Estimate parking generation rates for educational sites

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Abstract: The benefits of providing sufficient parking spaces in a particular place return to the whole city, not just the intended place. Estimation of the required parking demand must rely on rates and models produced from the local studies, according to the local conditions, transportation habits, and law. This research is interested in educational sites (universities and colleges) in Iraq and works to establish a reliable reference to determine the required parking supply for them. Four educational sites in Baghdad city were selected to develop parking generation rates and models, besides two other sites were also chosen to verify the developed rates and models. Data collection was conducted using interviews and field surveys. Two kinds of data are collected, the first is about site characteristics, employees, and population, and the second is about the parked car accumulation, of three days, during two periods (am and pm). And then all the collected data were analyzed, and by using several different variables many parking generation rates and models were produced. The Data analysis and model production was done by using (SPSS) computer program. The research adopted the American Institute of transportation engineers (ITE) procedure as the main work reference. The results of the study can be used as guidance for the local government agencies to determine the required amount of parking spaces for educational sites.

1. Introduction.
The Parking is considered as an integral portion of the total urban system of the transportation network and land use. And it is one of the key elements of urban planning. [7]. the parking problems are not a new thing globally, where the economic growth led naturally to increase the car ownerships, besides the changes in the socio-economic characteristics, attitudes, the community dynamics and the urban development. All of these made the parking a serious problem suffering from it all the cities around the world and Iraq also. Therefore, many countries work on setting their parking policy which consistent with them. Sitting the appropriate parking policy in urban areas considers as challenging work for transportation planners [6], and it is the product of many parking studies.

The basic purpose of the parking plan is to provide long-range guidance to a city in order to permit accommodation of traffic-related demand while minimizing expenditure and disruption [1]. Many negative effects of insufficient parking spaces, of which most important is increasing the on-street parked vehicles, traffic conflicting movements, traffic congestion, delay times, accidents, [1] further, it
compromise the economy and reduces the value of the facilities, whereas, the influence of the parking is not limited to the neighboring streets but also beyond it.

In Iraq, there is a lack of parking studies, and therefore, there is a lot of missing information, which if be found, will be very valuable for the transportation network system, and help to better manage the system by the transportation planners or government agencies. Urgent need to generate parking rates will help in planning decisions, assessing transportation systems, traffic impact studies (TIS), and help to update and improve any available regulation of parking.

2. Background

The universities and colleges consider as main activity centers sites which generate traffic and parking needs. The universities also affected by the increasing car owners and their lack of sufficient parking spaces and, its bad effects. The parking generation is a derivative of trip generation, wherein the term (parking generation) is used to refer to the number of parking spaces required as a resulting of number attracted trips in a particular site [1]. Many states around the world have prepared and published trip and parking generation rates/equation in multi-form such as books, manuals, and handbooks, etc.

For the international studies, The American Institute of transportation engineer (ITE), is considered one of the pioneers in developing the parking generation rates and models. It published many manuals and reports provide models and rates, for predicting parking demand for different land-use types. The latest published manual in 2019 is the (ITE 5th edition) report contains 121 land-use types [8]. The last three editions of the ITE report trended to demonstrate a reasonable relationship between parking demands and a single independent variable, by using the simple linear regression. The 5th edition of the parking generation report produced various levels of statics ranging from, poor to good relying on the variables that used in predicting the parking demand, for example, when using site gross floor area (GFA) with parking demand, produces the high coefficient of variation. However, when using the number of employees it produces a low coefficient of variation [3]. Furthermore, it concluded that the homogeneous data set or small data set may produce a low coefficient of variation and this does not mean a more reliable relationship. Wherein, statically reliable data do not cover all sites, but they form a long-range goal.

Indeed, average or mean parking accumulation has been used in developing parking generation models and rates. [3]. The 5th ITE report [8], presents the parking generation rates and models, for the universities/colleges' land use in location general urban/suburban. The rates and models were developed only for the peak period of the parking demand from the period of (9 am – 3 pm), and by using only two variables are students and school population. Where the developed rates were 0.28 parking spaces per person of the school population and 0.33 parking spaces per student.

For regional studies, Palestine, Jordan, and Abu Dhabi have made also similar studies for developing parking generation rates and models, for different land-use types. Every study addressed the predominant land uses types in their countries. Each study have developed rates and models by using different independent variables, these variables form in their opinion the important factors affect the parking demand in their countries. Further, all the studies used the simple linear regression in developing the parking generation models.

