MODELING THE IMPACT OF ON-STREET PARKING ON VEHICULAR TRAFFIC

Paper Identification number: SCS12-006

Marc Alvin LIM[1], Eriko Luis HALLARE[1], Jesus Gerard BRIONES[1]

[1]Civil Engineering, Students
De La Salle University – Manila
Telephone: 632 – 8195580
E-mail: marcalvinlim@gmail.com

Abstract

The use of most major streets in Metro Manila are not properly monitored and managed especially with regards to on-street parking thereby reducing the capacity of the road and even could cause accidents. By understanding the effects as well the relationship of on-street parking to moving vehicles and integrating it into an equation model, the model could be able to measure the impact of on-street parking on moving traffic and provide a better means of estimating the level of service and capacity of the road. Analytical survey method and experimental method were used in this study by videotaping the traffic flow of the street and analyzing the effects of on-street parking to moving traffic. The results of the study showed that the presence of on-street parking as well as the maneuvering of vehicles in and out of an on-street parking prolongs the travel time of moving vehicles whether it be parallel or angled to the curb. In addition, several other factors were found to have contributed to the prolonging of the travel time of moving vehicles such as the assistance of an attendant, the slowing down of vehicles due to drivers that carefully avoid obstructions or hindrances along its path and the total maneuvering process.

Keywords: On-street Parking, Vehicular Traffic, Modeling

1. Introduction

1.1 Background

Based on previous studies done by Oyon-Oyon, G. et al. (2009), on-street parking in Metro Manila are not properly monitored properly as shown below in Fig. 1, allowing several people to park their vehicles anywhere they want with no regards to whatsoever effect it might cause on other uses of the road thus causing traffic congestion. In addition to that, even in streets that provide or allow on-street parking, several problems still occur such as the accumulation of vehicles along the road as a result of a vehicle maneuvering in or out of a parking stall.

If on-street parking can be monitored and its effect on vehicular flow understood properly, this could be incorporated in the estimation of the capacity of the road/street. The capacity management of the city's road system is important so that on-street parking should be properly managed on roads with high vehicular demand.

On-street parking slows down and impedes vehicles and disrupts the flow of traffic especially when vehicles are maneuvering in and out of the curb, but when on-street parking is properly designed, properly regulated and properly incorporated in the estimation of road capacity with the use of an equation model, this could lessen the disruption caused by the on-street parking to the flow of traffic.

Fig. 1 Vehicle Parking along a "No Parking" Area

The scope of the study was only within the Metro Manila area such as Roxas Boulevard, San Juan and Makati. The study considered on-street parking whether it was parallel, angled or perpendicular parking and one sided or two sided

parking along the street. The study also considered the effects of on-street parking to both private and public moving vehicles moving along the same street.

One of the limitations of the study were what the camera can only see and what the camera was only able to capture, limiting the length of trap that could have been designated and that it was also limited to only videotaping the midspan of the road segment and that the equation generated was only applicable for 2 to 4 lane road segment as well as one-way and two-way directions only. The study's data was also limited to what was seen and available during the period of time for the videotaping done for the data gathering as well as the number of locations that were available that met the needed proper criteria for videotaping the impact done by the on-street parking to the moving vehicles (see Chapter IV for the proper criteria needed in locating a decent site for videotaping).

By understanding the effects as well as the relationship of on-street parking on moving vehicles, this could provide a better means of measuring the capacity of the road. On-street parking should not be allowed on roads with high vehicular demand while on-street parking should be allowed on roads with less vehicular demand.

This would also benefit a lot of people especially those who bring their vehicles to work and to other places since it would provide a better vehicular flow as well as reduce the number of accidents with regards to on-street parking.

This would also provide data and background literatures for studies conducted by future researchers that are concerned with on-street parking studies since there are few studies conducted with regards to the said topic in the Philippines.

1.2 Objectives of the Study

The main objective of the study is to develop a model that could measure the impact of on-street parking on vehicular traffic.

The specific objectives are as follows:

- To characterize on-street parking behavior such as the number of maneuvering vehicles in and out of the curb per time period as well as the time consumed when doing the maneuvering.
- To determine the effects of different parking designs such as parallel and angled parking on vehicular flow.
- To determine and estimate the effect of on-street parking on the capacity of the road.
- To recommend solutions to improve the flow of traffic especially on roads where on-street parking is allowed.

