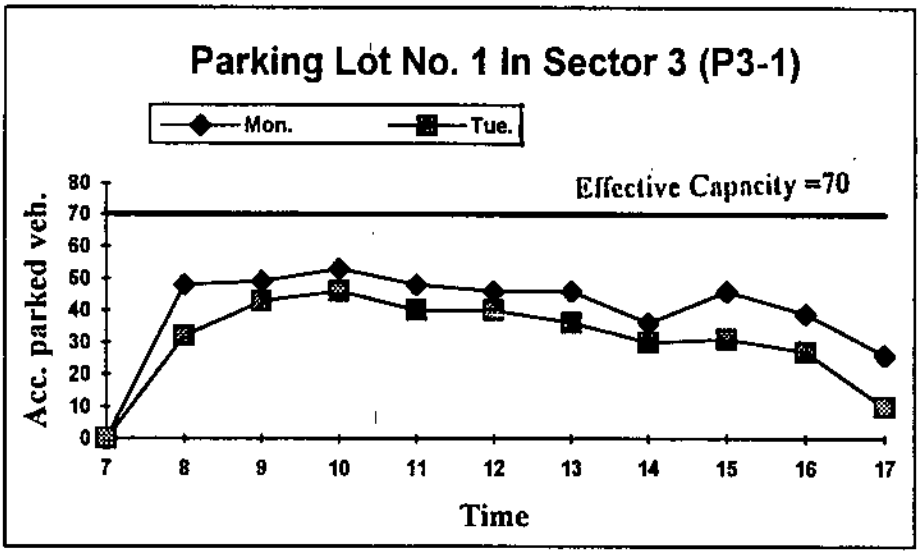
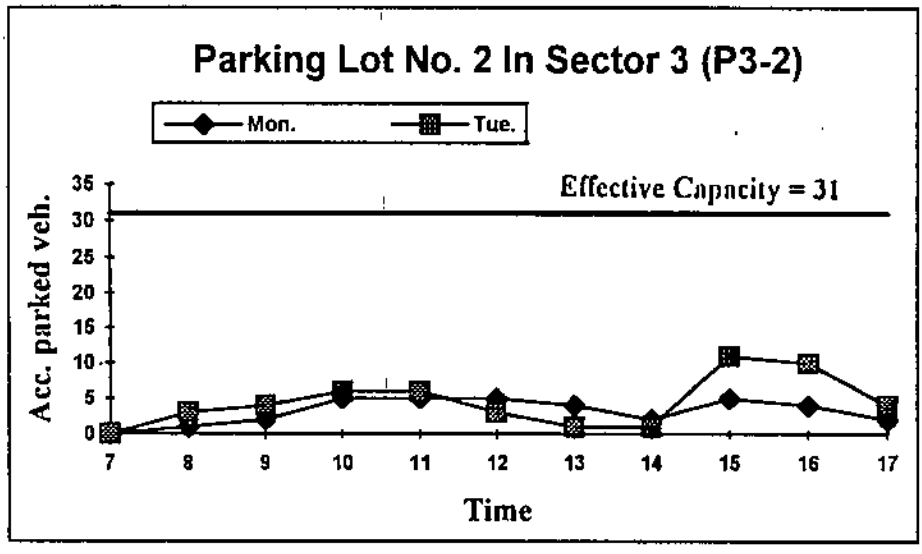




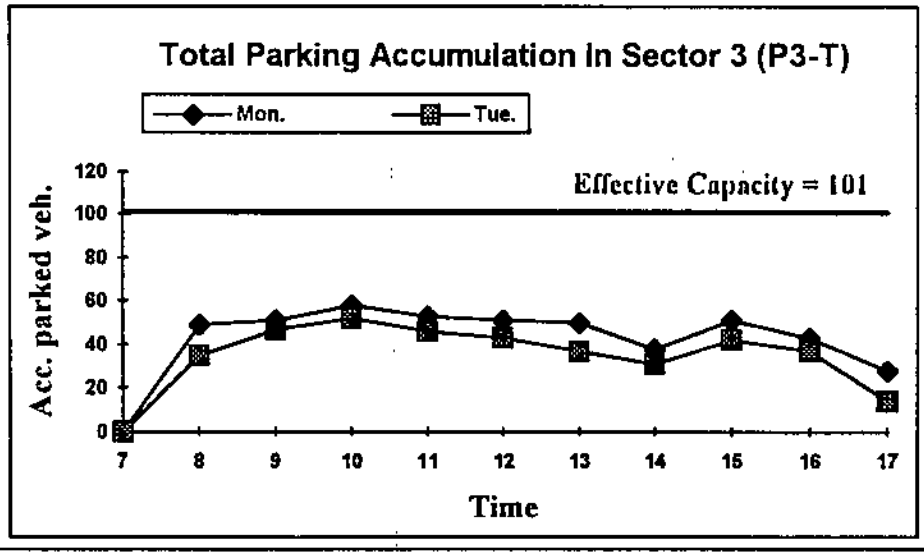
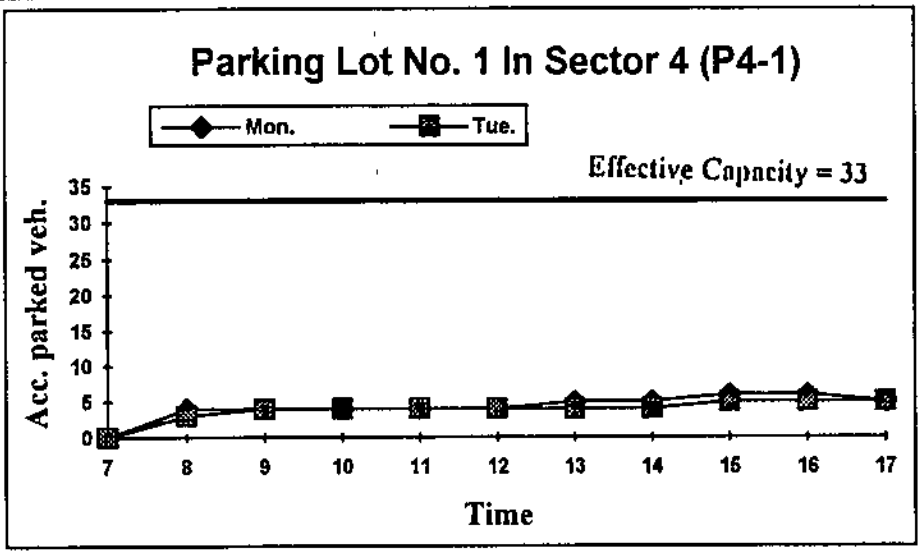
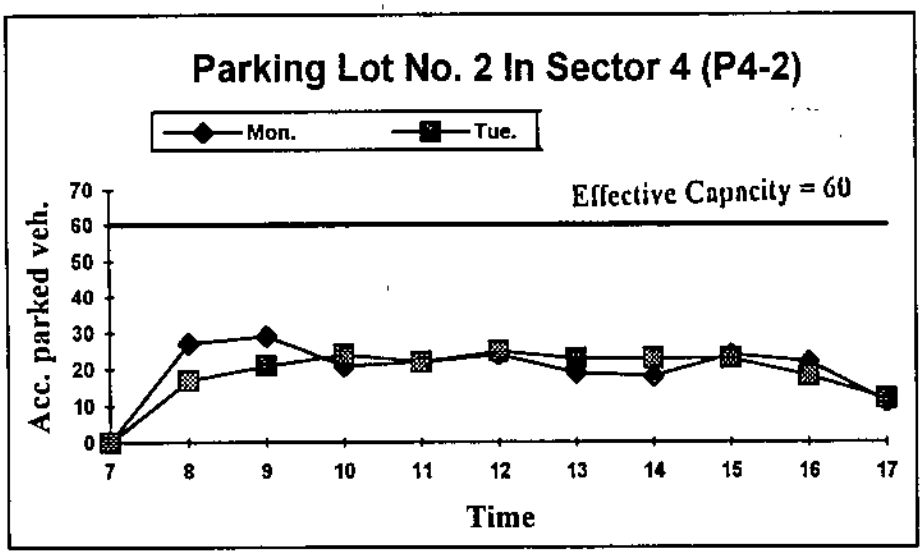