As for Local studies, a small scale of parking studies was done in Iraq. And the existing parking studies interest with other objectives such as parking characteristics, parking efficiency, etc. however, a part of these studies could avail in this research: Al-Harbowee (1990) made a study about traffic and parking at the University of Mosul's main campus. Although the study has other goals, it gives us a vision about parking demand and supply at that time. The campus was having many areas for parking legal and illegal, so for the best result, the campus was divided into 11 sectors. Each sector had an area for parking have special characteristics. The research results show there a deficiency in supply by 492 parking spaces, unevenly distributed on campus. [1]. Raid KRAIDI (2011) made a study on the parking of AL-Mustansiriyah university's main campus, The main purpose of this study was to evaluate the supply and demand of parking spaces on the campus, as well as the study provided a recommendation for the number
of parking spaces that should be provided to serve the various campus users for the target year 2015. The study concluded that the parking supply was sufficient to accommodate campus peak parking demand, in case of using private and public parking lots outside campus beside campus parking lots. While parking demand exceeded 90% of the total available supply of parking spaces, between 12:00 and 12:30 PM. [4].

3. Research Methodology
The methodology was developed on several steps, explained below:

3.1. Site selection
The most important condition that must be present at the selected sites, is must have a parking lot or garage clearly. The ITE guide (2010) and (2019) suggests some criteria for selecting sites that enhance the outputs of the study; [8, 3]
- The site should be mature (i.e. at least two years old).
- Site occupancy (i.e. at least 85%)
- The site should be clear to control parking counts in it.
- No abnormal condition beside selected sites, like construction.
- Accessible by the surveyors for collecting the total needed information.
- The site should be clear for the control of the parking area and the vehicles counting.

As well, the selected sites must have parking areas obvious and specific and only used by the site population. The site also must have a single land-use activity. Where this study deals only with sites that have single land use. In addition to the local polices in Iraq which request official authorization in order to allow us access to their sites. Besides the official approval signed by site administrators themselves.

3.2. Sample size determination
The ITE guide stated that a minimum of four sites for single land use should be provided, for best analysis and better outputs. The determined sample size in this research relies on the ITE guide, statistical considerations, significance levels, Land-use type, and available resources. The sample size of this research is four sites. Every site is to meet the site selection criteria explained earlier.

3.3. Data collection
The data collection is an essential part of the research; it provides the necessary data for analysis and model estimation. The collected data must serve the purpose of the research, to supply it with enough and suitable information. The data was collected in three ways are (Internet websites, Interviews, and Field surveys). The personal experiences besides the international and regional references played a role in the selection of the appropriate information and collection method.

3.3.1. Selection independent variables.
Each land use type has several variables simulate the main land use activity which can be used to predict the parking demand. The desk review, local condition, and ability to obtain the needed information were the main factors to select appropriate independent variables, which show below:
1-Total population; represent the total of (faculty members + campus employees + students).
2-Total employees; represent the total of (faculty members + campus employees).
3-Site Gross floor area (GFA); represent the total area of the sites except the areas used for parking (parking lot) [6], and this variable divided per 100 m. to facilitate calculations.

3.3.2. Parking surveys data
Two types of surveys were done.
1. The parking supply survey; the information about parking supply spaces, do not directly participate in parking model generation, but it gives more clarification for parking demand phenomena as related to a specified site. And can be used for comparison purposes also. As well, the ITE guide and some references recommended providing such information.

2. Parking demand survey; Total parking demand is the accumulation of vehicles parked at given site at any associated point of time. This survey is done by two steps:
   A. Determination Counting periods and duration; this study objective is depending on finding peak periods parking demand of each site during the weekdays for selected periods. The ITE guide stated the counting duration for two days is appropriate, and a time interval of 1 an hour is suitable for most sites and land use types. And the periods of counting must coincide with the peak parking demand, to gain the peak parking accumulation of the site for the two period’s morning and evening. The counting time for this research is for period 7 AM – 3 PM.
   B. Counting the maximum parking demand. The maximum parking demand is the maximum accumulation of vehicles parked at a given site at any point time. Parking counted were conducted at every hour, for period 7 am - 3 pm. The survey covers the whole near area parking including by that the private parking lots and on streets.

