



## Evaluation of Parking Demand and Future Requirement in the Urban Area

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### Abstract

Whatever vehicle is traveling, it needs to stop in order to arrive road users their different goals. In most universities, parking becomes an important campus resource, for being as a place to come frequently and to spend long period. Now days parking problems increase with repaid growth of car ownership. So traffic and parking impact can be consider as a major source of contention within any community and can raise additional costs for universities, as well as urban areas facilities. The study aims to evaluate the current parking situation on the university campus in terms of the available supply and required demand of parking spaces in order to recommend future parking spaces need for the next five years. Data has had been collected according to field traffic and engineering survey, Videography method was used for this purpose. Inventories, Interviews and questionnaires included. Data analysis conducted with the aided of AASHTO and equation methods. The study concluded future parking required is 140 vehicle- spaces for the year 2026, according to population rate of growth also illegal parking leads to interference with the movements of pedestrians and their crossing, as well as reducing the capacity of the roads in the study area.

*Keywords:* Parking; Parking Accumulations; Parking Demand; Urban Area.

### 1. Introduction

Most of the large and medium cities, as well as large educational areas such as universities and research centers suffer from the problem of parking availability. Due to the lack of planning and not given enough importance in master plan this problem appears clearly according to the mounting growth with rapid increase of Car Ownership matched by the growth in demand for stopped in suitable parking vehicles. When determining the width of a parking lane, keep in mind that it will likely be used as a traffic lane in the future, either constantly or throughout peak times [1]. In the city of Zurich, a study was conducted to find the best way to operate the mobility and parking systems on demand. The study found that the system can function successfully even when there are a limited number of parking spaces available, and that expanding capacity of parking by one parking place per automobile cannot provide any advantages. Furthermore, it ensures optimum parking spaces' distribution for a certain on-demands and city transportations system [2].

The major objective of the University Tange National case research depending project had been on the demand and supply car-parking facilities for students in college of engineering. Depending on the results of the parking interview, 88 percent of students reported to have parking problems. Nevertheless, in the assessment of current

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parking supply, this scenario was the polar opposite, with just 85 percent of parking spaces available. The parking load is 89 percent, indicating there was a parking issue [3]. The study used two direct parking surveys, which will provide the latest reliable information as well as in developing parking policies in the capital [4]. A research was performed on the major campus parking owing to an analysis of projected parking demand, compared to the continuous increase in vehicle ownership, and exceeded the existing parking supply at Al- Mustansiriyah University. Depending on the predictive algorithms, 644 more parking spaces will be required by the targeted year 2015 to meet the study area's projected parking demand [5].

Parking studies in Delhi were conducted in nine sectors, including business and retail locations. The peak parking saturation for cars and bikes is 3.25 and 6.21, respectively, indicating a significant spillover situation. The study conducted according to parking characteristics analysis it was suggested optimal utilization of available space as well as the study useful for engineers, planners and decision makers [6]. The goal of parking lot layout is to optimize the total parking spaces' number in the given area by taking three factors into account. First and foremost, the parking plan must allow for a constant flow of vehicles across the parking lots. Secondly, the designed to allow for safe pedestrian circulation from parking to building, as well as suitable parking space planting without interfering with sites illumination [7].

Utilizing the average, Fully Time Equivalents (FTE) staff number are projected to be approximately 625,000 and student numbers are anticipated to be over 2,800,000 throughout the UK Higher and Further Education sector, according to the British Parking Associations. The average result for vehicle parking bays at the UK University provides an estimation of 270,000 bays [8]. Excessive parking has a price tag attached to it. Parking garage development seems to have a high financial cost, as well as substantial opportunity costs. In several mixed-use areas, space is at a premium, and every parking space or garage signifies a lost chance for more stores, restaurants, and residences [9]. The main objective of this research is study the current situation of parking on the university campus in terms of the available supply and required demand of parking spaces. Evaluate the current situation by following the approved technical standards in order to recommend future parking spaces need for the next five years with aid of inventories, Interviews and questionnaires, taking into account the growth of the university and the random increase in the level of car ownership.

## 2. Literature Review

Several studies and researches have had been conducted for parking lots in terms of their capacity, demand and supply for parking in universities and urban areas, which are summarized as follows:

A research of parking supply and demand was performed at Shahid Bahonar University of Kerman (SBUK) in Kerman, Iran, utilizing a suggested technique to improve parking pays management for university employees and students. The research found that the suggested approach may assist decrease the time spent walking about looking for a suitable parking pays for both students and employees. Furthermore, the suggested application has the potential to improve employees and students satisfaction with parking management [10]. Two studies were conducted in the cities of Al-Hilla and Najaf in Iraq, the first one dealt with the off-street parking and the second with the on-street parking. According to the first research, average off-street parking turnover varies from 1.9 to 2.6, indicating poor use of each pays in the city center. The second discovered that most parked cars in both locations had a 30-minute waiting time, demonstrating that unlawful parking seems to be prevalent in the research region city on both weekends and weekdays [11, 12].