1.3 Operational Definition of Terms

Freeflow Time as used in this study refers to the regular or normal time a vehicle passes through the trap length without any disruptions.

Time Delay as used in this study refers to the delayed time caused by the maneuvering in or the maneuvering out of a vehicle from the parking stall hindering the sample vehicle passing through the trap length. This also considers other variables that slows down the sample vehicle.

2. Literature Review

In a study done by Oyon-Oyon G. et al. (2009), they have observed that there is an insufficient amount of parking facilities in the Ermita-Malate area thus resulting to some of the vehicles being parked along the streets. As an effect of the illegally parked vehicles along the streets, congestions may occur as well as hindering the flow of traffic. Therefore, as a solution, they introduced a parking scheme that would help improve the vehicular flow along the streets and at the same time provide revenues for the city. They studied and designed a new parking scheme for the Ermita-Malate area in the city of Manila and estimated actual demands and capacities for on-street parking during peak hours in the morning and evening during summer and academic seasons. Their study has concluded that seasonal parking demands differ in commercial and institutional areas. However, with regards to residential areas, the demand doesn't seem to change as much due to season simply because the residents living there are still there whether it be summer time or not. They also conducted designs wherein vehicles should be prohibited to park on main roads, on roads where public transport passes by, and a clear distance of 6 meters from the corner should be prohibited for parking and a clear path for fire hydrants and

gates/driveways. Their work also tells us more about the demands of on-street parking in areas near schools, malls, etc. wherein off-street parking facilities are already unable to accommodate the number of vehicles willing to park thus on-street parking should no longer be prohibited but rather implemented with proper supervision by authorities or local city government officials.

Their thesis is related to the present study because of the significance of their study wherein it not only helps to provide revenue for the city but also improves the vehicular flow through an orderly and efficient use of road space through their said proposed designs.

In a study done by Manguera et al. (2010) wherein it discusses about whether off-street parking facilities are able to satisfy the parking demands of customers and whether infrastructures within their study area were able to meet and follow the requirements stated in the National Building Code of the Philippines with regards to supplying enough parking spaces. They chose certain establishments which were the major traffic generators within the study area. Their data showed that at certain periods of the day, especially in the afternoon, off-street parking facilities were already at its peak and were no longer able to accommodate for other incoming vehicles. It can also be seen in their data that 24% of the respondents from their survey parked on-street. They also stated that "The distribution may be due to the availability of these assortments of parking types around the survey area." Here, it can be assumed that some of those 24% that parked on-street, parked along the street because of the limited availability of off-street parking facilities. Therefore, parking demand and parking supplied by off-street parking facilities also do affect on-street parking since people tend to find or look for other possible parking areas when bringing their vehicles.

This study is related to the present study because it studies the parking demands of customers and whether parking supply requirements are met and followed by different infrastructures as stated in the National Building Code of the Philippines. It is also related to the present study since the parking demand of customers also affects the on-street parking since the tendency of people bringing vehicles are to look for other possible parking areas when faced with insufficient off-street parking facilities. Therefore, on-street parking tends to attract more people when off-street parking is no longer available.

3. Methodology

The researchers used the analytical survey method and the experimental method for the present study. The researchers initially did a site selection for the present study. The researchers decided to study both the traffic flow where on-street parking was permitted and not permitted within the area of Metro Manila such as the commercial districts of Roxas Boulevard, San Juan and the Makati Central Business District (CBD). The criteria for selecting an appropriate site was that it has to have an ample amount of vehicles parked along the curb and an elevated location providing a sufficient enough view of the road segment for videotaping.

Upon choosing the area to be studied, the researchers looked for a secured and safe location wherein it was also elevated in order to have a sufficient view for videotaping the traffic flow of the street. The purpose of videotaping the areas studied were to record the traffic flow and the vehicles parking in and out of the curb as well as other situations in those areas such as vehicles loading and/or unloading, pedestrians crossing among others. After placing and setting the video camera, the researchers designated a trap length wherein the vehicle's speed and travel time as the vehicles entering and leaving the trap could be obtained. The recorded videos were used to determine the speed and density of the flow of traffic of the study area. The recorded videos were also used to determine and analyze the impact of on-street parking on moving traffic as well as the average time it took for a vehicle to maneuver in and out of the parking stall and other useful data.

