Parking Utilization Pattern of Park and Ride Facility at Public Transportation Terminals

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Abstract: Parking utilization survey was administered to examine the parking usage at two existing park and ride facilities along the Kelana Jaya LRT Line. This study also analyses the existing parking supply and its physical conditions through parking space inventory survey at the two selected facilities. Parking characteristics such as parking occupancy, parking accumulation, parking volume, parking turnover and parking duration at each facility were also examined. Findings showed that overall parking utilization pattern at the two facilities was generally high with the occupancy rate of more than 85% (Terminal Putra station) and more than 92% (Kelana Jaya station). Additionally, both stations were found long-term parkers (more than 7 hours). The results from this study were found to be comparable with park and ride studies at Shah Alam and Seremban KTM stations and Washington. Finally, recommendations to improve parking supply to meet increase in parking demand and conclusions are also drawn.

Keywords: Park and ride, Utilization, Accumulation, Occupancy, Duration

1. INTRODUCTION

The increasing reliance on the private vehicles has caused the modal split for public transport to steadily decline since 1990 in Kuala Lumpur; in 1990 it was 40% and in 2000 it has down to 16% (Kuala Lumpur Structure Plan, 2000). Many improvements to the public transportation system in Kuala Lumpur were made in the last decade in order to address the burgeoning issue of traffic congestion; one such measure was the implementation of the Kelana Jaya LRT line. The Kelana Jaya LRT Line, formerly known as PUTRA LRT, is currently owned by Syarikat Prasarana Negara Berhad (SPNB) and operated by Rapid KL. The first phase of Kelana Jaya LRT Line was commenced on September 1, 1998 from Subang Depot to Pasar Seni station and second phase, from Pasar Seni station to Terminal Putra in June 1999. In 2002, the system carried its 150 millionth passenger, with an average of 160,000 passengers riding the system daily at that time. Today, it carries over 190,000 passengers a day and over 350,000 a day during national events.

Kuala Lumpur is the most important city in Malaysia. The Road Transport Department Malaysia (2011) stated that Kuala Lumpur continues to be flooded with newly-registered motor vehicles each year. The number of vehicles has increased from 115,661 vehicles in 2000 to 208,560 in 2010 with an annual average growth rate of 4.45%. With the increase in the country's overall average income level, there are increases in demand for private vehicle

ownership. Besides, the affordable prices of locally-manufactured cars also encourage the high demand for private vehicle ownership.

The construction of highways and ring roads in and around the city yet improved the traffic flow, but to some extent, the city centre suffers morning and evening traffic congestion, typically from the increase of automobiles dependency in the metropolitan area. Combined with improvements in transport infrastructure connecting the suburbs and the city and relatively cheaper housing in the outskirts of the city, there exists a mismatch between residential and employment concentration at the city areas (Hamid, 2009). Furthermore, the over-utilization of the roads and highways as well as the limited capacity of these infrastructures in accommodating the increase in the traffic volume, the issue of accessibility to the city centre has become one of the main agenda of the urban planners (Hamid, 2009). It is also agreed by most authorities that congestion is going to get worse, as the capacity of the network will never increase in tandem with the increase in demand (Banister, 2001). Even if it is possible to invest in expanding the infrastructure, this is not seen to be desirable for financial and environmental reasons (Banister, 2001). Additionally the high number of private vehicles in urban areas led to the issues of congestion and pollution. In order to address these issues, Lam (2001) and Runkel (1993), have agreed that the implementation of the park and ride schemes can be viewed as part of the answers towards reducing congestion in the urban areas.

The purpose of this paper is to investigate the utilization pattern of parking spaces at the Kelana Jaya and Terminal Putra park and ride LRT stations. The adequacy of parking spaces to cater for the park and ride users is another important aspect which is covered in this paper. The parking utilization characteristics such as parking accumulation, parking turnover, parking duration and parking occupancy were analysed at these two park and ride LRT stations. These two stations were chosen because their location covers a wider population catchment comprising mainly various types of residential areas which would, eventually, propel users to use LRT services. This paper aims to examine the parking usage at Kelana Jaya and Terminal Putra park and ride stations in order to determine the adequacy of parking provisions at these stations. Section 2 provides literature review on this subject; section 3 on the background of the selected study areas. Section 4 describes the objectives and methodology of this study. Section 5 discusses the analysis on parking usage at Kelana Jaya and Terminal Putra park and ride stations. Discussion and recommendations are provided in Section 6 and section 7 provides conclusions with suggestions for further research.