University of Kufa study parking demand in the university campus was suggested the required additional parking spaces are 260 and using the smart parks give encouraging results [13]. The study in university of Nizwa showed that the current demand for parking is more than the currently available parking spaces, and people may park their cars in illegal places. Based on the estimated demand, the required parking spaces for both students and staff have been calculated, taking into account improvement plans for the new campus [14]. The distribution of parking is insufficient, and there are irregular between supply and demand, as well as the parking duration highly and illegally [15].

In this study, parking data including parking duration, loads, and accumulation were used to analyze sub zones. After a thorough examination of the data, the research determines the parking issue for this subzone [16]. The study of Texas A&M Transportation Institute in downtown Houston, shown that the introduction of a SFpark-style smart parking system will save about 200,000 hours per year in decreases congestion delays while saving the city \$4.4 million annually in congestion costs. Also Daily occupancy between (53-80)% was noted which have a significant spatial imbalance in the parking offered compared to the demand, meanwhile the parking oversupply may increase further if an intelligent parking system that focuses on efficiency and spatial distribution using dynamic pricing is introduced [17].

Previous studies and research that dealt with the demand for parking, which is actually available, showed that there is an increasing demand for parking, which is offset by a shortage of parking spaces in the urban area. Therefore, our study is one of the important research that addresses the increasing demand for parking, and it helps decision-makers

to predict the actual need to parking spaces for the next five years, based on mathematical models and according to the approved technical specifications.

### 3. Materials and Methods

Due to the rapid changes in the economic and social aspect that directly affected ownership in the Babylon province, this accompanied by a growing demand for parking in the city in general and the University of Babylon in particular, as it represents a center of attraction for trips different types. The parking supply available at the university provides 250 parking spaces approximately, distributed according to the master plan into one main and another four secondary parking lots. Study problem is summarizing as follow:

- The lack of an efficient and adequate program that adopts the process of defining and distributing the parking areas, according to the different objectives of the vehicle users on and off campus.
- The aggravation of random and illegal parking of vehicles and their failure to stop in designated places led to reduce the roadways capacity, as well as cases of overtaking on sidewalks, roads and various land uses.

The study used the scientific methodology in research, data collection and analysis to reach logical results, as shown in Figure 1. The campus is located 10 km south of Hilla city. Arrival and departure trips use Hilla -Najaf multi-lane roadways and (80- street) major arterial. As shown in Figure 2.

