PARKING DEMAND ANALYSIS OF REST AND SERVICE AREA ALONG EXPRESSWAY IN SOUTHERN REGION, JOHOR MALAYSIA

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Abstract: Rest and Service Area (RSA) is an important aspect in highway operation in terms of safety and comfort for highway users. Stopping and resting at these facilities will help reducing users fatigue and thus avoiding possible accidents. Existing guidelines for RSA planning apparently provides insufficient information on the design capacity for estimating parking requirements for RSA. The objectives of this study were to determine the parking demand trend on RSA, and to evaluate significant parameters related to parking demand. This study was conducted on six RSA located in southern region of Peninsular Malaysia, Johor. Variations of traffic volume on major road and the size of the facilities on RSA were observed on two days for 10 hours for each site. Correlation analyses were conducted to determine the relationship of these two parameters as related to parking demand on RSA. It was found that the parking demand varies with time of the day and day of week. The analysis showed that there is a significant correlation between vehicular volume on major road and gross floor area to parking demand on RSA. Linear regression models were developed to predict parking demand on the RSA land use type. The developed models equations are recommended to be used for RSA land use type.

Keywords: *Parking demand, rest service area, expressway*

1.0   Introduction

In these recent years, there is rapid increase in the number of vehicles on road in Malaysia. The increase in number of vehicles on road will lead to congestion in the next few years. Besides that, as the vehicles on the road increase, the amount of parking area demand also affected. Thus, transportation planner and traffic engineers need to properly estimate the traffic volume attracted to or produced by the land uses Rest and Service Area (RSA) or in Malaysian term *Rehat & Rawat* (R&R). RSA is an important facility in highway and expressway that provide safety and comfort aspect to road users. In Malaysia, RSA facilities are built along North–South Expressway (NSE) which is meant for long distance travel. Currently, neither manual nor handbook in Malaysia that can provide guidelines for professionals to design or predict future parking demands.

On the other hand, a guideline for Malaysia Toll Expressway System was published by Malaysian Highway Authority as known as Lembaga Lebuhraya Malaysia (Lembaga Lebuhraya Malaysia,LLM 2008). This existing guidance for RSA planning apparently provides insufficient information on the design capacity for parking requirements for RSA. As reported, the design of capacity for parking provision is based on "Turn-in rate" which represent the rate of vehicles volume on main line entering the facilities. However the propose value that address in the standard literally cannot be taken because other factors were not considered. Moreover, the size of facilities was expected to affect traveler's choice due to amenities provided. There is an urgent need of parking data in RSA collected and the pattern of the parking demand studied. Thus, this study conducted to investigate the characteristics or trend of parking demand on RSA. The parking demand of RSA may be varies with time of the day and day of week (weekdays and weekend). Vehicular volume on major road and the size of facilities were taken into consideration as parameters affecting the parking demand. Correlation analysis was conducted to analyze the significant relationship between the parking demand and aforementioned parameters.

1.1   Background of Study

In western countries, "Heuristic model" was introduced and recommended by The Institute of Transportation Engineers (ITE) for predicting parking space provision. This method can specify the parking space provision which depends on the nature of the land use (Institute of Transportation Engineers,ITE 2010). This method was set up to determine a minimum (or maximum) number of spaces to be provided in any development before planning approval would be given. This approach, at best, provides a partial measure of parking use and encourages the designer trying to extract the maximum number of spaces from the appointed area. However, the ITE's Parking Generation guidelines includes different 108 types of land uses but does not cover the land use type "Rest Service Areas" located along the Expressways.

Design Guidelines For Highway Rest and Service Area (RSA) and Lay-by (2011) by Malaysia Highway Authority (LLM) is used for physical planning and decision making on RSA such as parking lot size and layout on RSA. The guideline predicts 5% to 15% of vehicular volume on main line contributing to the parking demand for the RSA (Lembaga Lebuhraya Malaysia,LLM 2008; 2011). These guidelines were based on the data of national used rates.

Recent study conducted by Abd. Wahab et al. (2015) on one of the RSA located in southern region Malaysia reported variations of traffic volume on main corridor exhibit significant relationship on parking demand. The variations of traffic volume were conducted through four different events (weekdays, weekends, public holiday and festive season). The study also observed parking demand slightly higher from maximum

15% turn-in rate standard design by the guideline (Lembaga Lebuhraya Malaysia,LLM 2008) during the higher traffic volume on main line traffic volume.