4. Study Area
Baghdad is the study area of this research. Four sites in different parts of Baghdad were selected to produce the parking generation rates and models. Each site is meeting the site selection criteria explained earlier, the selected sites were tabulated, in Table 1 as shown below;

| Site name                      | Location                      |
|-------------------------------|-------------------------------|
| Technology university         | Al-rusafaa. Al-wahdah district. Sinaa street. |
| Iraqi university              | Al-rusafaa. Adhamiya district. Saba' Abkar region. |
| Administration and economic college | Al-rusafaa. Adhamiya district. Mashatel street. |
| Physical education college    | Al-rusafaa. Karadaa district. Jadriyah region. |

4.1. Technology University
The university contains 13 colleges in addition to administrative offices and university presidency. It surrounded by residential and commercial areas. It has three gates for vehicles entering and exiting. Each gate opens on a certain street, the first gate opens on the commercial street, the second on an urban local street and the third open on a service street separates the university from the expressway, where this street is closed for security purposes usually, and be full of vehicles, that back to the university employees according to the university supervisors sayings. Almost all the secondary local streets surrounding the university are filled with vehicles during the work hours. And there is no university or college nearby from it. Image 1 shows the technology university location and surveys sites.

4.2. Iraqi university
The selected site of the Iraqi university is located on Adhamiya district, Saba' Abkar region. The site is containing four colleges in addition to the central library, small shopping center, and four places of student clubs, and other offices. The university surrounded by educational and institutional buildings, it has one gate for the vehicles entering and exiting, the gate opens on a local street usually closed for traffic movement except for the university population. The university is adjacent to four large buildings used as
male student's hostels, while the female student's hostels are located in another area. Nearby from the university two colleges, one secondary school, and 3 government institutional. The university also nearby from Imam Ali Street (the army canal). Image 2 shows an Iraqi university with survey sites.

4.3. Administration and economic college.
This college is affiliated to Baghdad University, is located at Adhamiya district, Mashatel Street. The college contains 7 departments in addition to administrative offices and different scientific centers. The college has one gate for cars entering and exiting. It has one parking lot in addition to there was an irregular area deducted from the street fenced with an iron fence used for vehicle parking. The gate opens on Local Street, there is also a short street separate the college from the main traffic on Al Mashatel Street. The college has no student hostels for male and female, image 3 show the administration and economic college with the survey sites.

4.4. physical Education College
This college is also affiliated to Baghdad University which is shown in Image 4. It is located within Baghdad University but in an isolated place and independent gate and parking lot. The college contains 3 scientific branches, spacious playgrounds, a large swimming pool, a sports hall, and administrative offices. It has one gate for cars entering and exiting and it open on local street leads directly to Baghdad University, usually the traffic at this street is limited for Baghdad university population. In front of the college two government ministries.

Image 1. The location of Technology University site and surveyed parking areas.
Lines keys, Blue; university boundaries, Red; inside parking, Green; outside parking.
Image 2. The location of Iraqi University, and the surveyed parking areas. 

Lines keys. Green; university boundaries Blue; inside parking. Red; outside parking.

Image 3. The location of Administration and Economic College, and the survey sites. 

Lines Keys. Green; college boundaries. Blue; inside parking. Red; outside parking.
5. Sites Characteristics
The collected data about the selected independent variables (explained in research methodology/data collection) were tabulated in Table 2 and Table 3. Table 2 shows, the necessary collected data about the campus population and total employees. While, Table 3 shows, the necessary collected data about the total area for every site and its parking area.

Table 2. Sites Characteristics for each educational site.

| University/College | Faculty members | Campus Employees | Total employees | Students | Population |
|--------------------|-----------------|------------------|----------------|----------|------------|
| Technology         | 1552            | 880              | 2432           | 12443    | 14875      |
| Iraqi              | 471             | 276              | 747            | 10107    | 10854      |
| Administration     | 214             | 204              | 418            | 6358     | 6776       |
| Sport              | 236             | 150              | 386            | 1383     | 1769       |

A Total employees = faculty members + campus employees,
B Population = total employees + students.