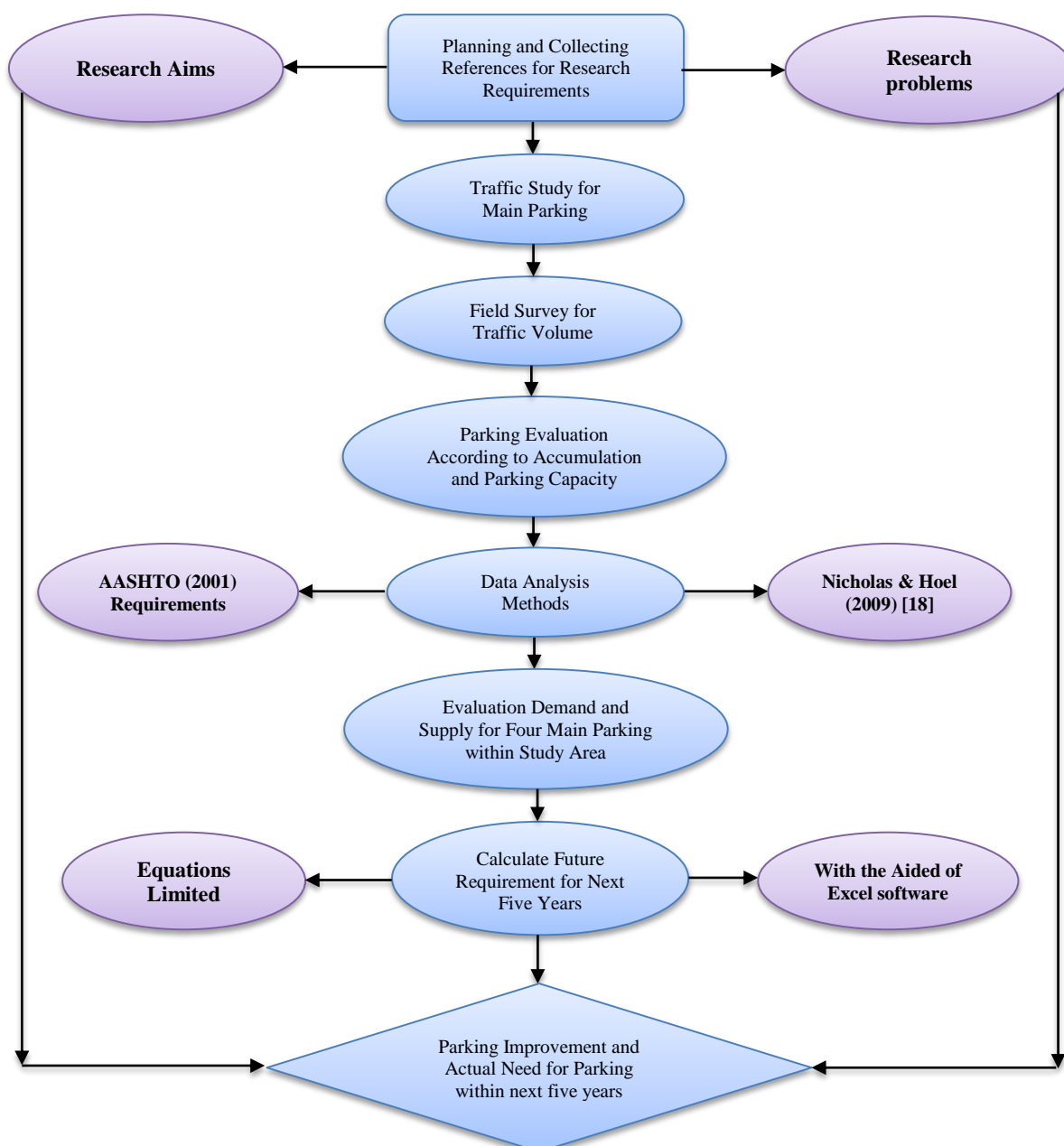


Figure 1. Flowchart Represent the Research Methodology



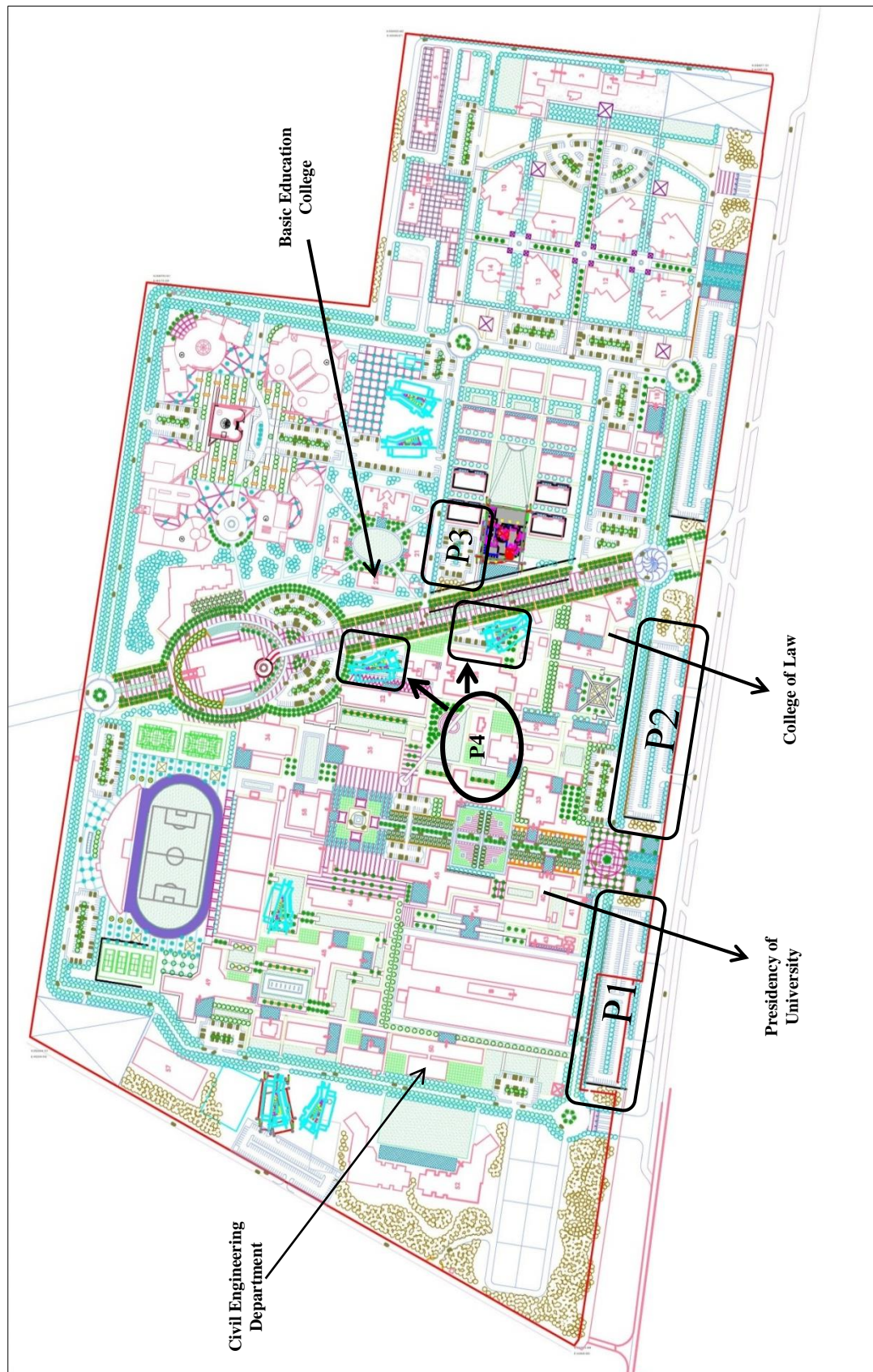


Figure 2. Master Plan Illustrated the Study Area

Data was calm depending on field survey traffic information and engineering survey included within A.M. and P.M. Peaking Hours Volume (PHV). Video technique method used in order to collect parked vehicles with the aid of questionnaire and interview to assess the current situation then suggest the appropriate development. Data listed in Tables and Figures. The study chose three parking lots within university of Babylon master plan, they are:



- Parking no. 1 located in the south gate of university campus
- Parking no. 2 located in front of faculty of Law.
- Parking no. 3 located in front of College of Science.
- Parking no. 4 located in the College of the Basic Education

The layout for each parking represented in Figures 3 to 5.

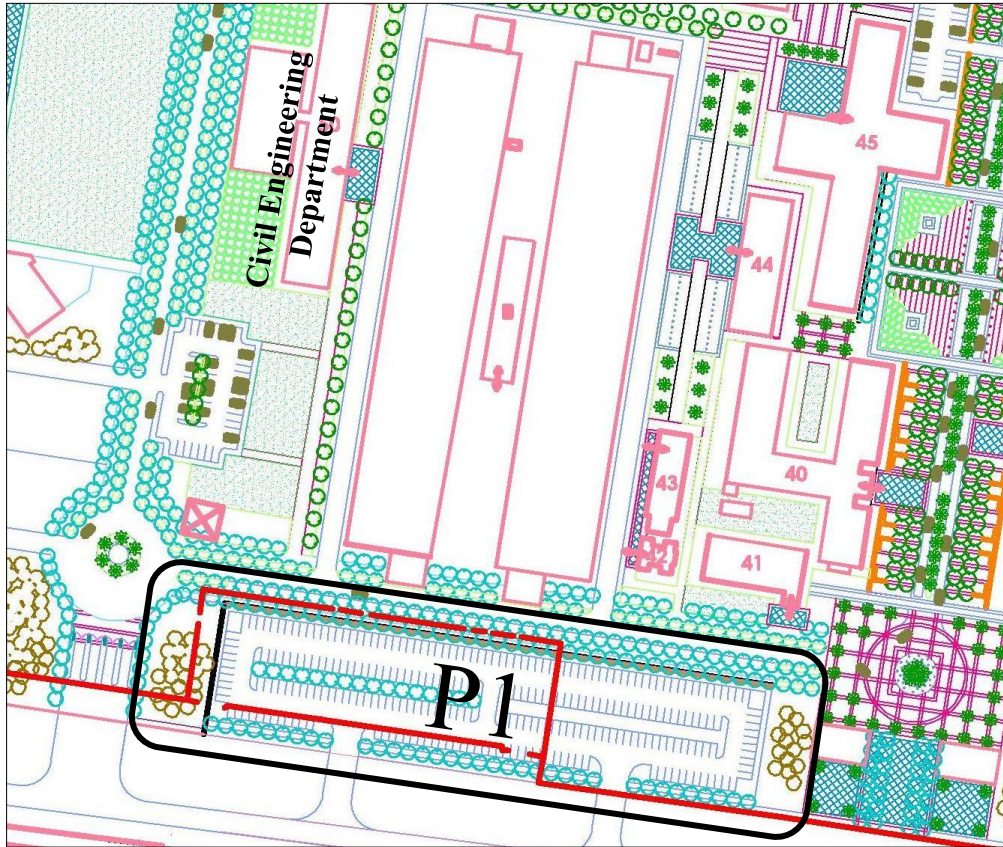


Figure 3. Illustrated the Layout of Parking No. 1 within Study Area

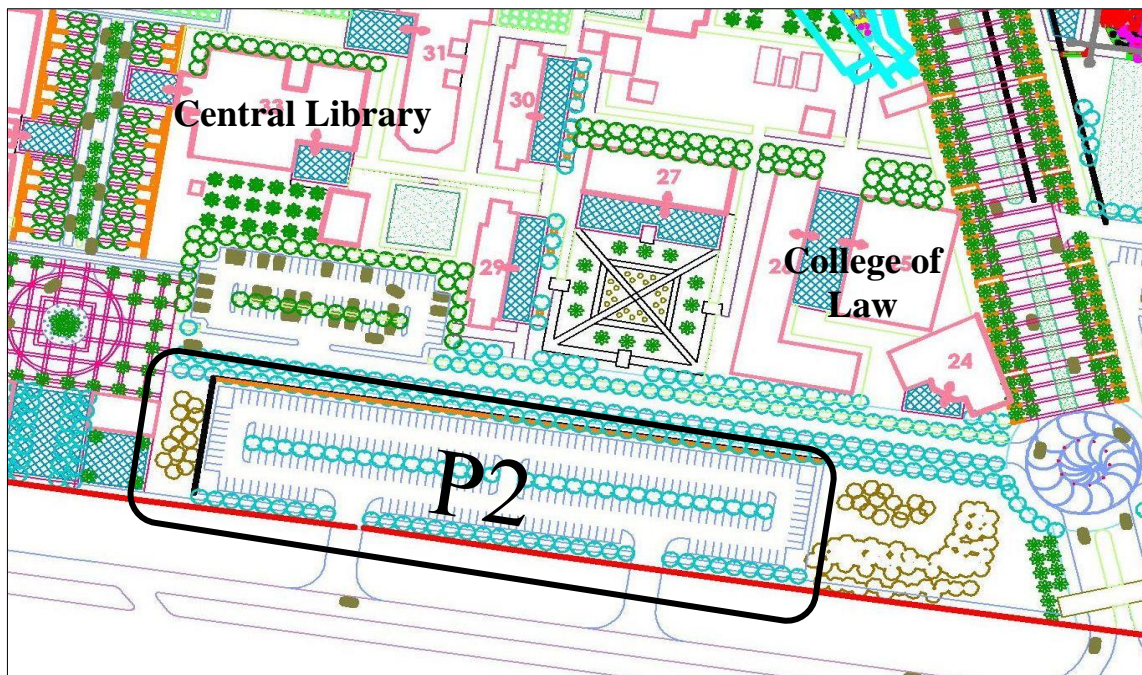


Figure 4. Illustrated the Layout of Parking No. 2 within Study Area



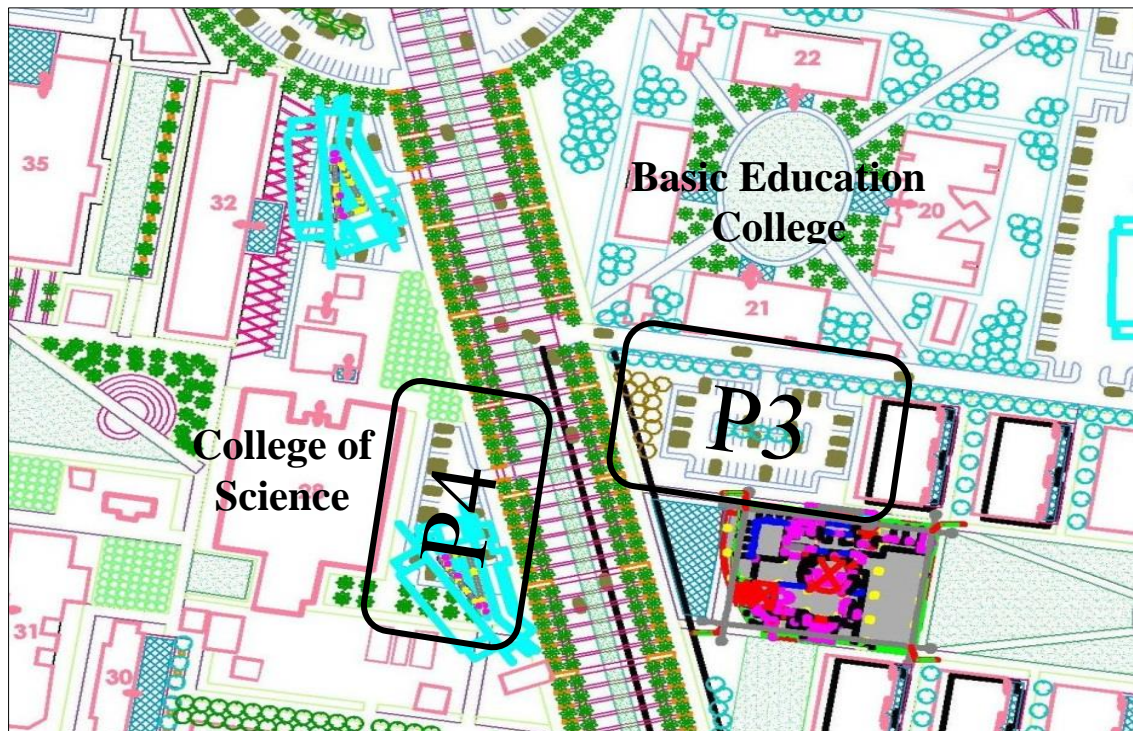


Figure 5. Illustrated the Layout of Parking No. 3 & 4 within Study Area

Table 1 illustrates the characteristics of parking; While Table 2 and Figure 2 explain the calculation of Parking Accumulation for Parking No. 1

Table 1. Parking Capacities and Characteristics within Study Area

Parking Site & No.	Type	No. of Bays (Veh.)	Parking Users
Parking No. 1	Public	156	All
Parking No. 2	Public	116	Staff
Parking No. 3	Public	68	Staff and Faculty
Parking No. 4	Public	68	Staff and Faculty

Table 2. Represent Parking Accumulative for Parking no. 1.