An empirical study was conducted on traffic use of rest areas on rural highway throughout in state of Montana published in 2011 (Al-Kaisy et al. 2011). This study primarily focused on 44 RSA located by main-line traffic with different highway categories (high and low-volume interstates and arterials). The study found the turn-in rate RSA were varied from 8.4% to 12.3%. The study also identified the peak demand for rest service was fall on midday. Researchers suggest on midday peak period should be considered on planning and design the facilities. Moreover, most of the facilities exhibit approximately from 13% to 17% average rate of use during midday period. A practical guidelines for estimation of RSA use on rural interstates and arterial highways published in 2012 was developed based on previous empirical observations of 44 study sites (Al-kaisy et al. 2012). This guideline represent of a significant proportion of existing and future RSA in rural locales development. The study was found the baseline turn-in rate by main-line peak traffic on interstate highways and rural arterials of 16% and 25 % respectively for designing the facilities. Researchers also suggest counting of vehicles and average dwell time (average parking durations) during daytime peak period be used to determine parked vehicles needs at the facilities.

Functionality of highway RSA use did not only relate to the type of highways, but also relate to the traffic volume on the main-line, traffic rate (turn-in rate) and facilities provided by the RSA (Jiang et al. 2011). The higher traffic volume examined higher turn-in rate. From this point lay-out and planning are crucial for controlling the density of volume in the RSA. Obviously, the main things travelers halt on the RSA to refuel, resting, eating and other amenities used. The study presented the functional analysis of highway RSA based on travelers demand can be categorized into three parts of services (vehicle services, traveler services and ancillary services facilities). These services generate trip purpose from the travelers thus will increase the parking demand on RSA. Institute of Transportation Engineers reported study conducted by Fan et. al. (1997) on parking generation rate on commercial land used in Singapore using gloss floor area (GFA) and leasable floor area (LFA). From the study, both GFA and LFA have high correlation values which were 0.92 and 0.97 respectively. GFA was more practical than LFA since it is more practical. Hence, to represent the amenities provided by the RSA, the used of GFA taking into considerations. GFA includes the main facilities (stalls, dining hall, restrooms etc.), petrol stations and other facilities provided.

2.0   Methodology

This study was conducted at 6 sites of RSA along E2 expressway located in southern region Malaysia, Johor referring to Table 1. The sites located on established highway that handled by PLUS Malaysia Berhad (PLUS) concession. North-South Expressway

(NSE) was the longest (772 km) expressway in Malaysia which running from southern state to northern states. This expressway links to major cities/CBD on west coast. This study primary focused part of the expressway (180 km) which was part of Johor state only.

Table 1: Name and Locations of Study Sites

Site(s) Name	Expressway Bound(s)	Location on Expressway (km)
Gelang Patah	Southbound	4.9
Gelang Patah	Northbound	5.7
Machap	Southbound	74.7
Machap	Northbound	74.6
Pagoh	Southbound	135.5
Pagoh	Northbound	146.6

2.1   Preliminary Study

In this study, two stages preliminary study were conducted before conducting parking demand observations. First stage of preliminary study was conducted to distinguish the trend of vehicular volume entering the RSA. This study was conducted on three selected sites. Automatic traffic counters (ATC) with pneumatic road tubes were used to collect traffic volume entering the RSA. Traffic counts were collected from each RSA for 1 week during normal days (7 days continuously, including weekends) and excluding festive season. The traffic counts entering RSA demonstrate higher traffic volume during daytime period. Based on the finding, period of study for parking demand observation was conducted from 9:00 a.m. to 18:00 p.m. Second stage for the preliminary study was turnover study. Turnover parking defined as the number of different vehicles parked in a specific area of facility in a given period of time divided by the number of spaces/bays. Turnover may be calculated during the course of an entire day or separately for daytime and evening parking. The purpose of turnover study was to determine the suitable time interval for parking demand data collection. The parking utilization in RSA can be assumed as short period parking such 15 minute, thus the 5-minute time interval was used initially for parking turnover study in this area (Institute of Transportation Engineers,ITE 2010). Turnover studies were conducted on weekday and weekend for 3 hours in total during a.m. period and p.m. period. Turnover observations were done for each hour with the interval of 5 minute. It was found that the range value for turnover study on weekdays were 2.11-2.74 with average 2.40 vehicles/hour/bay respectively and 2.13-2.51 with average 2.24 vehicles/hour/bay on weekends for six sites. The result indicates that the amount of vehicle per hour that occupied the parking space did not exceed three, which indicates that 20 minutes time interval can be used in the parking demand study. However, there were cases in which the number of vehicle occupied parking space is more than three vehicles, therefore, 15-

minute time interval was considered as sufficient to be used in parking demand observation. If parking spaces in a facility are underutilized, the turnover rate will be very low (Institute of Transportation Engineers,ITE 2009).