Figure (B-2): The Accumulation Of Parked Vehicles In Sector Three





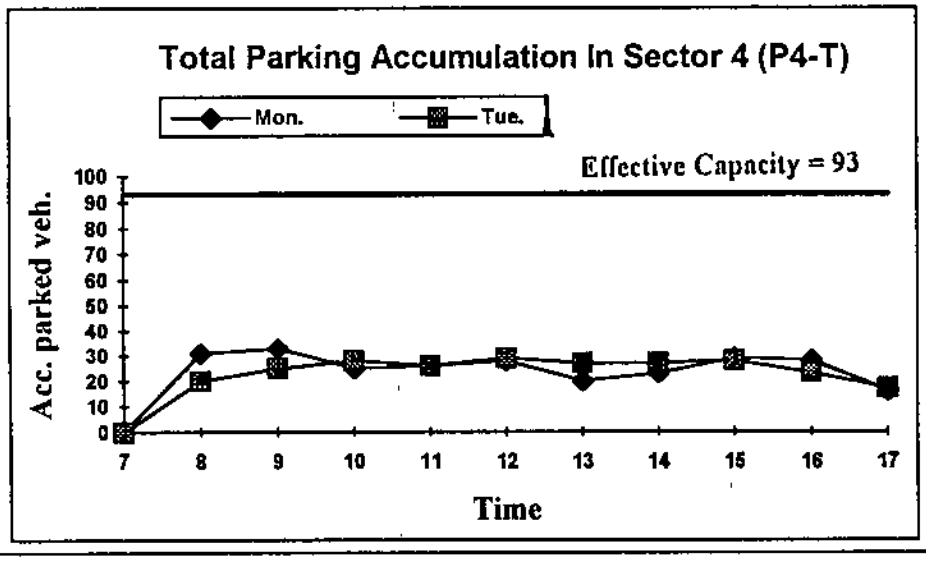
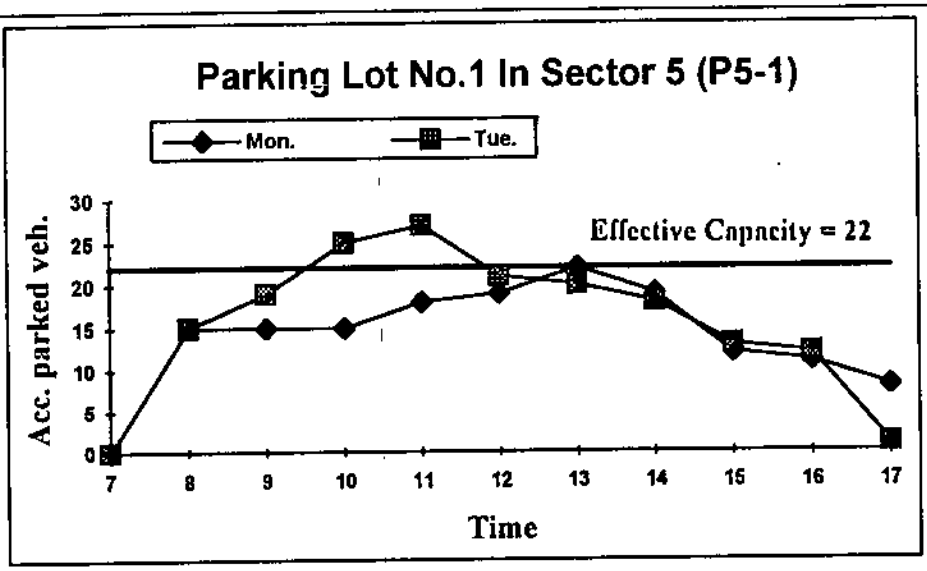
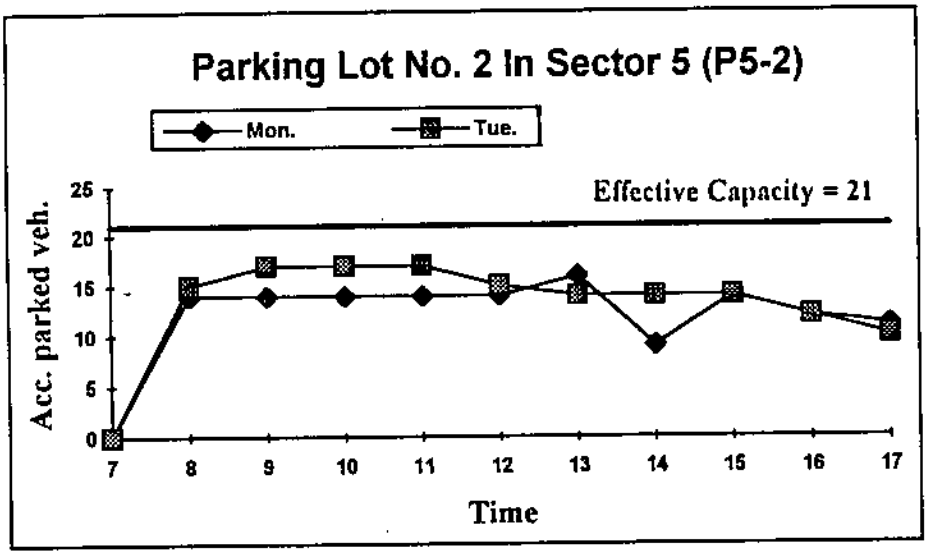