The data and certain parameters such as speed, density and number of lanes, and the data needed as mentioned earlier such as the impact of on-street parking on moving traffic and such were then extracted from the videos and studied and were integrated into a multiple regression model in order to generate an equation model that was used for the present study.

In analyzing the video data, the researchers first took the volume per fifteen minute for each direction as well as the number of vehicles maneuvering in and out of the stall. The researchers also took into account the actual time of the day the

vehicles maneuvered in and out of the parking stalls as well as the time delay such actions caused to the moving traffic. Other variables that affected the travel time of the affected vehicle (sample vehicle that was affected by the maneuvering in or out of a vehicle from the parking stall) were also taken into consideration. These data were then grouped accordingly. Graphs were also made so as to show the data visually and more effectively as shown in later chapters. After the data was studied and carefully analyzed for variables that affected the freeflow travel time of the vehicle as well as the delayed time of the vehicles, these data or variables were then integrated into a multiple regression.

The equation model generated through the use of the multiple regression was used to mathematically figure out the causes of congestion or the decrease of vehicular speed and prolonged travel time when faced with on-street parking. Actual values were used and incorporated in the regression analysis for some variables while the other variables were considered as dummy variables wherein these variables were only given values of 1s and 0s whether those variables were present or not during the analysis. T – statistics can also be seen in the regression output. This allowed the researchers to determine whether the independent variable had significant effect to the dependent variable. T – stat values that had values below 1.96 were neglected and removed for the succeeding analyses. The coefficient value was also taken into consideration while analyzing the regression output. Values that were negative or had a value of zero were also eliminated and neglected since it would be illogical for hindrances such as the independent variables stated before to further decrease the travel time rather than increasing or prolonging the moving vehicle's travel time.

The variables mentioned earlier were also used in performing the correlation analysis. This allowed the researchers to see the relationship between the variables that were considered. Together with the regression output, the correlation analysis allowed the researchers to remove and eliminate insignificant variables that did not have much effect to the dependent variable. Both analysis were performed to eliminate and remove insignificant variables that were considered before-hand. These procedures were repeated until the remaining variables were attained.

The research design of the present study was mainly based on the data extracted from the recorded videos. Data from the videos were primary data since the data were directly videotaped by the researchers and were also the main source of data and information for the present study. The data were secured in a storage device such as tapes, CDs, external drives or USBs. The data collected and stored in the devices mentioned earlier was used and interpreted by carefully examining the videos taken and finding out certain parameters that was considered for the present study.

Other than the primary data mentioned above, the researchers also got data from what they observed in the studied areas. The researchers also included in their observations: type of on-street parking (be it parallel or angled; one sided or two sided), the type of buildings that surround the road (commercial, business, etc), the number of lanes, and such.

With these data, the researchers generated an equation model with the use of the multiple regression where the independent variables were mentioned earlier such as the maneuvering in and out of vehicles from the parking stall, actual number of pedestrians, number of lanes used for the moving vehicles, etc while the dependent variable was considered as the delayed travel time of the vehicle. With the equation generated, the researchers checked whether the independent variables were contributing factors causing congestion due to on-street parking. The equations for each area studied were also compared and checked for any significant differences. Correlation and t – statistic values were also considered in analyzing the variables as well as the values of the coefficient obtained through regression analysis.

4. Results of the Study

4.1 Site A: Annapolis Street

The on-street parking seen in the figure below, Fig. 2, has a 60 degree angle from the curb and that there is only on-street parking on one side of the road. The researchers considered a trap length of 61 meters and a trap width of 14 meters as shown below in Fig. 2. The researchers were able to videotape Site A for a period of around 8 hours.