2.2   *Parking Demand Observation*

Parking demand observation was conducted through 2 different days (weekday and weekend excluding the seasonal events) to allow variations of the vehicular volume on main-line traffics and parking demand on RSA. The parking demand survey was conducted based on the procedures outlined by ITE (Institute of Transportation Engineers,ITE 2010a; 2010b). The observation was conducted to count the number of vehicles parked throughout the day (9:00 a.m. to 16:00 p.m.). The parking observation was conducted continuously during the study period with the time interval 15-minute determined from the preliminary study. At the same duration, the digital video camera was used to record the vehicular volume on major road (expressway). So that, the vehicular count on the parking area, vehicular count entering (turn-in vehicles volume) RSA and vehicular count on the main-line traffic can be done simultaneously. The data for non-designated parked vehicles were included for the observations.

2.3   *Rest Service Area (RSA) Variables*

Two variables that are believed to affect the parking demand on the RSA were examined in this study. These variables are :

- Total vehicular volume on main-line expressway, which is summation of vehicular volume passing by the RSA and vehicular volume entering the RSA
- The size of the facilities, which is represent the amenities provided by the RSA

Correlation analyses were conducted to identify relationships between these variables and observation on parking demand in RSA. Furthermore, regression analyses will attempt to develop equation for predicting peak hour parking demand by the "Rest Service Areas" land use type.

### 3.0   **Results and Discussion**

The data of parking demand observation was analyzed for each study site, and the results are presented in this section. Further discussions the parking demand trends includes vehicular volume entering RSA are tabulated. These data are presented to understand the characteristics of the trends between parking demand and turn-in vehicles volume the RSA.

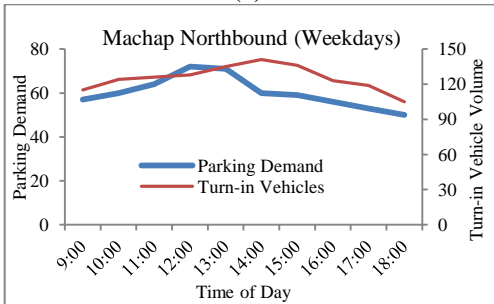### 3.1   *Parking Demand Trends*

Data were tabulated into two parts which presenting for two different events referring to Figures 1 and 2 for each site. Some of sites showed slightly similar trends between parking and turn-in vehicles volume. Somehow, most of the sites clearly have different trends between these parameters. The trend indicates relationship between time of day and parking demand at the RSA. It was observed that the highest parking demand occurred in midday between 12:00-14:00pm as shown in Figures 1(a),(c),(e),(f) and Figures 2(a),(c),(e). Meanwhile, figures 1(b),(c) and figures 2(b),(d),(f) demonstrate highest parking demand occurred in evening between 15:00-17:00pm.
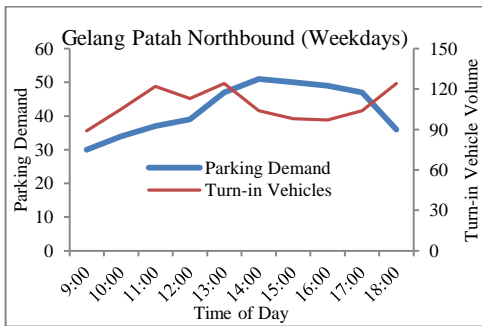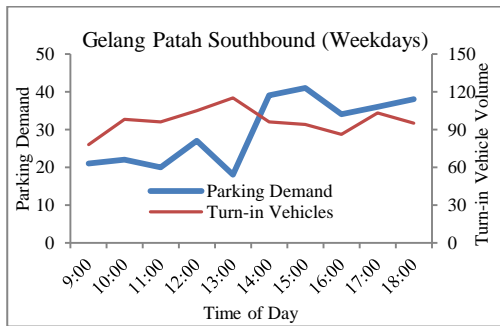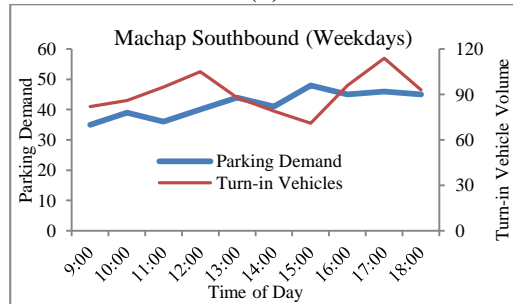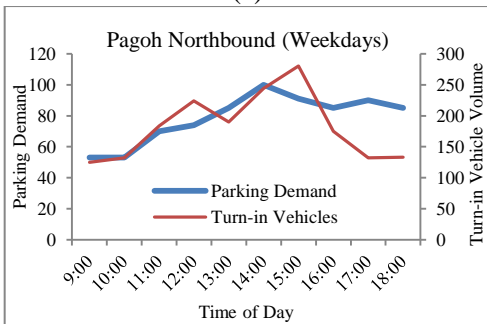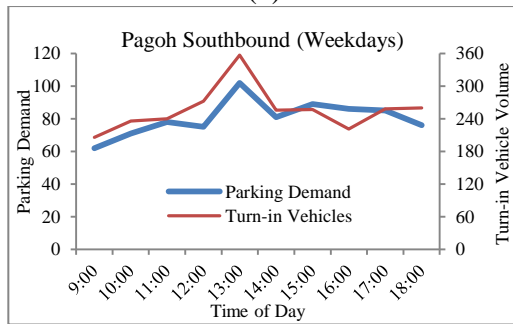