2. LITERATURE REVIEW

Parking is a basic need for transportation. As the number of vehicles increase, the need for parking facilities also increases. It is crucial to minimize traffic congestions, accidents, pollution and unwanted fuel use through parking management and policies (Almselati, *et al*., 2011). Park and ride is a scheme where the provision of parking spaces at a site, with some distance and access to public transport to achieve the destination (Ashley, 1994); a large off-site parking space with a shuttle-bus serving the workplace (Hole, 2004). With efficient planning of service networks and attracts rider who may not have otherwise used transit, park and ride is considered as an ideal element of urban mass transportation systems (Barnum, 2007).

As highlighted by Simpson (1994), the park and ride has two main purposes which are first, to shift the modal split towards public transport and second, to reduce the needs for parking spaces in town centre. This will grant an access to town centre with relatively little

environmental damage from traffic. Furthermore, Hole (2004) also mentioned that park and ride is particularly effective in reducing car use if the workplace has limited parking space on-site.

The ability of park and ride to reduce car use has been debated since mid 1990s (Meek, 2010). Parkhurst (1995) has started to identify the implications of park and ride among Oxford & York users. He found that generated trips will increase mileage. Thus, trips to park and ride were considered as contributor to the increasing of car use.

Later, Parkhurst (1999) argued that park and ride could induce a net increase rather than achieving reductions in traffic. He highlighted that high frequency and low load were factors that park and ride buses caused in a net increase in the distance travelled in car equilibrium terms. Thus, Topp (1995) and Parkhurst (2000) proposed and developed the concept of 'Link and Ride' where it decentralized the park and ride sites. The sites are spread along a corridor, away from the city center but still could directly link to the satellite settlements. This concept has proven efficiently increase distance of bus journey, at the same time reduce car access trips in UK (Meek, 2010).

Additionally, Liu *et al*. (2009) mentioned that the attractiveness and effectiveness of park and ride depend mainly on the locations and parking charges of facility, service quality and fares of public transits, road congestion, road tolls and parking charges at the city centre. The location of park and ride particularly in close proximity to residential areas, may serve users to use variety of modes (automobiles, motorcycles and pedestrian) as they transfer to transit or carpools (Aragon, 2004). Parkhurst *et al*. (2002) narrated that the general model of UK park and ride were located about 2-6 km radial routes from the urban core. Meek *et al.* (2010) discuss that the sites for park and ride should be designed to attract the motorist with pleasant surroundings and on-site facilities such as waiting areas. He further explained that the sites must be integrated with other transport modes; with high quality buses operate at high frequency, generally between 8 and 15 minutes during peak periods and only one or two stops are usually made to minimize journey time.

Study methodology used by Snyder (1999) regarding the study on parking supply and utilization in urban and suburban communities around the Puget Sound area of Washington State was referred. Parking utilization at six neighbourhood commercial center in this study found in average rates, ranged between 40% to 67%. It makes the percentage of parking spaces used was below full capacity. Parking supply exceeding demand, indeed, resulted in one site showing utilization rates far below the Urban Land Institute's recommendations for regional shopping centers. Furthermore, the dissimilarities between on-street and off-street utilization rates in the urban sites tend to depend, in part, on the relative convenience of the on-street parking. Therefore, there exists opportunities for shared parking as some parking lots and on-street parking spaces were less full than others within a site.

Further, study methodology by Hamid (2009), the parking utilization study was undertaken to analyze the demand and supply of the rail based park and ride facility of two commuter stations located at the fringe of the KL conurbation which were Shah Alam and Seremban station. The study found that both stations showed a relatively good level of utilization, exceeding the 80% mark and below the 95% level. In term of parking utilization, both stations shows similarity as the majority were long term parkers (more than 8 hours), mainly due to work trips. However, there were higher demands for long term parking for Seremban parkers compared to Shah Alam. This indicates that there is indeed demand for the park and ride facility for even a relatively small conurbation. Further, high percentage of long term parkers indicates that there is demand to use the facility particularly among the work trip makers of the suburban population.

To conclude, parking is an essential part of the overall transportation and land development system. It also a means to help realize other community development objectives such as land use efficiency, good urban design and economic vitality. An oversupply of parking is costly for business, visually unattractive, and may negatively impact urban design and streetscape. Conversely, an undersupply of spaces may compromise access and circulation, and create spill over problems for adjacent uses. It is, therefore, important to ensure balance between oversupply and undersupply when planning for parking. Thus, parking utilization study is vital to produce a succinct analysis of existing parking dynamics that can be employed over time to support and inform decision-makers about the development of parking.