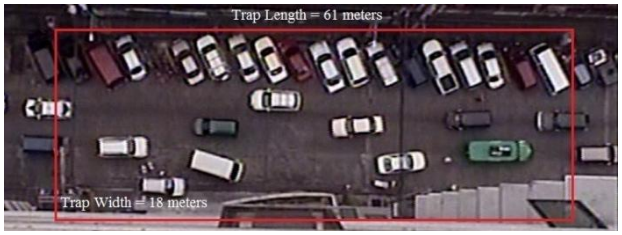

Fig. 2 Trap Length for Annapolist Street

The table below, Table 1, illustrates the average amount of time for a vehicle to pass through the said trap length without any delay. It also shows the number of samples that were taken into account when averaging the freeflow time for each direction as well as for both directions.

In addition, Table 1 shows that there is a 95% level of confidence that the average freeflow time for Westbound vehicles to have a value between 9.04 to 9.72 seconds. On the other hand, there is also a 95% level of confidence for Eastbound vehicles to have an average freeflow time of around 9.22 to 9.70 seconds. Lastly, there is a 95% level of confidence that the average freeflow time for both directions to have a value ranging from 9.22 to 9.70 seconds.

Table 1 Average Freeflow Time

	No. of Samples	Average Freeflow Time (secs)	95% Level of Confidence
Westbound	113	9.38	$9.04 < \mu < 9.72$
Eastbound	198	9.46	$9.22 < \mu < 9.70$
Both Directions	311	9.43	$9.23 < \mu < 9.63$

It can be seen in Table 2 that vehicles took a longer time to maneuver out of the parking stall than to maneuver in. Having an average maneuvering in time of 24.37 seconds and an average maneuvering out time of 21.94 seconds. This may be due to the fact that most vehicles had to move backwards when maneuvering out as seen in Fig. 2 above.

Table 2 F-Test Two-Sample for Variances

	M. In	*M. Out*
Mean (secs)	21.94	24.37
Variance	258.1957	135.7575
Observations	31	30
df	30	29
F	1.90188	
P(F<=f) one-tail	0.04351	
F Critical one-tail	1.85429	

Table 2 was used to determine whether to use a t-Test: Two-Sample Assuming Unequal Variances or to use a t-Test: Two-Sample Assuming Equal Variances for the average time consumed of vehicles maneuvering in and out of the parking slot.

It can be seen that the F Critical One-Tail is less than the F-test since by looking at the table below, Table 2, F Critical One-Tail has a value of 1.85 while the F-test has a value of 1.90. Therefore, a t-test: two-sample assuming unequal variances was used.

It can be seen in Table 3 that the t-Stat was less than the t-critical one-tail having values of 0.678 and 1.673, respectively. Therefore, at 95% level of confidence there is no difference in terms of the average time consumed in seconds between vehicles maneuvering in from vehicles maneuvering out.

Table 3 t-Test: Two-Sample Assuming Unequal Variances

Hypothesized Mean Difference	0
df	55
t Stat	0.67810
P(T<=t) one-tail	0.25027
t Critical one-tail	1.67303
P(T<=t) two-tail	0.50054
t Critical two-tail	2.00404

The table below, Table 4, shows the average delayed travel time of vehicles going in and out of the trap length caused by the maneuvering of vehicles in and out of a parking stall.

Table 4 Time Delay due to the Maneuvering of Vehicles In and Out of a Parking Stall

	No. of Samples	Average Travel Time Consumed (secs)	95% Level of Confidence
Westbound	30	35.57	$30.02 < \mu < 41.12$
Eastbound	16	34.31	$25.34 < \mu < 43.28$
Both Directions	46	35.13	$30.56 < \mu < 39.70$

4.2 Site B: Aguirre Street

For this location, a parallel type of on-street parking is being used. The researchers considered a trap length of 71 meters and a trap width of 10 meters as shown below in Fig. 3. It was videotaped for a period of around 10 hours.

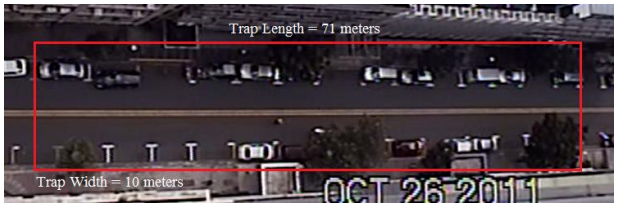

Fig. 3 Trap Length for Aguirre Street

Table 5 Average Freeflow Time

	No. of Samples	Average Freeflow Time (secs)	95% Level of Confidence
Westbound	70	9.43	$9.11 < \mu < 9.75$
Eastbound	31	9.61	$9.21 < \mu < 10.01$
Both Directions	101	9.49	$9.24 < \mu < 9.74$

It can be seen in Table 6 that vehicles took a longer amount of time to maneuver in than out, having values or 20.27 seconds and 10.61 seconds, respectively. This may be due to the fact that drivers had to carefully maneuver their vehicles when maneuvering in the parking stalls since it is rather harder to park vehicles parallel to the curb than it is to maneuver out of a parallel parking.