Figure (B-3): The Accumulation Of Parked Vehicles In Sector Four





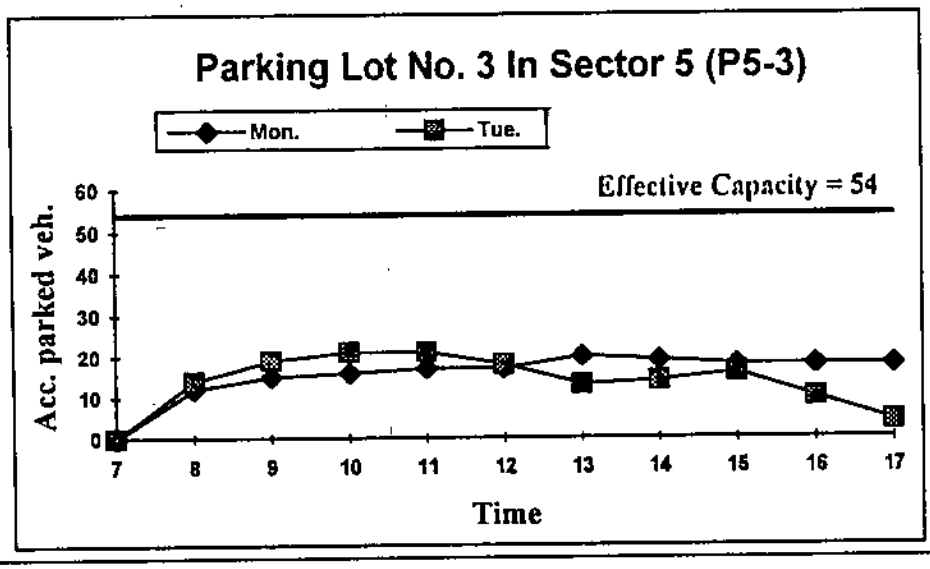
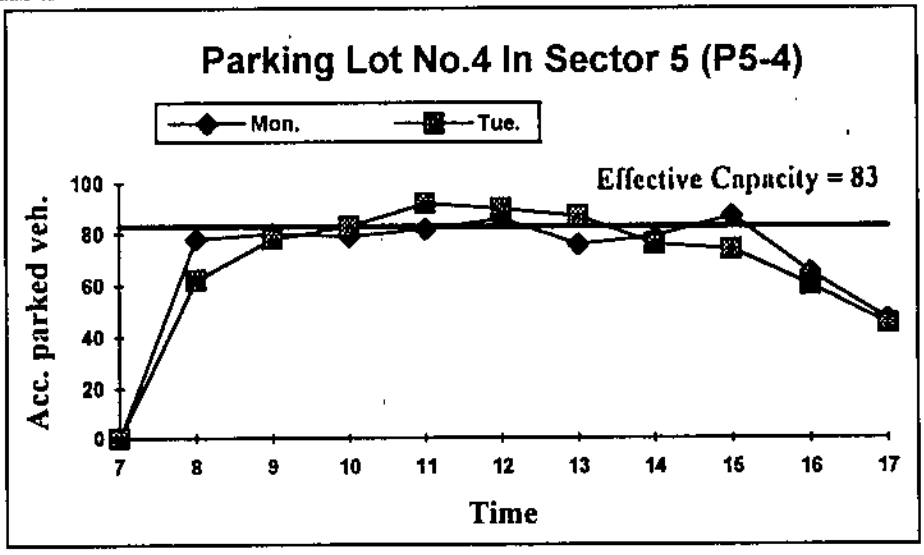
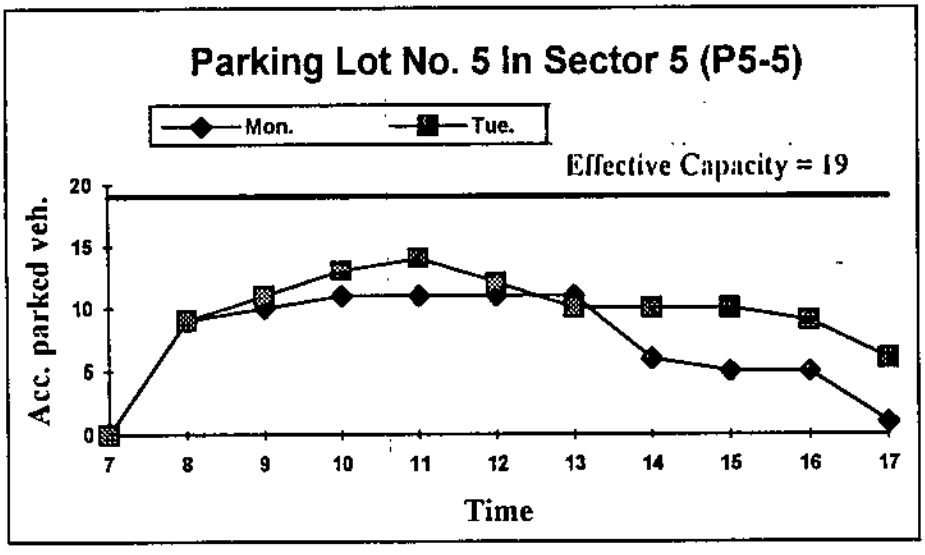
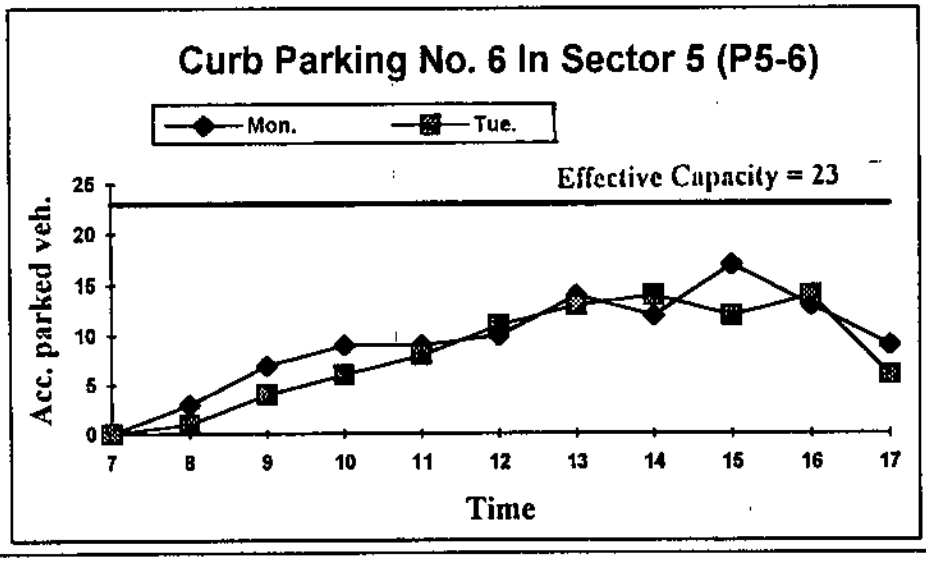