Table 3. The Site Area information for each educational site.

| University/College | Total area per 100 m. sq. | No of parking | Parking area per 100 m. sq. | GFA area per 100 m. sq. |
|--------------------|---------------------------|---------------|------------------------------|-------------------------|
| Technology         | 2025.90                   | 2             | 147.26                       | 1878.64                 |
| Iraq               | 900.00                    | 2             | 55.85                        | 844.15                  |
| Administration     | 349.33                    | 1             | 16.53                        | 332.8                   |
As for parking survey data, the collected data are shown in Table 4. Total supply represents the number of parking spaces supplied by the site. The demand represents the average of two days of the max accumulations of the parked vehicles for the two-period Am and Pm. The demand is divided into the campus demand and out-campus demand. While the total demand represents, the summation of the demand in and out the campus which used in parking generation rates and models.

Table 4. Parking Survey Data.

| University      | Total supply | Time | Campus demand. | Out-campus demand. | Total demand. |
|-----------------|--------------|------|----------------|--------------------|---------------|
| Technology      | 269          | Am   | 740            | 499                | 1239          |
|                 |              | pm   | 661            | 452                | 1113          |
| Iraqi           | 98           | Am   | 323            | 256                | 579           |
|                 |              | pm   | 290            | 251                | 541           |
| Administration  | 43           | Am   | 67             | 189                | 256           |
|                 |              | pm   | 55             | 187                | 242           |
| Sport           | 68           | Am   | 101            | 251                | 352           |
|                 |              | pm   | 85             | 217                | 302           |

6. Data Statistical Analysis. (Descriptive statistics).

Part of the statistical measurements were used in the research, to give an overview of characterizes of the collected data for the different variables, which then will use in the build-up of the parking generation rates and models. More focus has been on statistically dispersion measurements. The used statistical measurements of this research are (mean, standard deviation (std. dev.), range, minimum value, maximum value, and the coefficient of variation (CV).

The coefficient of variation (CV): is the ratio of the standard deviation to the mean. The higher the coefficient of variation, the greater the level of dispersion around the mean. It is generally expressed as a percentage. Without units, it allows for comparison between distributions of values whose scales of measurement are not comparable [5]. The collected data about universities/colleges are the number of total population and employees, total sites gross floor area and max parked vehicles at each site at Am and Pm periods. Table 5 present the descriptive statistics of the collected data.

Table 5. The descriptive statistics of the collected data about universities/colleges.

| Variable                  | Mean   | Std. dev. A | CV % A | Maximum | Minimum | Range     |
|---------------------------|--------|--------------|--------|---------|---------|-----------|
| No. of Population         | 8568.5 | 5610.75      | 65.4   | 14875   | 1769    | 13106     |
| Total GFA per 100 m²      | 920.75 | 672.54       | 73     | 1878.64 | 332.80  | 1545.8    |
| No. of total employees    | 955.75 | 971.3        | 101    | 2432    | 386     | 2046      |
| Total demand (AM)         | 607    | 442.8        | 72.9   | 1239    | 256     | 983       |
| Total demand (PM)         | 550    | 389.4        | 68.6   | 1113    | 242     | 871       |
From the descriptive statistics in Table 5, all the variables show high variation, especially the number of total employees where the CV% value for it more than 100 percent which indicates there is a high dispersion of data about the mean. While the Population shows the less variation between the independent variables, their CV% value is 65.4 percent, mean lower dispersion of data about the mean. Also from the table, the average of max parked vehicles, in the morning period (607 vehicles) higher than the average in the evening period (550 vehicles), and this is normal because it was noted from the field survey, that the universities/colleges have a higher turnout in the morning even in universities/colleges that have evening courses.

7. Regression analysis and Models generation.

This research is used simple linear regression in developing the parking generation rates and models based on the ITE guide and the other researches. Moreover, one of the reasons to use the simple linear regression in models estimation that ‘in most situations when the new developments are proposed there will be limited sources of information about a particular site or activity’. D. the parking generation models were developed for single independent variable predictor (X), and dependent variable (P) which represents the parking demand. The independent variables used in developing the models were already explained in the research methodology. Different forms of regression models were developed such as:

\[ P = B_1 X + B_0 + E. \text{ (linear)} \]
\[ P = B_0 + B_1 \ln(X). \text{ (Logarithm)} \]
\[ P = B_0 X^{B_1}. \text{ (Power)} \]
\[ P = B_0 e^{B_1 X}. \text{ (Exponential)} \]

P = parking demand (independent variable).
X= independent variable (predictor).
B_0 = the intercept (constant).
B_1 = the variable coefficient (slope).