Table 6 F-Test Two-Sample for Variances

	M. In	*M. Out*
Mean (secs)	20.27	10.61
Variance	227.00887	56.21176
Observations	122	143
df	121	142
F	4.03845	
P(F<=f) one-tail	2.89993E-15	
F Critical one-tail	1.33231	

Table 6 was used to determine whether to use a t-Test: Two-Sample Assuming Unequal Variances or to use a t-Test: Two-Sample Assuming Equal Variances for the average time consumed of vehicles maneuvering in and out of the parking slot.

It can be seen that the F Critical One-Tail is less than the F-test since by looking at the table below, Table 6, F Critical One-Tail has a value of 1.33 while the F-test has a value of 4.04. Therefore, a t-test: two-sample assuming unequal variances was used.

It can be seen in Table 7 that with a hypothesis mean difference of 5, the t-Stat was greater than the t-critical one-tail having values of 3.105 and 1.653, respectively. Therefore, at 95% level of confidence there is a difference of greater than 5 seconds in terms of the average time consumed between vehicles maneuvering in from vehicles maneuvering out.

Table 7 t-Test: Two-Sample Assuming Unequal Variances

Hypothesized Mean Difference	5
df	171
t Stat	3.10543
P(T<=t) one-tail	0.00111
t Critical one-tail	1.65381
P(T<=t) two-tail	0.00222
t Critical two-tail	1.97393

Table 8 Time Delay due to the Maneuvering of Vehicles In and Out of a Parking Stall

	No. of Samples	Average Travel Time Consumed (secs)	95% Level of Confidence
Westbound	26	20.5	$17.57 < \mu < 23.43$
Eastbound	4	20.5	$10.07 < \mu < 30.93$
Both Directions	30	20.5	$17,87 < \mu < 23.13$

4.3 Site C: Chino Roces Avenue

Similar to Aguirre Street, parallel parking is considered for this location. However, the researchers considered a trap length of 62 meters and a trap width of 13 meters as shown below in Figure 4. The area was videotaped for a period of around 6 hours.

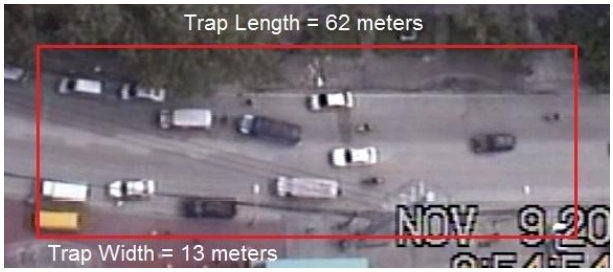

Fig. 4 Trap Length for Chino Roces Avenue

Table 9 Average Freeflow Time

	No. of Samples	Average Freeflow Time (secs)	95% Level of Confidence
Westbound	188	10.93	$10.62 < \mu < 11.24$

It can be seen in Table 10 that vehicles had a longer time to maneuver out of the parallel parking than to maneuver in with values of 13.48 seconds to maneuver out and 11.79 seconds to maneuver in. This may be due to the fact that drivers or vehicles had to carefully watch out for upcoming vehicles along the road that they might hit or might hit them since the conducted study area for this site was a main road as compared to the other sites considered thus having a greater amount of vehicular volume.

Table 10 was used to determine whether to use a t-Test: Two-Sample Assuming Unequal Variances or to use a t-Test: Two-Sample Assuming Equal Variances for the average time consumed of vehicles maneuvering in and out of the parking slot.

It can be seen that the F Critical One-Tail is greater than the F-test since by looking at the table below, Table 10, F Critical One-Tail has a value of 0.630 while the F-test has a value of 0.366. Therefore, a t-test: two-sample assuming equal variances was used.