Figure 1: Trends of Parking demand and Turn-in Vehicle Volume on Weekday
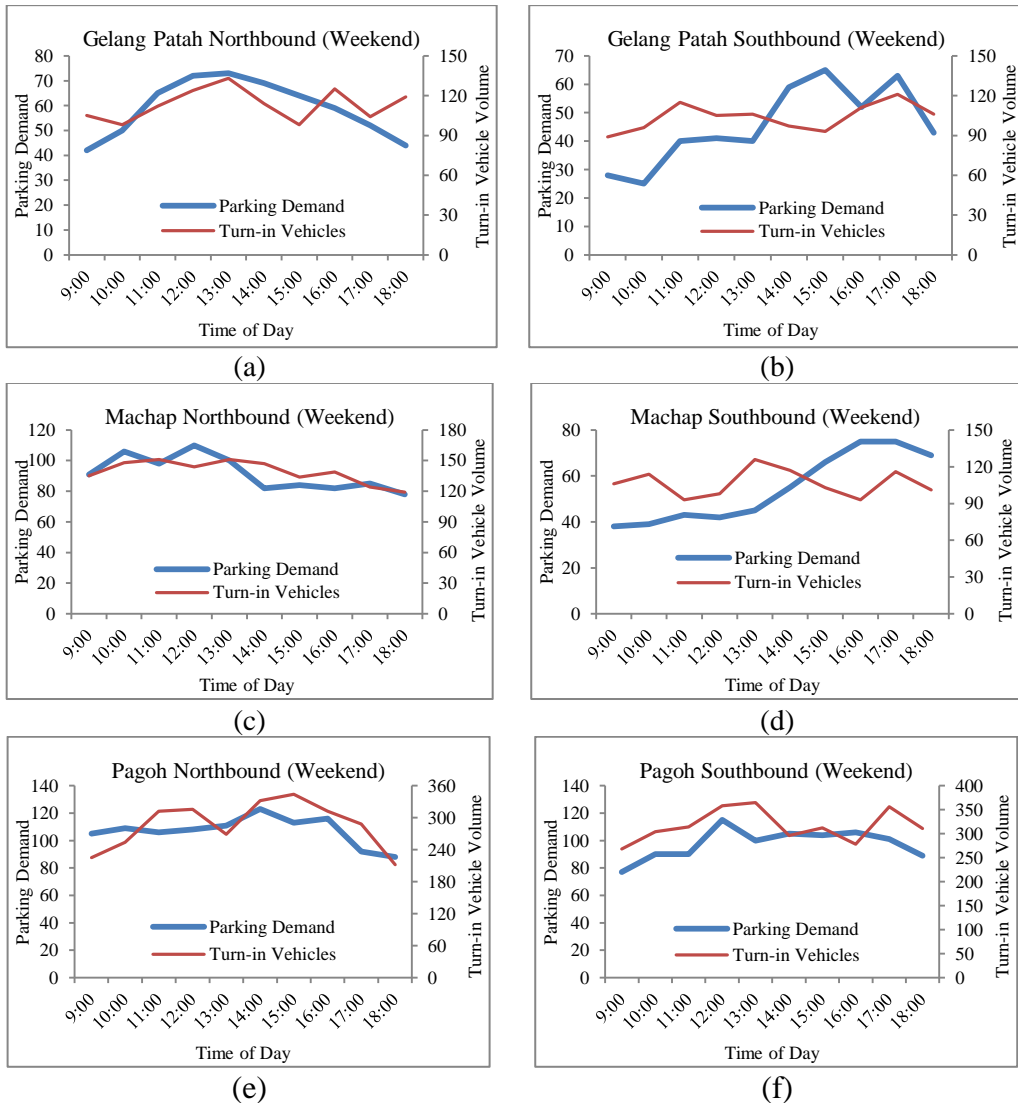
Figure 2: Trends of Parking demand and Turn-in Vehicle Volume on Weekend