The ITE guide used simple regression with one independent variable to minimize the least square error of the developed models. The best models are with a higher coefficient of determination (R^2) which measures the goodness fit of the regression line to the points, and according to the ITE guide, the models with R^2 more than 0.5 are acceptable. Also, the error of models (the distance between the regression line and points) should be minimized for better models.

Furthermore, the adjusted R^2 represents the modified value of R^2, which has been adjusted based on sample size and the number of independent variables used in the model. Because sometimes the estimated R^2 for the models that have a small sample size, tends to be higher than the actual R^2 for the population. Therefore, use of the adj. R^2 considered better, in some cases. The adj. R^2, used when it differs by a large amount from actual R^2.

The statistical tests were used to measure the accuracy of the developed models in predication. Two tests were used the first is the F-test analysis of variance (ANOVA) gives information about how the regression models measure the variability of the independent variable. The F-test is considered an indicator of model reliability, where it used to check the significance of the whole model at a predefined confidence interval. The second test is a T-test used to check the significance of the coefficients by check the hypotheses about them. The hypotheses were tested by the T-test at a predefined confidence interval. The null hypothesis (H0) represents when the coefficients are not significant, zero or they do not have an impact on the equation, and the alternative hypothesis (H1) when the coefficients are significant not zero,
which they have an impact on the equation. The two tests have checked the models at a 95% confidence interval in this research. [3, 8, 5]

7.1. Morning period (AM).
7.1.1. Number of campus population;
The population of university/college considered the main base of trips attraction and its productions. The produced parking generation models for the campus population and their characteristics are presenting in Table 6.

Table 6. Parking generation models (AM) for variable No. of Population.

| no | Model | type | $R^2$ | Adj. $R^2$ | F-test value | p-value | t-test value | p-value | Model error |
|----|-------|------|-------|-----------|--------------|---------|--------------|---------|-------------|
| 1  | $P = 0.067 X + 36.39$ | Linear. | 0.71 | 0.57 | 4.91 | 0.16 | 0.03 | 2.217 | 291.72 |
| 2  | $P = 312.7\ln X - 2145.2$ | Log. | 0.44 | 0.16 | 1.56 | 0.34 | 249.9 | 1.251 | 406.26 |
| 3  | $P = X^{0.475} \times 7.721$ | Power. | 0.42 | 0.13 | 1.45 | 0.35 | 0.394 | 25.88 | 0.640 |
| 4  | $P = e^{0.001X} \times 210$ | Exp. | 0.70 | 0.54 | 4.56 | 0.17 | 0.000048 | 98.95 | 2.138 |

From Table 6 the linear and exponential models show accepted $R^2$ values (more than 0.5), the significance of the F-test indicates that all the developed models for the variable No. of Population are not significant models at a 95% confidence interval because of their p-value >0.05). So the developed models are poor models for prediction, rates can be used instead of it. Lower confidence interval here may be appropriate because of the small sample size. Figure 1 shows the model plot of parking demand (AM) for the variable No. of population, where it showed clearly the deviation of the points from the regression line.

Figure 1. Model plot of parking demand (AM) vs. No. of Population.
7.1.2. Number of total employees.
The employees are the most car owner and they make work trips to university /college more than the students. Therefore No. of employees is used to develop the parking generation models presenting in table 7 with their characteristics.

Table 7. Parking generation models (AM) for variable No. of employees.

| no | Model             | type   | R²  | Adj. R² | F-test  | t-test  | Model error |
|----|------------------|--------|-----|---------|---------|---------|-------------|
|    |                  |        |     |         | value   | p-value | value       | p-value     |             |
| 1  | \( P = 0.45X + 158.7 \) | Linear.| 0.97| 0.96    | 71.978  | 0.01    | 8.464       | 0.01        | 48.17       |
| 2  | \( P = 516.4\ln X - 2802 \) | Log.   | 0.98| 0.97    | 104.211 | 0.009   | 10.208      | 0.009       | 18.8        |
| 3  | \( P = X^{0.781} \times 2.901 \) | Power. | 0.93| 0.90    | 28.174  | 0.03    | 5.308       | 0.003       | 0.136       |
| 4  | \( P = e^{0.001X} \times 261.38 \) | Exp.   | 0.87| 0.81    | 13.421  | 0.06    | 3.663       | 0.06        | 0.201       |

From Table 7 the developed models have high R² values which indicate the strong models for prediction. The linear, logarithm and power models are significant models at a 95% confidence interval (p-values < 0.05). The exponential model shows no significance at a 95% confidence interval, so it is not recommended. Also, the linear model shows a high model error of estimate (89.18) and that may affect the model prediction, so must careful in using it.