Table 10 F-Test Two-Sample for Variances

	M. In	*M. Out*
Mean (secs)	11.79	13.48
Variance	41.62597	113.70168
Observations	56	48
df	55	47
F	0.36609	
P(F<=f) one-tail	0.00019	
F Critical one-tail	0.63032	

It can be seen in Table 11 that the t-Stat was less than the t-critical one-tail having values of 0.995 and 1.660, respectively. Therefore, at 95% level of confidence there is no difference in terms of the average time consumed in seconds between vehicles maneuvering in from vehicles maneuvering out.

Table 11 t-Test: Two-Sample Assuming Equal Variances

Pooled Variance	74.83733
Hypothesized Mean Difference	0
df	102
t Stat	0.99520
P(T<=t) one-tail	0.16099
t Critical one-tail	1.65992
P(T<=t) two-tail	0.32199
t Critical two-tail	1.98349

Table 12 Time Delay due to the Maneuvering of Vehicles In and Out of a Parking Stall

	No. of Samples	Average Travel Time Consumed (secs)	95% Level of Confidence
Westbound	20	20.05	$16.70 < \mu < 23.40$

4.4 Site D: Roxas Boulevard

For this site of on-street parking, it is perpendicular to the curb. The researchers considered a trap length of 40 meters and a trap width of 12 meters as seen in Fig. 5. The trap length considered was only 40 meters
because this was the optimum distance that could be seen and can still be recognizable as seen in the video or in Fig. 5. The researchers were able to videotape this area for a time period of around 8 hours.

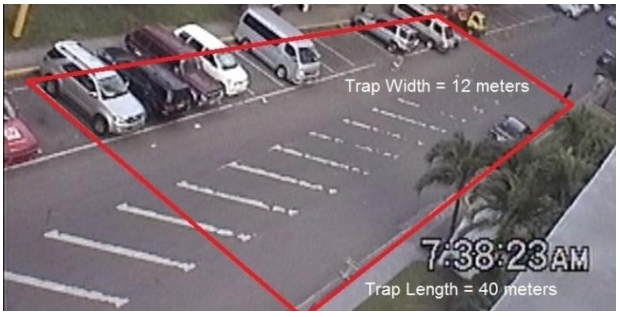

Fig. 5 Trap Length for Roxas Boulevard

Table 13 Average Freeflow Time

	No. of Samples	Average Freeflow Time (secs)	95% Level of Confidence
Westbound	540	5.44	$5.32 < \mu < 5.56$
Eastbound	191	5.20	$5.04 < \mu < 5.36$
Both Directions	731	5.38	$5.28 < \mu < 5.48$

It can be seen in Table 14 that vehicles had a longer time to maneuver in than to maneuver out since by looking at the said table below, it can be seen that vehicles had an average time to maneuver in of 25.2 seconds and an average time to maneuver out time of 18.04 seconds. This may be because most of the vehicles maneuvering in to the parking stalls had to move backwards as seen in Fig. 5 above. This takes a longer amount of time to do for several drivers than to maneuver out moving forward.

Table 14 was used to determine whether to use a t-Test: Two-Sample Assuming Unequal Variances or to use a t-Test: Two-Sample Assuming Equal Variances for the average time consumed of vehicles maneuvering in and out of the parking slot.

It can be seen that the F Critical One-Tail is less than the F-test since by looking at the table below, Table 14, F Critical One-Tail has a value of 1.930 while the F-test has a value of 2.443. Therefore, a t-test: two-sample assuming unequal variances was used.

Table 14 F-Test Two-Sample for Variances

	M. In	*M. Out*
Mean (secs)	25.2	18.04
Variance	179.75	73.59126
Observations	25	28
df	24	27
F	2.44254	
P(F<=f) one-tail	0.01320	
F Critical one-tail	1.92994	

It can be seen in Table 15 that the t-Stat was greater than the t-critical one-tail having values of 2.286 and 1.684, respectively. Therefore, at 95% level of confidence there is a difference in terms of the average time consumed in seconds greater than 0 between vehicles maneuvering in from vehicles maneuvering out.