3. BACKGROUND OF STUDY AREA

Kelana Jaya LRT line is a medium capacity rail transport system and one of the three rail transit lines in the Kuala Lumpur rail transit system operated by RapidKL rail network. The other rail transit is the Ampang line and monorail line. This line is aligned along the north-south direction, and passes through city centre of Kuala Lumpur with "Terminal Putra" and "Kelana Jaya" station as terminal stations of this line. These two terminal stations cover a wider population catchment living in various types of residential areas. Thus, it attracts high number of park and ride users.

Terminal Putra, or officially listed as 'Stesen Rel Gombak' by RapidKL, acts as the northern terminal for Kelana Jaya LRT line **(**Figure 1**).** This facility is currently managed by Operasi Jitu Sdn. Bhd with a total of 538 parking spaces. Furthermore, this station also act as a bus transport hub for two of RapidKL's local shuttle bus routes, otherwise known as the 'Tempatan' route, and 'Genting Skyway' buses ferrying travelers to the Genting Skyway station in Genting Highlands recreational area.

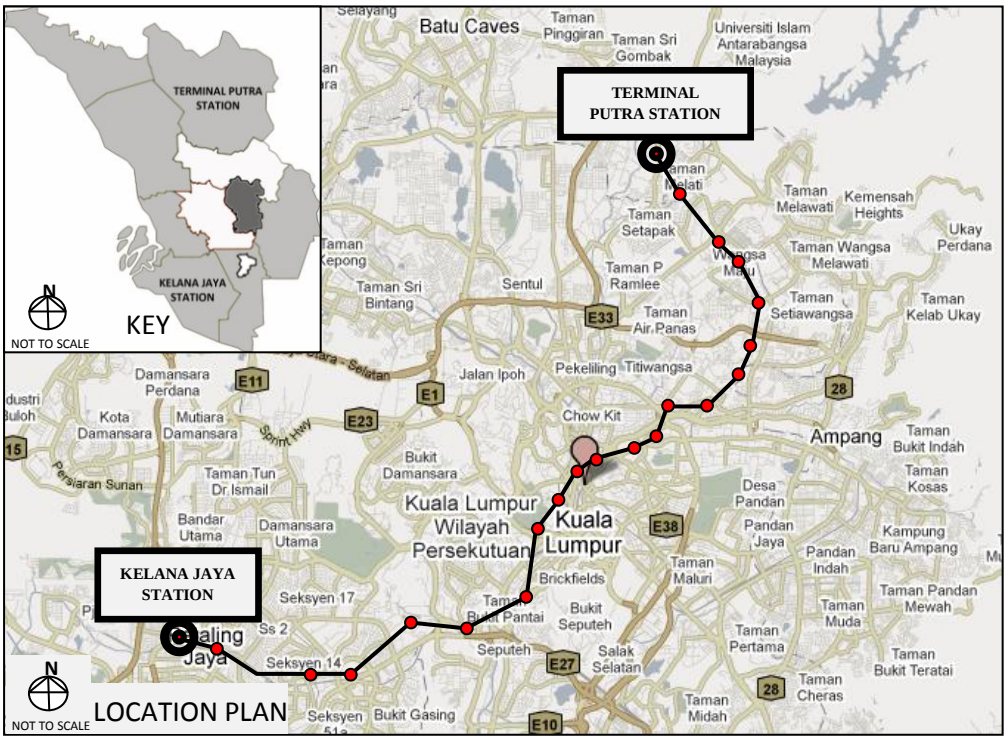

Figure 1. Geographic location of study area and the LRT route

In 15 February 2013, the station has started operating a new park and ride facility; a six level multi-stories parking which could accommodate 1260 vehicles at one time with special parking provision at the ground level for ladies and physically impaired persons. The development project started on June 2010 to February 2013 explained why the data used for Terminal Putra was in 2009, as the facility was closed for renovation.

The Kelana Jaya station is located at Kelana Jaya and it is the western terminus for passenger services on the Kelana Jaya LRT Line which is managed by Syarikat Prasarana Negara Berhad (Prasarana) **(**Figure 1**).** Kelana Jaya LRT station is also a rapidKL bus hub and accessible via other rapidKL bus routes connecting Damansara, Subang Jaya and Petaling Jaya areas. There are two parking zones (Zone A and Zone B) with total 529 parking bays in Kelana Jaya park and ride facility. The park and ride facilities were opened in September 1, 1998; the same day of the commencement of Kelana Jaya LRT Line services. These park and ride facilities charge users a flat parking rate of RM 3.00 per entry (US$1.00) for LRT users and also operated with Touch ‘n Go system, a smartcard payment method.