Time	In	Out	Parking Accumulative	No. of Bays
07:30 - 08:00	6	2	9	
08:00 - 08:30	12	1	20	
08:30 - 09:00	25	2	43	
09:00 - 09:30	22	2	62	
09:30 - 10:00	18	2	78	
10:00 - 10:30	16	4	91	
10:30 - 11:00	18	6	102	
11:00 - 11:30	18	5	115	
11:30 - 12:00	14	3	125	
12:00 - 12:30	8	12	120	
12:30 - 01:00	4	17	108	156
01:00 - 01:30	6	21	92	
01:30 - 02:00	5	24	73	
02:00 - 02:30	3	30	46	
02:30 - 03:00	13	7	53	
03:00 - 03:30	8	6	55	
03:30 - 04:00	6	14	47	
04:00 - 04:30	0	17	30	
04:30 - 05:00	0	23	7	
05:00 - 05:30	0	3	5	

Traffic Data for parking observed from 07:30 A.M - 05:30 P.M was noted Maximum accumulation appear at 11:30 A.M when the No. of Bays equal to 156 vehicles. The initial found = 5 vehicle, peak hour period accrue from 11:00 A.M. to 12:00 P.M. The parking demand decrease respectively until 05:30 P.M. At the end period of data collection, the same method has used in order to calculate the parking parameters, as shown in Table 3 and Figure 6.

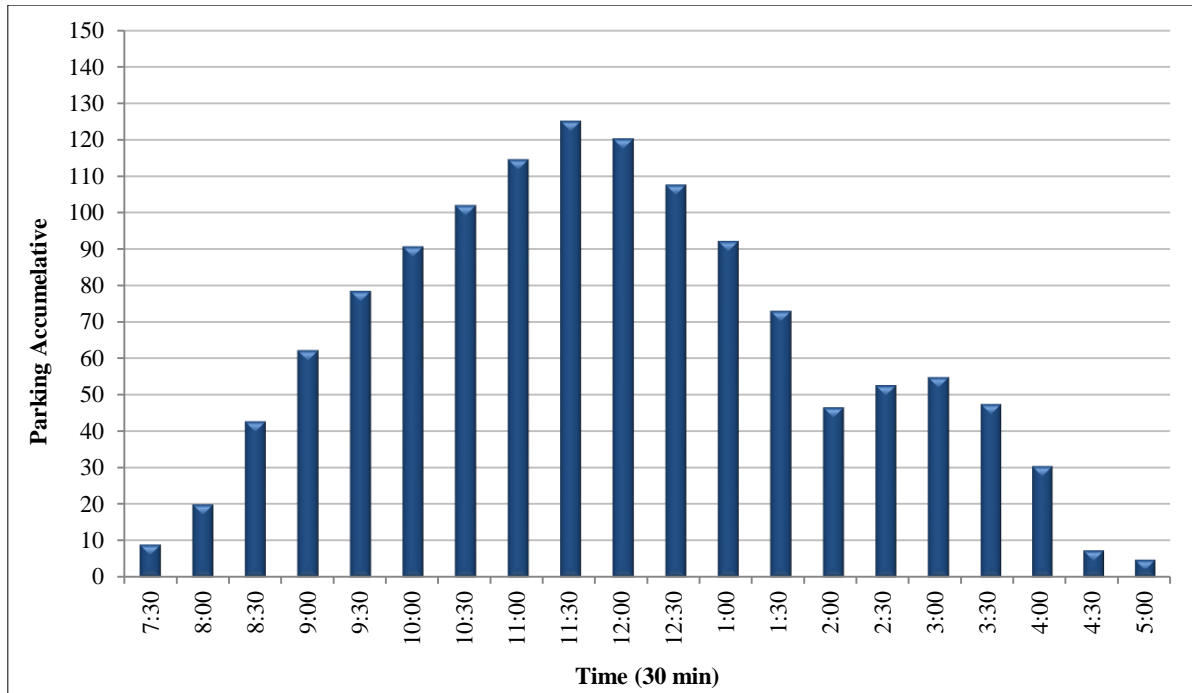


Figure 6. Represent Parking Accumulation for Parking No. 1

Table 3. Characteristics of Parking According to Peak Hour in the Study Area

Parking No.	No. of Bays	Peak hour period	Data collection period
P2	116	10:15 - 11:15 A.M. 01:45 - 02:45 P.M.	07:15 A.M - 05:45 P.M.
P3	68	12:15 - 01:15 P.M.	07:15 A.M. - 05:15 P.M.
P4	68	11:45 A.M. - 12:45 P.M.	07:15 A.M. - 05:45 P.M.