Figure (B-4): The Accumulation Of Parked Vehicles In Sector Five







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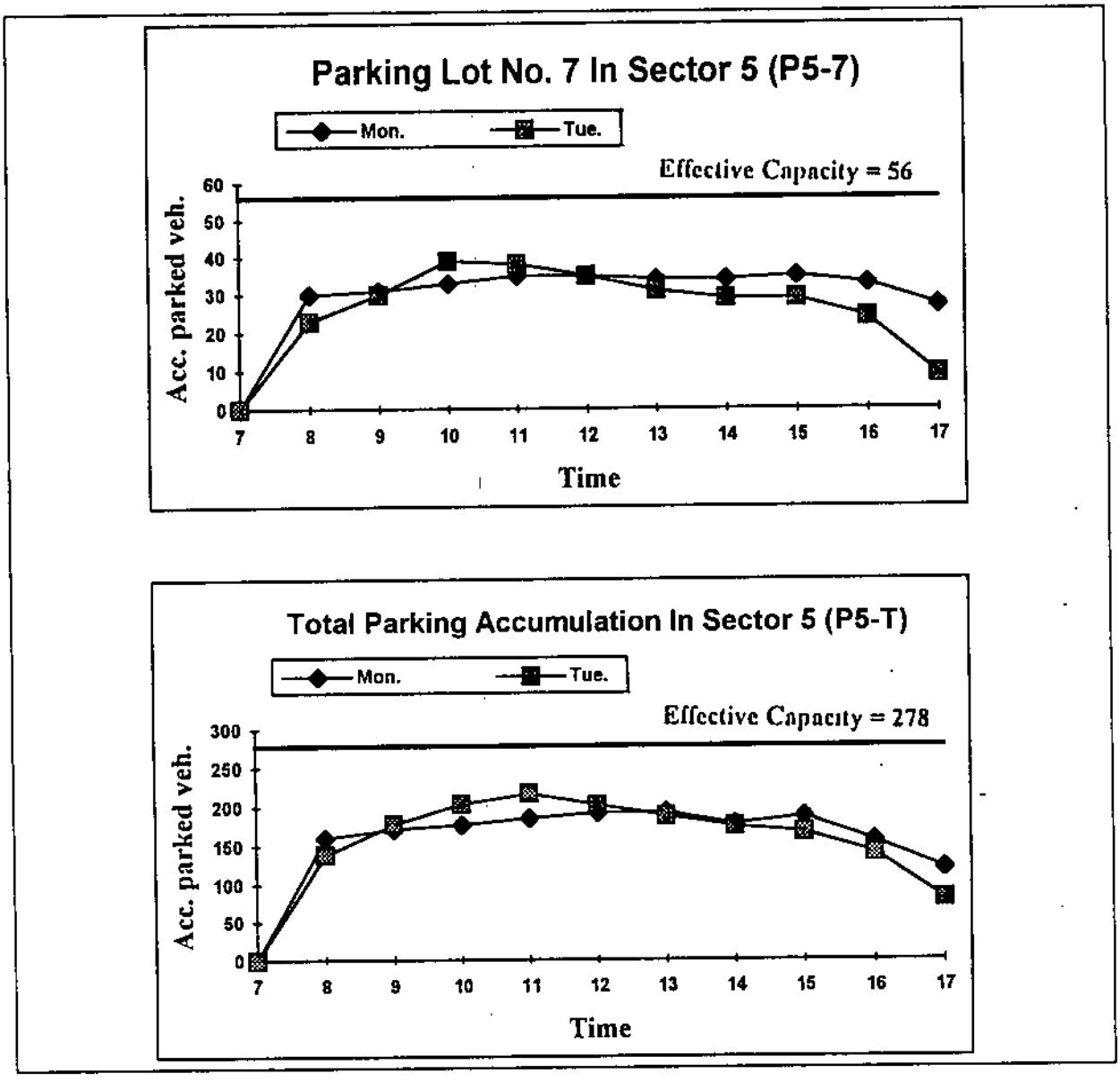

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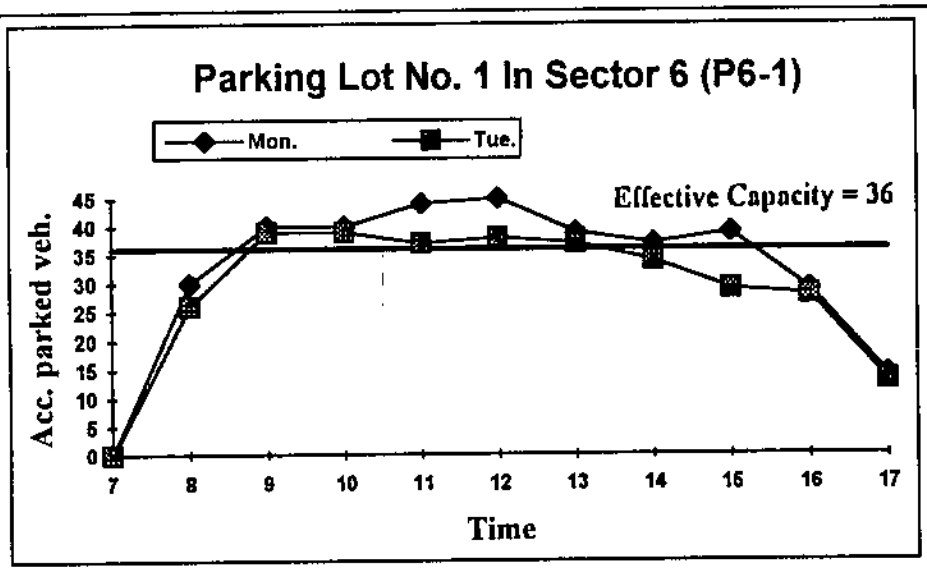
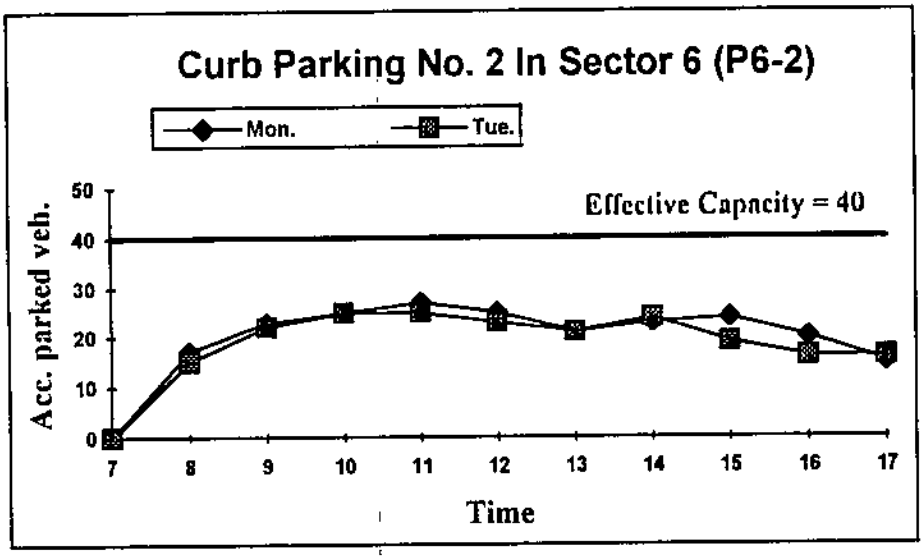