3.2   *Descriptive Statistics on Parking Demand*

Table 2 show the descriptive statistics for parking demand on RSA two different days (weekday and weekend). The average of overall parking demand was 65.71 veh/hour whereas the average parking demands by different days were varied 55.47 veh/hour (weekday) and 75.95 veh/hour (weekend) respectively. This indicates the demand by the traveler on weekend was higher than weekday. The result signifying there is a relatively

high degree of variation of parking demand in RSA. This is mainly because the parking demand in RSA varies throughout the day for each site and also different site demonstrate varies parking demand.

Table 2: Statistics for Parking demand on RSA for Weekday and Weekend

	No. of Observations	Mean (veh/hour)	Standard Deviation	85th Percentile (veh/hour)	90th Percentile (veh/hour)	95th Percentile (veh/hour)	Range (veh/hour)
Parking Demand (Weekday)	60	55.47	21.549	85.00	85.90	90.95	18-102
Parking Demand (Weekend)	60	75.95	26.574	106.00	109.90	114.90	25-123
Overall Parking Demand	120	65.71	26.194	100.00	105.00	109.95	18-123

*Number of observations on each site for 10 hours period
*Mean values represent as average of parked vehicles for 10 hours period (veh/hour)

3.3 Correlation Analysis

To identify the effect of each study variables on parking demand in RSA, correlation analysis was performed in an attempt to determine the relationships between variables. The correlation between parking demand and each of the variables were established for different days (weekday and weekend) as shown in Table 3.

Table 3: Correlation between Variables on Parking Demand

		Gross Floor Area (GFA)	Total Vehicular Volume on Expressway
Parking Demand (weekday)	Pearson Correlation	0.735	0.908
	Sig.	>0.05	>0.05
	N	60	60
Parking Demand (weekend)	Pearson Correlation	0.676	0.815
	Sig.	>0.05	>0.05
	N	60	60

**Correlation is significant at the 0.01 level (2-tailed)
* N – Number of observations; Sig – Coefficient correlation

The first variables (GFA), the hypothesis been made that the larger size of facilities will increase the parking demand. The result indicates there are significant positive relationships between GFA and parking demand for weekday and weekend with correlation 0.735 and 0.676 respectively at 95% confidence level. On the other hand, second variable which was total vehicular volume on expressway has a strong positive relationship with parking demand for weekday and weekend with correlation 0.908 and 0.815 respectively at 95% confidence level. Thus, these two variables can be used as predictor for predicting parking demand on the RSA.