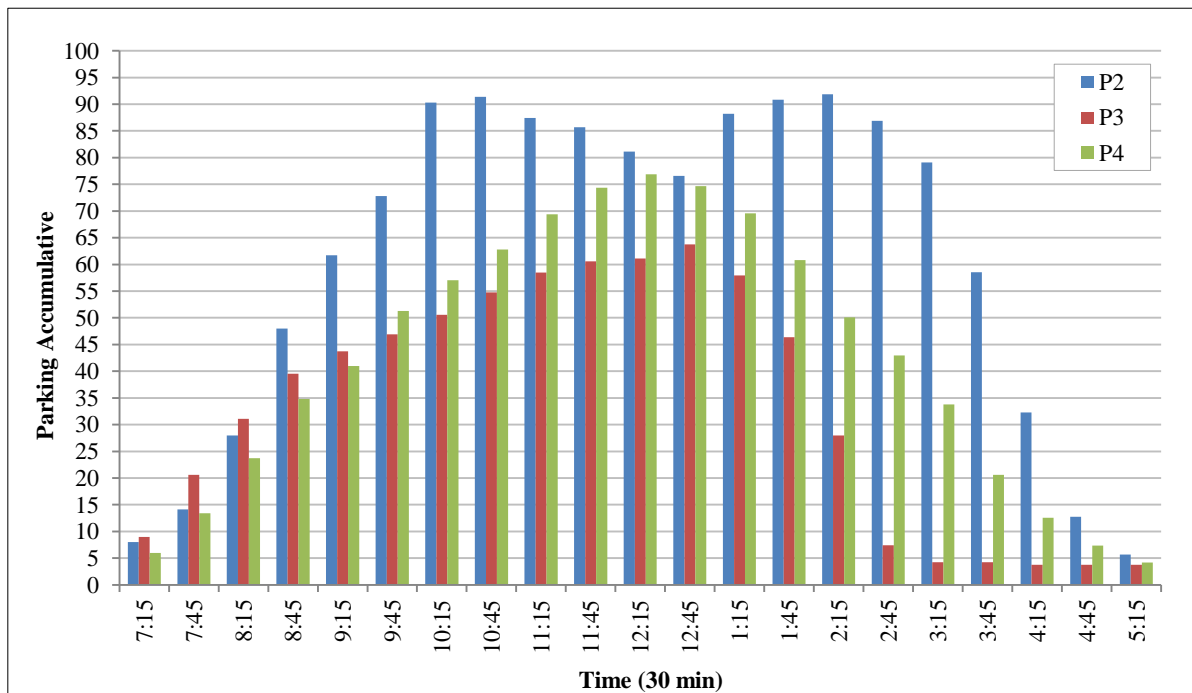


Figure 7. Represent Parking Accumulation for Parking (1, 2, 3)

From Figure 7 the distribution of parked vehicle for parking No. 2, parking accumulation at 07:15 A.M, the initial found is 5 vehicle, then its increase respectively until reaching the A.M peak hour (10:15 A.M to 11:15 A.M) then the parked vehicle increase within P.M peak hour (01:45 P.M to 02:45 P.M). The distribution of Park vehicle decreases until reach at 05:45 P.M the end of data collection period. The study observed that the distribution of parked vehicle for parking No. 3, the parking accumulation at 07:15 A.M, the initial found is 5 vehicle, Then it's increase respectively until reaching the peak hour (12:15 to 01:15 P.M) the distribution of Park vehicle decreases till reach at 05:45 P.M the end of data collection period.

Finally the distribution of parked vehicle for parking No. 4, The parking accumulation started at 7:15 A.M. the initial found is 5 vehicle, Then it's increase respectively until reaching the peak hour (11:45 to 12:45 P.M.) the distribution of Park vehicle decreases till reach at 05:45 P.M. the end of data collection period. The Maximum parking accumulation for all parking lot in within study area equal to (582) vehicle.

### 3.1. Parking Duration

Due to traffic and exploratory survey within study area, the duration period in the parking of the university campus was determined as show in Table 4.

**Table 4. Represent Parking Duration in the university campus**

Parking No.	Duration of parking Period	Percentage of parked vehicles (%)
1	15 min.	4
	15 - 60 min.	13
	1 - 4 hr.	40
	> 4 hr.	43
2	15 min.	10
	15 - 60 min.	18
	1 - 4 hr.	51
	>4 hr.	21
3	15 min.	5
	15 - 60 min.	10
	1 - 4 hr.	33
	> 4 hr.	52
4	15 min.	11
	15 - 60 min.	18
	1.0 - 4 hr.	55
	> 4 hr.	16

From Table 4, it is clear that the percentage of parked vehicles (1-4 hr.) and (>4 hr.) is higher than the rest, which indicated significant impact on demand for parking in the study area.

### 3.2. Walking Distance

Walking distance one of the indicative indicators of the parking efficiency, In addition, it contributes to reduce illegally parking, which causes conflict points in movements between vehicles and pedestrians. The average walking distance for the study parking was (189) m, which is considered as average shortest distance between pedestrian parking exit and the entrance of nearest building in study parking facilities.