Figure 2. Model plot of parking demand (AM) vs. No. of employees.
7.1.3. Site Gross floor area.
The Site parking demand is related to the site gross area in most cases. So it is used as the third independent variable in developing parking generation models and their characteristics which are present in Table 8.

Table 8. Parking generation models (AM) for variable GFA.

| no | Model                     | type | $R^2$ | Adj. $R^2$ | F-test value | F-test p-value | t-test value | t-test p-value | Model error value | Model error p-value |
|----|---------------------------|------|-------|------------|--------------|----------------|--------------|----------------|------------------|---------------------|
| 1  | $P = 0.66 X + 2.85$       | Linear. | 0.99  | 0.98       | 224.605      | 0.004          | 14.987       | 0.004           | 50.95             | 0.006               |
| 2  | $P = 585.7\ln X - 3278$  | Log.  | 0.91  | 0.90       | 19.086       | 0.049          | 4.369        | 0.049           | 167.1             | 0.06                |
| 3  | $P = X^{0.94} \cdot 0.987$| Power. | 0.97  | 0.95       | 63.538       | 0.015          | 7.971        | 0.015           | 0.147             | 0.33                |
| 4  | $P = e^{0.001X} \cdot 201$| Exp.  | 0.96  | 0.94       | 45.308       | 0.02           | 6.731        | 0.02            | 0.173             | 0.02                |

From the Table, all the developed models are strong models as their $R^2$ values are high. Which means 99%, 91%, 97%, and 96% of parking demand variation is related to site gross area. Further, the significance of the f-test for all models shows that all models are significance at a 95% confidence interval, (P-values lower than 0.05). The logarithm model has a high model error of estimate 167.1 that affects largely the performance of model prediction, so it is not recommended to use.

![Model plot of parking demand (Am) vs. sites GFA.](image)

Figure 3. Model plot of parking demand (Am) vs. sites GFA.

7.2. Evening period (PM.)
The same independent variables used in developing the parking generation models in the morning period, they are used in evening period parking generation models.
7.2.1. No. of population.
The developed parking generation models for Pm period for the variable No. of the population are also
invalid and show insignificant like the developed models present previously for the morning period.
Therefore they are not presented.
7-2.2. No. of employees
The developed parking generation models (Pm) for variable No. of employees are shown in table 9. The
high $R^2$ values indicate strong models. The lowest model errors are in power and exponential models.

| No | Model            | Type   | $R^2$ | Adj. $R^2$ | F-test   | T-test | Model Error |
|----|------------------|--------|-------|------------|----------|--------|-------------|
|    | $P = 0.4 X + 148.4$ | Linear | 0.97  | 0.96       | 64.538   | 8.034  | 84.4        |
|    | $P = 465\ln X - 2520$ | Log.   | 0.99  | 0.98       | 185.944  | 13.636 | 50.18       |
|    | $P = X^{0.782} \times 2.6$ | Power  | 0.95  | 0.92       | 36.682   | 6.057  | 0.19        |
|    | $P = e^{0.001X} \times 238.4$ | Exp. | 0.88  | 0.82       | 13.606   | 3.689  | 0.29        |

Further, All the models, except the exponential model, are significant at a 95% confidence interval (P-
values less than 0.05). The linear model show high model error (84.4) and that may affect the model
predication, so be careful in using it. Also, all the models can be adopted for parking demand
predication, except for the exponential model.

7.2.3. Gross floor area.
Table 10 presents the developed models and their properties for the parking generation at pm period
associated with site GFA. From table 10, strong models were developed by using the variable GFA, where
all the models have high $R^2$ values ranging from 0.99 to 0.92. As for the model's significance at a 95 %
confidence interval all the models are significant (P-value lower than 0.05). The power and exponential
models show the lesser model error. While the logarithm model shows a very high model error of estimate, so it is not be recommended.