3.4   Regression Analysis

Peak period of parking demand on every site were selected to attempt the analysis. This is the hour of the day (9.00am-18.00pm) during which the highest parking demand rate occurs. Relationships of parking demand with gross floor area on Figure 3 and total vehicular volume on expressway on Figure 4 were plotted. From the simple linear regression analysis, the result revealed that the R^2 values were higher and the coefficient of the variables was significant between parking demand (weekday and weekend) to the gross floor area and total vehicular volume. The values of R^2 between parking demand and gross floor area were 0.677 for weekday and 0.509 for weekend respectively. Moreover, the values of R^2 between parking demand and total vehicular volume shows 0.920 for weekday and 0.765 for weekend respectively. Since the variables were significant, the prediction for parking demand models based on these variables could be developed.
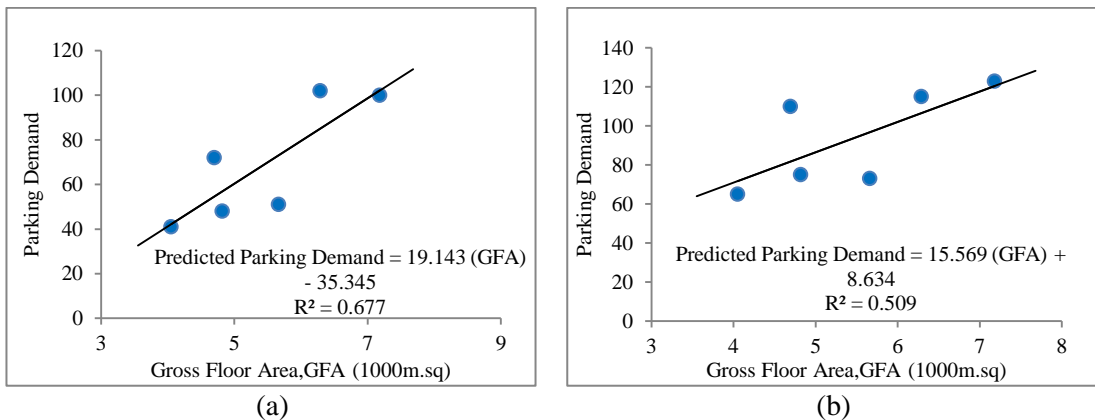

(a)   (b)

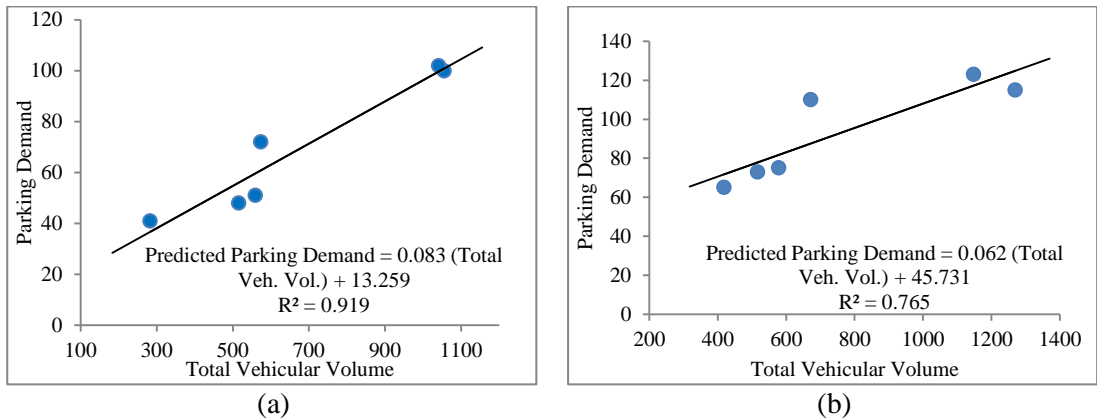Figure 3 : Relationship between parking demand and gross floor area ; (a) for weekday and (b) for weekend

Figure 4 : Relationship between parking demand and total vehicular volume ; (a) for weekday and (b) for weekend

4.0   Summary of Finding

This study has investigated two parameters that were believed to affect parking demand in RSA. Analysis of the parking demand at 6 sites along expressway in southern region Malaysia, Johor with two different days (weekday and weekend) was conducted. The results of this study may applicable for transport planners in predicting parking demand in Johor. The main findings of this study are as follows:

- Higher parking demand on each RSA was observed during midday (12:00 p.m. to 14:00 p.m.) and evening (15:00 p.m. to 17:00 p.m.) time period.
- Not all vehicles entering the RSA utilizing the parking space provided in RSA. Some of travelers having a quick stops or petrol fueling. This situation did not affect the capacity parking provided in RSA.
- The average parking demands by different days were varied by 55.47 vehicles/hour (weekday) and 75.95 vehicles/hour (weekend) respectively. This indicates the demand by the traveler on weekend was higher than weekday. The different mean values also signifying that the parking demands were varies with day of the week.
- The standard deviations on parking demand for two different days are 21.549 (weekday), and 26.574 (weekend) respectively. The result signifying there is a relatively high degree of variation of parking demand in RSA. This is mainly because the parking demand in RSA varies through the time of day.
- The correlation analysis has showed that there are significant positive correlations of parking demand with two variables: vehicular volume on major road and gross floor area. Thus these parameters may be used as predictor to parking demand in RSA.

- Linear regression analyses based on variables developed through this study were capable of predicting parking demand for RSA land use type. This study will facilitate transportation planners to better estimate anticipated parking for this land use type. Therefore, the developed model equations are recommended to be used.

5.0   Acknowledgements

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