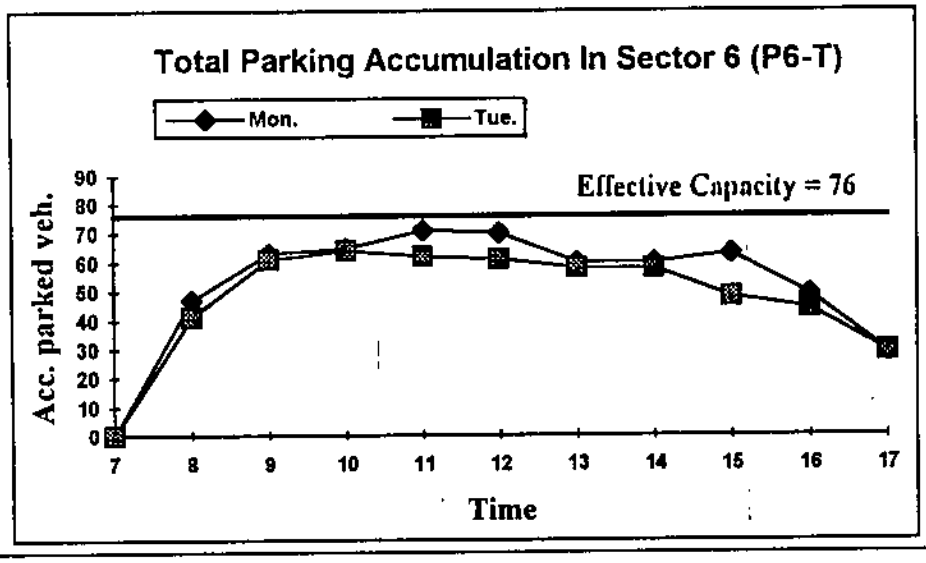
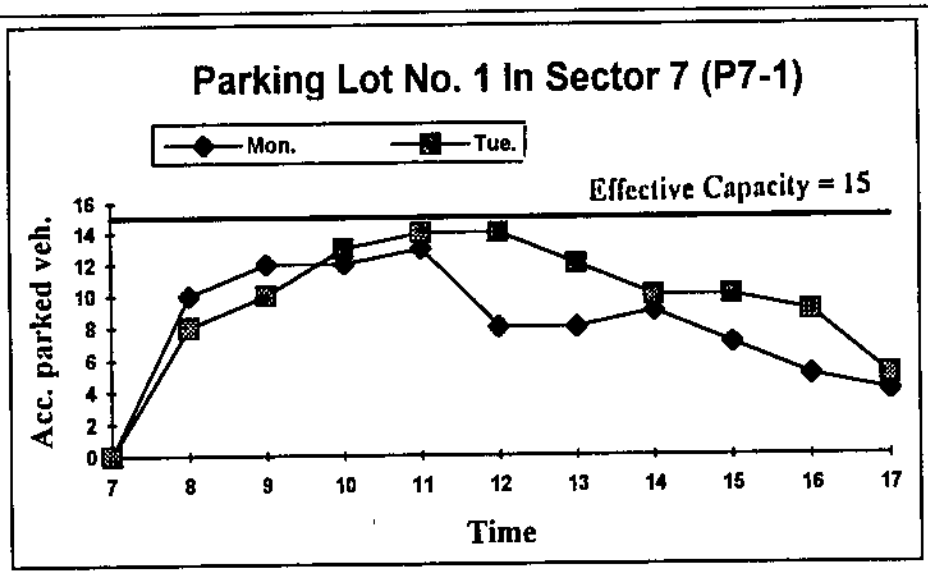
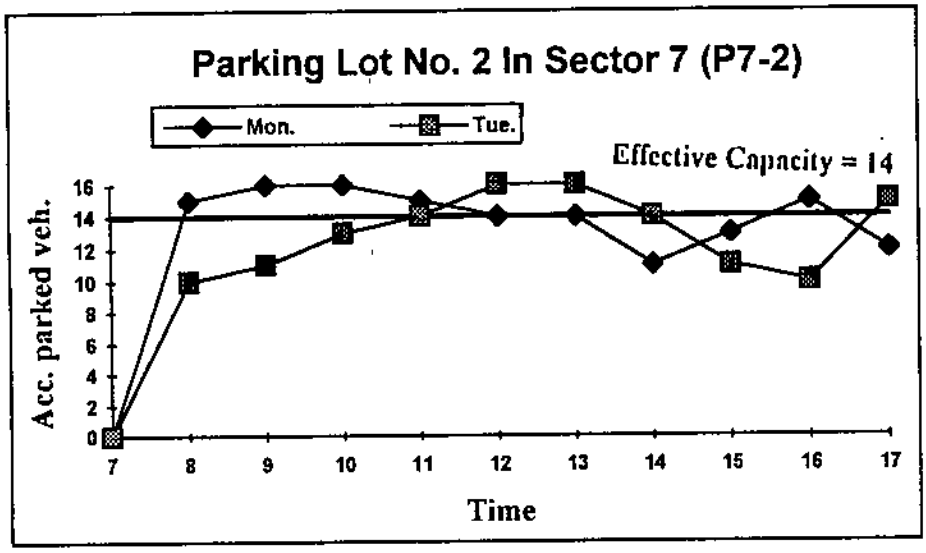
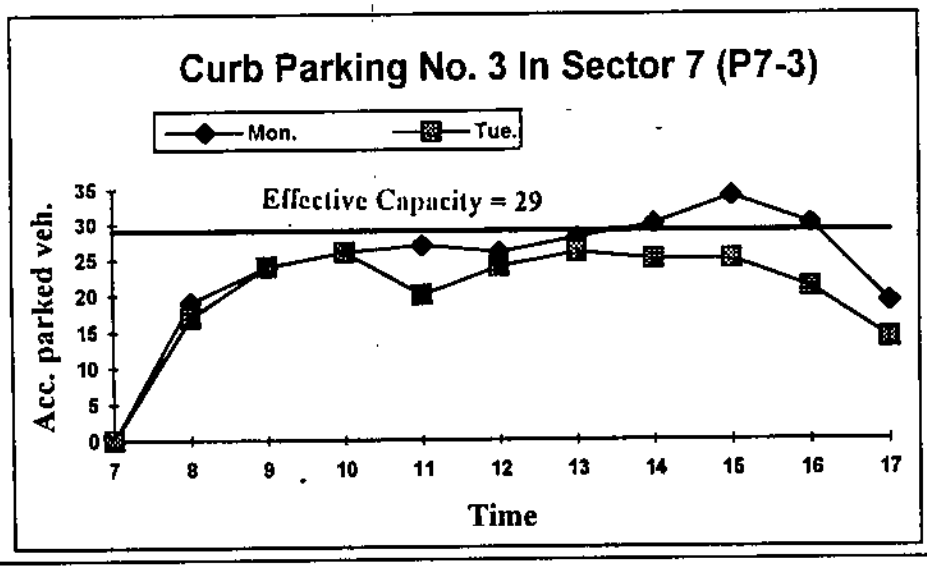