| No | Model            | Type   | $R^2$ | Adj. $R^2$ | F - test | T - test | Model Error |
|----|------------------|--------|-------|------------|----------|----------|-------------|
|    | $P = 0.4 X + 148.4$ | Linear | 0.97  | 0.96       | 64.538   | 8.034    | 84.4        |
|    | $P = 465\ln X - 2520$ | Log.   | 0.99  | 0.98       | 185.944  | 13.636   | 50.18       |
|    | $P = X^{0.782} \times 2.6$ | Power  | 0.95  | 0.92       | 36.682   | 6.057    | 0.19        |
|    | $P = e^{0.001X} \times 238.4$ | Exp. | 0.88  | 0.82       | 13.606   | 3.689    | 0.29        |
8. Parking Generation Rates

According to the ITE manual, the parking generation rate is ‘the ratio of the total parking demand (vehicles parked), divided by the all quantity of independent variable (such as building area or employees)’. [8], the rates are produced depending on the same independent variables used in the models previously for two periods (Am and Pm). The rates represent weighted mean as explain earlier, and the standard deviation, coefficient of variation and range were displayed to give more information about rate dispersion. The smaller dispersion means the better rates. Also, there is a range of rates which may be considered a better use in some cases. All the produced rates and their properties are present in table 11.

| No | Rates                          | Period | range | STD. dev. | CV %  | Rates Range |
|----|-------------------------------|--------|-------|-----------|-------|-------------|
| 1  | 0.071 space/ population person. | Am     | 0.161 | 0.073     | 114.8 | 0.2 – 0.062 |
| 2  | 0.61 space / faculty person.  | Am     | 0.402 | 0.177     | 25.6  | 0.91 – 0.51 |
| 3  | 0.66 spaces / 100 m² of GFA.  | Am     | 0.205 | 0.084     | 12.5  | 0.8 – 0.56  |
| 4  | 0.064 space/ population person. | Pm     | 0.141 | 0.064     | 110.8 | 0.18 – 0.036 |
| 5  | 0.55 space / faculty person.  | Pm     | 0.325 | 0.146     | 22.6  | 0.78 – 0.48 |
| 6  | 0.6 space / 100 m² of GFA.    | Pm     | 0.243 | 0.101     | 16.4  | 0.73 – 0.48 |

9. Verification of models and rates.
Models and rates verification are checked by using new and random sample selected from the studied land uses types. In this research, according to on studied sample size, and Hamadneh, J. M. (2015) reference, 30% of the size difference is acceptable as an average. Only the good models are verified. The new data that present in table 12 was used for the verification of models and rates.

| No | College name. | population | Total | GFA. | Am | Pm |
|----|---------------|------------|-------|------|----|----|

Table 12. The data used for Educational Models and Rates Verification.
IIbn. AL-Haitham college / Baghdad university.

| No. | Variable. | Models | R² | Rates | Range. |
|-----|-----------|--------|----|-------|--------|
| 1   | No. of population | -   | -  | 0.071 | 0.2 – 0.062 |
| 2   | No. of faculty. | $P = X^{0.781} \times 2.9$ | 0.93 | 0.61 | 0.91 – 0.51 |
| 3   | GFA (100 sq. m) | $P = X^{0.94} \times 0.987$ | 0.97 | 0.66 | 0.8 – 0.56 |

From the above table, no models recommended for variable No. of population, the present rates, and their range can be used instead of the models. As for variables No. of employees and site GFA, both models and rates are recommended. Used either of them is applicable but in general, the models are preferred statistically so they recommended using.

11. Conclusions
This research is prepared to establish parking generation rates and models to estimate the parking rates for universities/colleges. The selected sites were chosen within the urban area in deferent parts of Baghdad. All the collected data was statistical analyzed, the variables were with different coefficients of variation, a higher coefficient of variation is for an independent variable number of faculty, and the least variation coefficient is for the independent variable gross floor area. Simple regression analysis is used to develop parking generation models and rates. Using the SPSS computer program, four types of parking generation
models are linear, logarithm, power and exponential are produced. The independent variable number of Population show low correlate with the observed parked vehicles so it produces poor parking generation models with low (R² < 0.6), models for the number of employees and gross floor area show high correlate with the observed parked vehicles and thus it produces good parking generation models with high (R² > 0.85). Verification of models and rates show that almost all the models produced estimated values close to the observed values where the higher difference was less than 30 %, with some anomalies. Depending on the produced models and rates of this research, parking rate equal to 0.66 per GFA /100 m² represent the output of this study, this rate can be used for planning purpose for educational sites.

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