Table 15 t-Test: Two-Sample Assuming Unequal Variances

Hypothesized Mean Difference	0
df	40
t Stat	2.28641
P(T<=t) one-tail	0.01380
t Critical one-tail	1.68385
P(T<=t) two-tail	0.02760
t Critical two-tail	2.02107

Table 16 Time Delay due to the Maneuvering of Vehicles In and Out of a Parking Stall

	No. of Samples	Average Travel Time Consumed (secs)	95% Level of Confidence
Westbound	19	14.95	3.96
Eastbound	5	15.20	0.56
Both Directions	24	15.00	3.07

4.5 Analysis and Findings

After several trial and testing, it was found that the variables x5, x6 and x9 were the ones that had the highest correlation with the dependent variable y having values of 0.66499, 0.69517 and 0.73586, respectively, and that these variables had the largest or biggest impact to the moving vehicles' travel time. These independent variables are in fact variables that considered vehicles that were affected by a vehicle maneuvering in or out from the parking stall while being assisted by an attendant or guide, vehicles with a decelerated speed because of drivers carefully moving through traffic due to several obstruction or tight spaces along its path, and the variable that considers both or the total maneuvering (i.e. a vehicle maneuvering in affecting the travel time of a sample vehicle A and at the same time or in succession, a vehicle maneuvering out affecting the same or similar sample vehicle A and vice versa).

Table 17 Final Regression Statistics

Multiple R	0.800645			
R Square	0.641032			
Adjusted R Square	0.640287			
	Coefficients	Standard Error	t Stat	p-value
Intercept	7.3967	0.11109	66.59	0
x5	9.3359	0.75405	12.38	1.55E-33
x6	10.161	0.75563	13.45	6.28E-39
x9	7.4999	0.54680	13.72	2.42E-40

The t-stat values of the said variables were able to attain values of 12.3811, 13.4472 and 13.7160 for variables x5, x6 and x9, respectively, providing a higher percentage of confidence level. The regression analysis for the variables x5, x6, x9 and for the dependent variable y also had a high enough R squared value of 0.64 as seen in Table 17. This simply means that 64% of the data can be relatively explained. This also shows how well the regression model fits the data collected.

The following equation was generated through the several tests and trials and was a result of the findings mentioned earlier. This may help provide future land development projects and such in estimating the capacity of the road when considering and/or proving on-street parking for a road segment.

$$y = 7.3967 + 9.3359X_5 + 10.1611X_6 + 7.4999X_9 \quad (1)$$

Where:

y = Travel Time (seconds)

X_5 = Presence of an Attendant when Vehicles are Maneuvering In or Maneuvering Out of the Parking Stalls

X_6 = Presence of a Vehicle Slowing Down due to a Tight Space along the Road

X_9 = Total Number of Vehicles Maneuvering (Maneuvering In + Out)

Keep in mind though that the equation above, Eq (1), was generated with a somewhat limited availability of on-street parking sites that met the proper criteria as mentioned earlier in Chapter 3 of this manuscript. It was generated by only studying four different sites that included two parallel parking, one perpendicular and one angled parking. The equation above was also only limited to a short allowable time done for the study. The equation above was also only limited to what the camera was only capable of capturing due to the camera's limited capabilities and was also limited to the recording of the flow of the traffic, the limited number of vehicles maneuvering in or out, etc. It was generated by the limited variables that were observed, considered and thought about by the researchers that could affect the travelling time of a moving vehicle and such. Other variables that were not mentioned earlier were either disregarded or replaced due to its insignificancy such as the presence of public vehicles.

In the case of the present study, it was found that the actual width of the road (x10) as well as the lessened width of the road due to the vehicles that had already parked before-hand (x16) did not have much significant effect on the moving vehicles' travelling time. This may be due to the fact that vehicles have already parked there ever since whether it be night or day, already lessening the road's capacity throughout the whole day. In addition, it can be seen that the independent variables x10 and x16 have minimal effect to the dependent variable y, having correlation values of 0.22993 and 0.32359, respectively. These values were too low as compared to the other variables that were considered. As a result, the independent variables x10 and x16 were disregarded and neglected in the further and later regression analysis that was done. In addition, by looking at the coefficient values of these variables, it can be seen that x10 and x16 had values of 4.904E+13 and -5.847E+13, respectively. These coefficient values were too big making it highly unrealistic for a vehicle to stay that long or that quick inside the designated trap length.