Figure (B-5): The Accumulation Of Parked Vehicles In Sector Six







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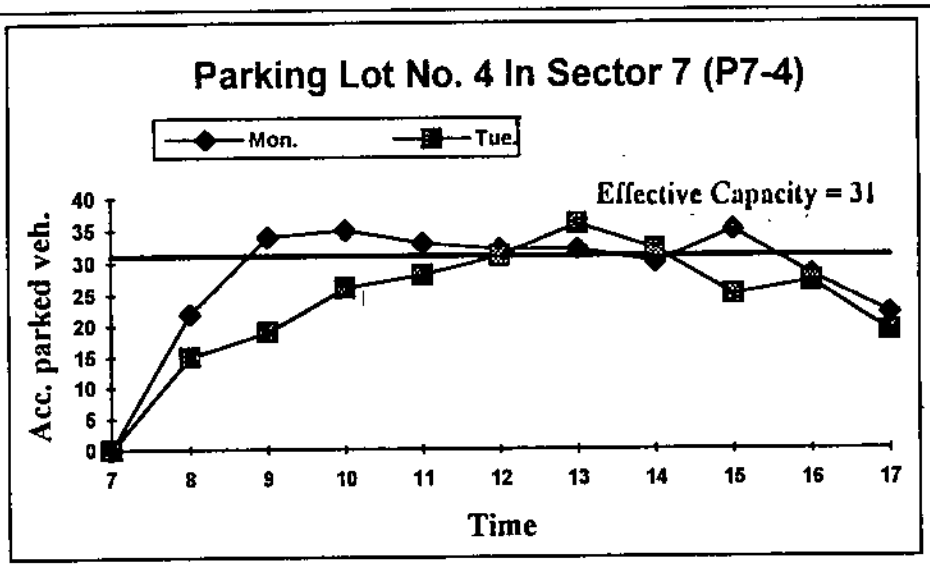

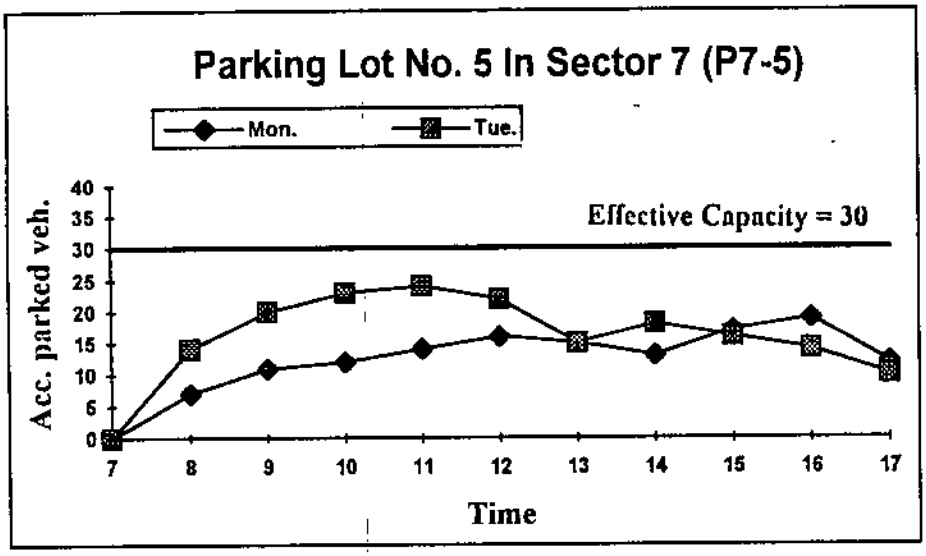

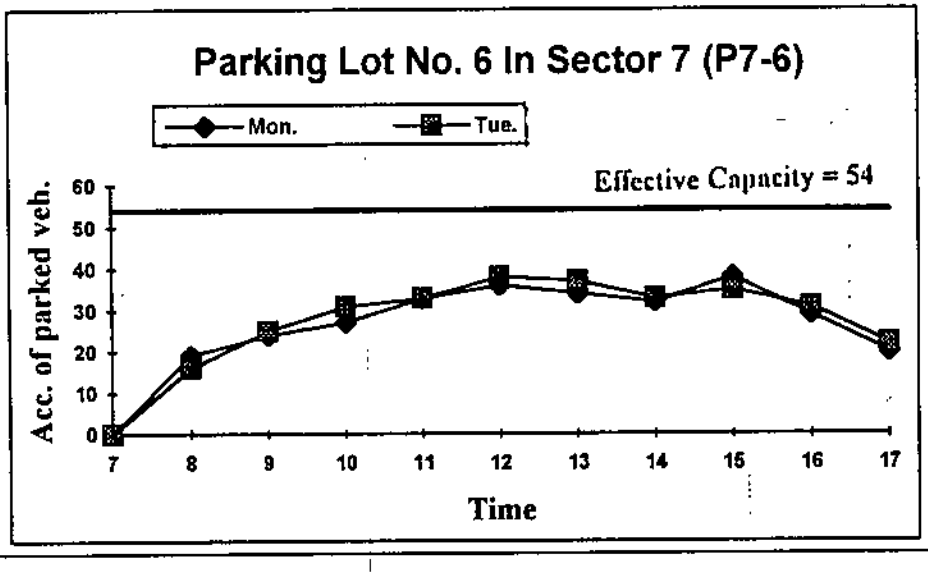

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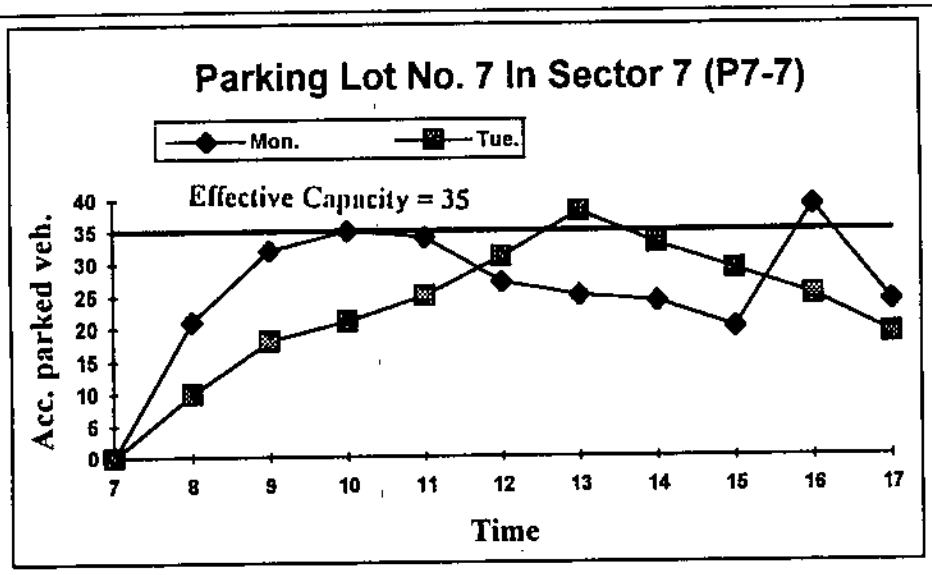