## 4. Data Analysis, Result and Discussions

For determining the demand for parking within selected study area, data analyzed with the aided of criteria and equations described in Table 5:



**Table 5. Parking Demand for Park no.1**

Parking Facilities	Description	Parking Facilities	Description
No. of bays	156	Commuters now being served	0.70×201×4=563 (space-hr.)
No. of vehicle parked daily	201	visitors now being served	0.3×201×2=121 (space-hr.)
Commuters parked %	70	Total (space- hour) served	563+121=684
Average commuters parked (hr.)	4	Total No. of vehicles turned away	18×4= 72
Visitor pared %	30	No. of (space – hr.) demand	684+72=756
Average visitor pared (hr.)	2	No. of parking space available	756-684=72
		No. of (space) required	17

To determine number of space required for each parking, the study use Equation 1 [18].

$$S = \sum_{i=1}^N (t_i) \tag{1}$$

where; S = practical numbers of space-hrs. of supply for a specific time, N = available numbers of parking pays, t<sub>i</sub> = total time’s length in hrs. once the i<sup>th</sup> pay could be legally parked throughout the specific time, f = efficiency factor. Recommended f value is (85)% for surface lots (0.85×5×N= 17), and N = 33 No. of parking space required.

In the same way, the calculated parking parameters in order to obtain the supply and required parking spaces. As Table 6;

**Table 6. Represent Calculated Parking Parameters in the study area**

Parking No.	No. of bays	No. of parked vehicle daily	Commuters now being served	visitors now being served	Total (space-hour) served	Total No. of vehicles turned away	No. of (space- hr.) demand	No. of parking space available	No. of parking (space) required
2	116	169	520	78	598	40	638	40	9
3	68	102	330	39	369	24	393	24	6
4	68	110	326	57	383	32	383	10	3

**4.1. Current Parking Demand and Future Forecast**

In order to determine the demand for parking in relation to the current situation and future forecasting, in the study area the following factors studied, as shown in Table 7.

**Table 7. Parking Demand and Future Forecasting within Study Area**

Required Parking Space	Illegally Parked Vehicles	Total paces Required for Parking Vehicles	No. of Parking Bays	Car Ownership Rate of Increase	Number of Campus Members (Study Year 2021)	Number of Campus Members (Target Year-2026)
35	69	104	408	3%	22984	26645

From observations, inventories available and the questionnaire form prepare in the study area, It was observed that (11.70) percent of the campus residents use the personal vehicle (PCU) as a means to arrive their goals, as shown in Equation: 22984 × 0.117 = 2689.

Assuming the annual car ownership for the campus population is 6 percent. This is consistent with the previous studies that were conducted, as well as the nature of the economic and social conditions that surround the city.

$$(1 + r)^n = (1 + 0.06)^5 = 1.338$$

$$1.338 \times 2689 = 3599$$

Future forecasting parking required (for next 5 years).

$$\frac{\text{future need on parking spaces}}{\text{No. of expected vehicle for the next 5 years}} = \frac{\text{Current demand for parking}}{\text{No. of vehicles in the study year}} \tag{2}$$

$$\frac{x}{3599} = \frac{104}{2689} = \text{Future need on Parking spaces} = 140$$

These results have been reached based on a comprehensive field traffic study in order to calculate expected number of parks vehicle daily and total space hour serviced to get number of parking space available and required. Then use a mathematical model to determine the number of spaces that are expected and needed for the target year 2026, which

agree with specification standard.

## 5. Conclusions

The study reached many conclusions and recommendations summarized as follows:

- The future parking required are 140 vehicle-space for the year 2026, according to university campus population rate of growth, based on analytical study of traffic data.
- The study monitored through observations and questionnaire that (4 hr.) Parking is the average parked vehicles in the study area.
- Parking accumulation accessed peak period at (11:00 A.M. to 12:00 P.M.), (10:15 - 11:15 A.M. and 01:45 - 02:45 P.M.), (12:15 - 01:15 P.M.) and (11:45 A.M. - 12:45 P.M.) for parking no.1, 2, 3 and 4, respectively. While the maximum vehicle space accumulation for all study parks equal to (582).
- The study observed that there is an illegal parking of vehicles, which leads to interference with the movements of pedestrians and their crossing, as well as reducing the capacity of the roads in the study area.
- Equipping the parking with the necessary traffic signs, marking and lighting, will increase level of service and parking efficiency.
- This study, with a scientific and technical methodology, will help decision-makers to determine the priorities, including working to provide parking spaces for vehicles based on the different uses of the land according to the basic design of master plan within study area, safely, efficiently and conveniently
- This study will encourage researchers and planners to carry out similar and comprehensive studies in urban areas, as well as providing a database that is compatible with the growth of parking demand, within a scientific planning that is consistent with university policies to avoid wasting financial and human resources.
- The study faced many challenges and difficulties in data collecting and analyzing especially during peak hour volume due to the conditions associated with the emergence of the Corona virus, which restricted researchers. Nevertheless, the study proceeded to provide the necessary data and samples to make it conform to the conditions of the study area.

## 6. Declarations

### 6.1. Author Contributions

A.N.A., A.R.I. A., and H.K.K.A. contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

### 6.2. Data Availability Statement

This data have been collected according to traffic and engineering survey with the aided of questionnaire and interviews with the approval of the College of Engineering - University of Babylon, Iraq.

### 6.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

### 6.4. Conflicts of Interest

The authors declare no conflict of interest.

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