It was also found that the different types of on-street parking did not have much effect on the vehicle's travel time for the present study since by looking at the variables x14 (site has parallel parking) and x15 (site has angled parking), and that the Intercept of the said variables also had unrealistic coefficient values of 0.0, 3.1352E+12 and -2.4271E+14, respectively. Poor t-stat values can also be seen for the said variables x14, x15 and the Intercept, having values of 65535, 0.82419 and -4.4734, respectively.

5. Conclusions and Recommendations

On-street parking is not properly monitored and incorporated in the estimation of road capacity thus overestimation of road capacity with on-street parking occur. The present study aimed to improve on this matter by generating an equation model that would provide a better model about traffic flow when and where on-street parking should be allowed, putting into account as well the maneuvering in or out of the vehicles to or from the parking stalls. The equation model would estimate the moving vehicles' travel time such as the average freeflow time as well as the delayed travel time caused by the presence of an on-street parking as well as the maneuvering of vehicles in or out of the parking stall. The present study also aimed to characterize on-street parking behavior, to determine the effects of the different types of parking designs, and to determine and estimate the effect of on-street parking on the road's capacity.

It was found that other than the maneuvering of a vehicle in or out a parking stall, other significant variables that affected the travel time of the vehicular flow were the presence and assistance of a guide or an attendant, the slowing down of another vehicle due to drivers that carefully avoid obstructions or hindrances along its path, and the total number of vehicles maneuvering in and out of the parking stall similar to what was mentioned earlier.

In the case of the present study, it was also found that the actual width of the road as well as the lessened width of the road due to the parked vehicles along the curb of the street did not have much effect on the travelling time of moving vehicles. This may be due to the fact that vehicles have already parked before-hand whether it be day or night thus already occupying particular lanes along the curb of the street for the entire day and not making much of an effect to the flow of traffic. Keep in mind though that such conclusions with regards to the width of the road were only based from the data that the researchers were only able to gather within the allotted time given for the study. It does not generally characterize that the width of the road has no effect for every situation that considers the width of the road and the lessened width of the road due to the on-street parking.

The effect of the different types of parking designs were considered on this study, but it can be seen that the different parking designs did not have much of an effect to the travel time of the moving vehicles as explained earlier. This may also be due to the fact that the study was only able to consider one perpendicular parking, one angled parking, and two parallel parking thus having insufficient data to make an accurate conclusion. Therefore, it was rather unclear or inconclusive as to what effect the different parking designs cause on moving vehicles.

Lastly, after several trial and testing, and analyses the researchers were able to conclude that the presence of an on-street parking along a street as well as the maneuvering of a vehicle both in and out of the parking stall really does hinder the flow

of traffic and prolongs the travel time of a moving vehicle.

In order to generate a better equation, the researchers would suggest and recommend to have more time in conducting such research since the three to four months that were allotted were not enough ample time to videotape a somewhat desirable number of sites of five to six locations.

The researchers would also like to recommend to further locate other sites that would provide different types of on-street parking design (parallel, perpendicular and angled parking). It is recommended that future researchers would consider at least two or more different sites or locations for each type of on-street parking such as two parallel parking, two perpendicular parking and two locations with angled parking. The more locations or study areas to be considered, the better since this would provide a more accurate and a more sufficient data, providing future researchers a better analysis of the impact done by on-street parking to moving vehicles. This would also provide a better output for generating an equation model.

The researchers would also like to recommend other variables to be considered other than the variables that have already been mentioned earlier or was already used for this study since there could be several other variables that could have been used and considered in generating an equation for the impact of on-street parking to the moving vehicles but was either not thought of by the researchers or was neglected and disregarded due to insufficient amount of data gathered for it.

References

[1] Manguera, et al. (2010) *Assessing parking Demand and supply of establishments in Ermita-Malate area, city of Manila*. BS Civil Engineering Thesis, De La Salle University, Manila, Philippines

[2] Oyon-oyon, G. et al. (2009). *On-street parking scheme in Ermita-Malate Area*. BS Civil Engineering Thesis, De La Salle University, Manila, Philippin