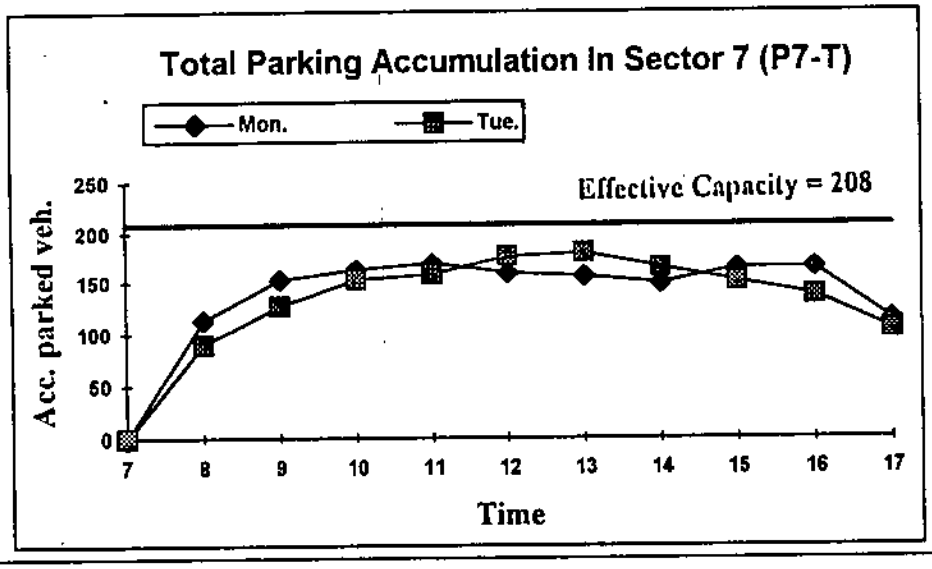

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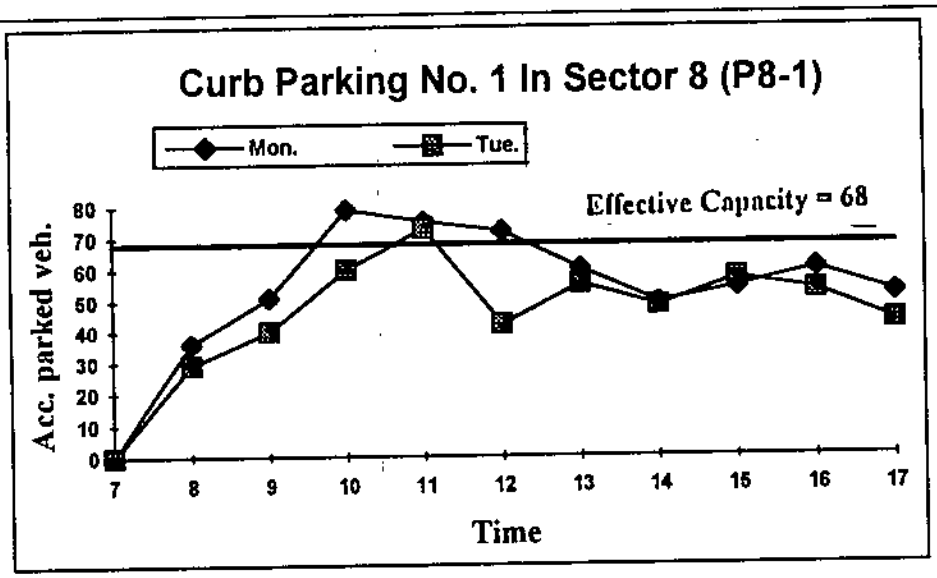
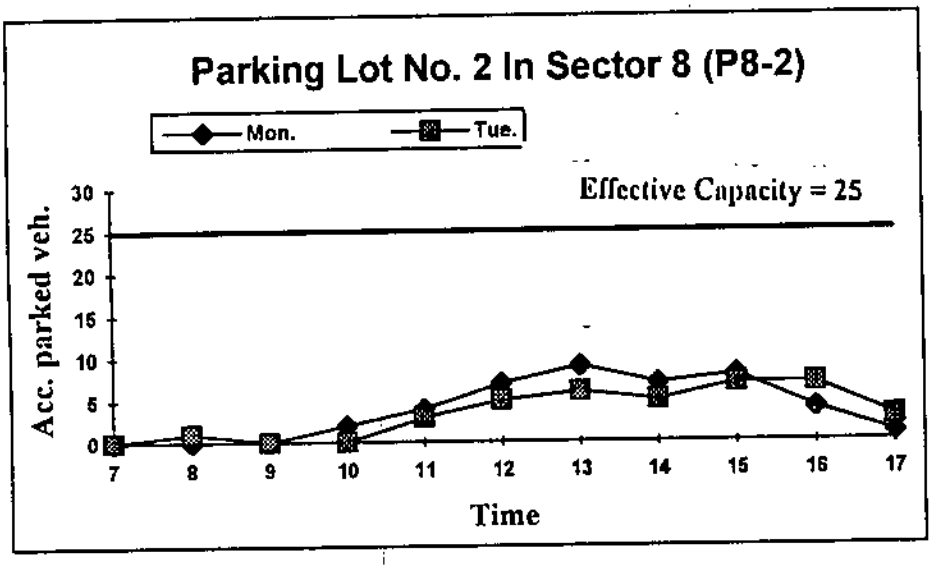




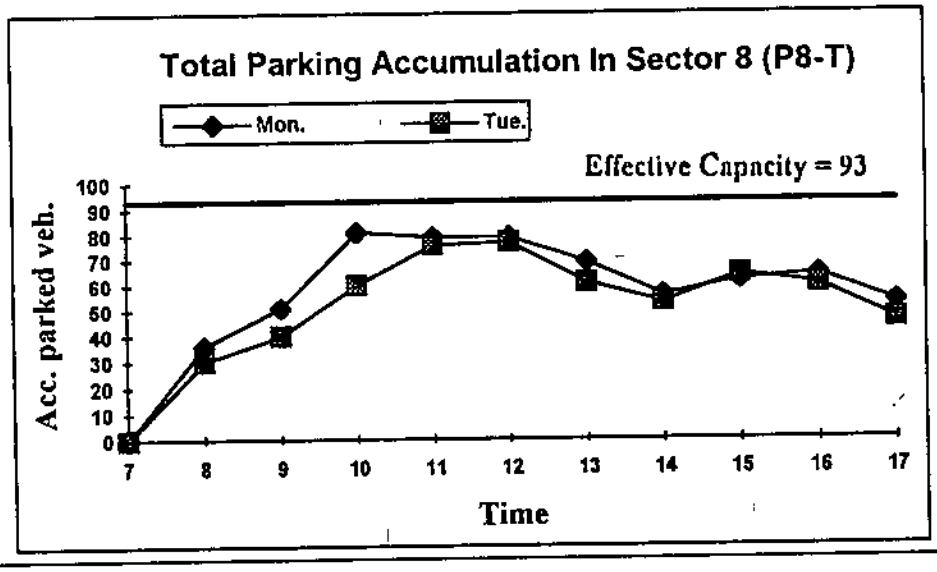
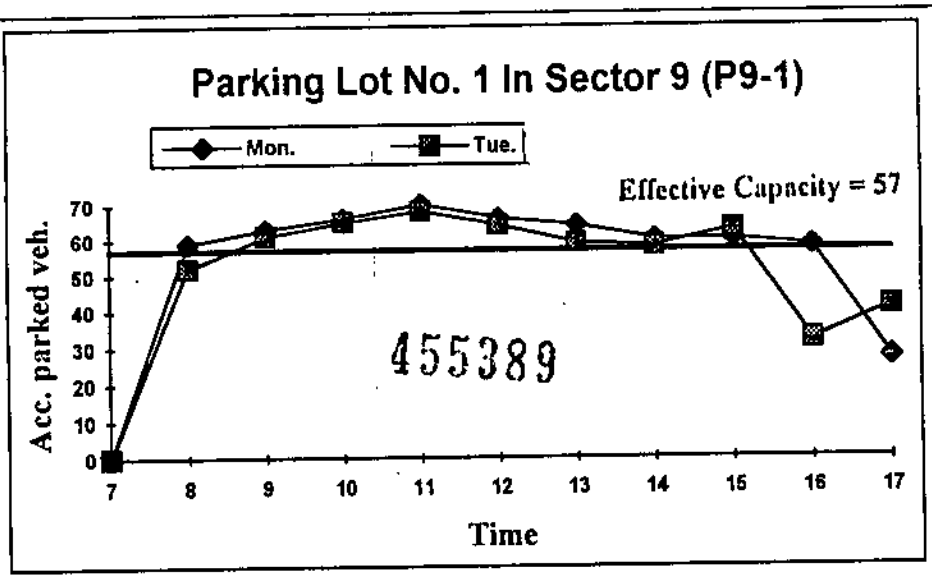
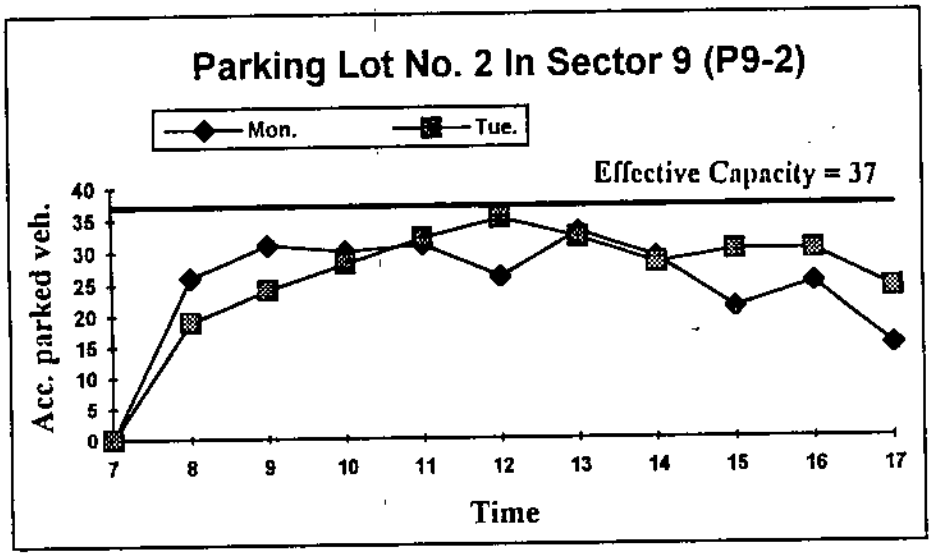


Figure (B-7): The Accumulation Of Parked Vehicles In Sector eight





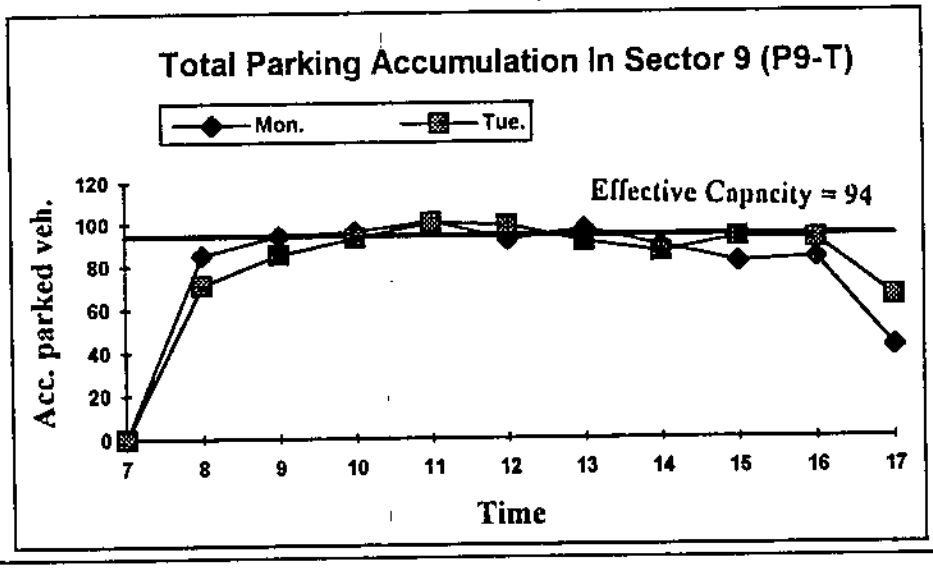


Figure (B-8): The Accumulation Of Parked Vehicles In Sector Nine

ملخـــص

حركة المرور وبرنامج مواقف السيارات في الجامعة الاردنية

رنا ذياب العوران

باشراف الدكتور نبيل خليل السلمان

أعدت الدراسة لتقييم الوضع الحالي والمستقبلي لحاجات المرور والمواقف وكذلك تنظيم حركة المرور لتوفير الراحة والحركة الامنة لجميع المستخدمين.

لقد تم تقسيم الحرم الجامعي الى تسعة قطاعات ثم تم جمع المعلومات حول عدد السكان وملكية المركبة في الحرم الجامعي، بالاضافة الى جمع المعلومات عن خصائص المواقف ومقدار الطلب. المعلومات التي تم جمعها في الميدان تشمل مسح لمواقف المركبات ومسح استمارة الاستبيان التي تم تنظيمها وتحليلها باستخدام الحاسوب لتحديد كافة مميزات حركة المرور ومواقف المركبات وتحديد مقدار الطلب الحالي ولقد تم حساب مقدار الطلب المستقبلي للسنوات العشرة القادمة باستخدام:

Regression analysis technique and the ratios of faculty to student and staff to student

لقد تم اعداد برنامج مقترح لحركة المرور ومواقف المركبات لاستيعاب الطلب المتوقع خلال عام ٢٠٠٣/٢٠٠٤ لخدمة الهيئة التدريسية، الموظفين، الطلبة والزوار. اضافة الى ذلك فأن البرنامج ينظم حركة المرور عن طريق توفير سياسة واعتبارات صارمة لحركة المرور ومواقف المركبات.

بالاضافة الى ذلك فأن مناطق وقوف المركبات قد صممت لاستيعاب مقدار الطلب المتوقع في ساعة الذروة ومع ذلك فأن اماكن وقوف المركبات قد صنفت الى ثلاثة انواع وحسب نوعية شعار الدخول للحرم الجامعي لخدمة مقدار الطلب المتوقع مستقبلا للمركبات وكذلك اقترح ستة مواقف جديدة وموقعين كموقف طوابق لاستيعاب الطلب المستقبلي كذلك اقترح انشاء بوابة جديدة على الجهة الشرقية من الجامعة الاردنية.