4. OBJECTIVES AND METHODOLOGY

The goal of this study is to examine the parking usage at Kelana Jaya and Terminal Putra park and ride stations in order to determine the adequacy of parking provisions at these stations. The following are the objectives of this study;

1) To analyze the existing parking supply and its physical conditions by parking space inventory survey.
2) To evaluate parking characteristics at the park and ride facility (such as parking occupancy, parking accumulation, and parking duration) and
3) To formulate recommendations to improve the park and ride services.

Two methods were applied for data collection; parking inventory and parking utilization surveys. ***Parking space inventory survey*** involves inventory of existing parking facilities and its physical conditions such as location, number of parking spaces, internal circulation system (Roess *et al.*, 2004). The ***parking space utilization survey*** involves determining the extent of parking usage (includes counting of parked vehicles, at regular interval over a period of time) over a pre-determined time period. The beat survey method was used where the data on parking demand was obtained by recording the registration plate number of the vehicles parked in each parking space for a period of 13 hours from 7:00 am to 8:00 pm with an interval period of 30 minutes. The data on parking demand is important in understanding the parking behavior (Slinn *et al.*, 1998) where this method was used to study the patterns of arrival and departure and parking duration of the users. However, this method was applied to collect data pertaining only to vehicle arrival at the parking areas. The parking utilization survey was administered in January 2009 (for Terminal Putra station) and March 2011 (for Kelana Jaya station).

The adequacy of parking provisions at the LRT stations is studied in terms of parking accumulation, occupancy, duration, volume and turnover. ***Parking accumulation*** refers to the number of vehicles parked at a given time (Roess *et al.*, 2004). Data is analyzed by calculating the total number of cars parked in the parking lot for each 30 minutes interval. The data then presented in line-chart form to display the fluctuations in parking accumulation throughout the study period.

Parking occupancy is the percentage of occupied parking spaces during a specific period of time. It refers to the utilization rate of the parking facility, and is expressed in percentages (%). It relates parking demand with the existing parking supply. Furthermore, the parking occupancy also indicates the peak-hour demand (Hamsa, 2005). From the parking

occupancy method, the data is analyzed by calculating the number of available parking that actually used in the facility. The data will be presented in histogram form to show the occupancy rates for the parking lot. The formula for parking occupancy:

$$\textbf{Parking Occupancy} = \frac{\text{Vehicle Accumulation}}{\text{Total number of Parking Spaces}} \text{ X } 100$$

Parking duration is the length of time a vehicle parked at a space (Hobbs *et al.*, 1967). When the parking duration is given in average, it indicates how frequent a parking space becomes available (Garber *et al.*, 2002). Besides that, the average parking duration also helps to identify whether a parking facility is used as a short-term or long-term (Hamsa, 2005). Duration is calculated by dividing the total vehicle-minutes parked (time period of vehicles occupying parking spaces at the facility) by the total number of vehicles parked. The average duration distribution is calculated by the formula:

$$\textbf{Parking Duration} = \frac{\text{Total Vehicles - Minutes of Parked Vehicles}}{\text{Total number of Vehicles Parked}}$$

Parking volume as defined by Ashley (1994) and Hobbs *et al.* (1967) is the total number of vehicles parked in a study area during specific period of time. It is calculated by dividing the total number of vehicles parked in the respective parking lots for the entire duration of the survey, by the total survey period.

$$\textbf{Average hourly Parking Volume} = \frac{\text{Total Accumulation of Vehicles}}{\text{Total Survey Period (in hours)}}$$

Parking turnover is the number of vehicles utilizing the same stall over a given period of time (Papacostas, 2005). In short, it is known as the rate of usage of parking space Ashley (1994); Hobbs *et al.* (1967). The parking turnover for individual parking spaces can be determined by counting the number of different cars using a particular parking space throughout the 13-hour study period. This is to determine the utilization rate of individual parking spaces (Hamsa, 2005). The parking turnover for individual parking spaces will be displayed in the form of map. As for the average parking turnover for the parking lots, it is computed by dividing the total number of cars parked throughout the study period with the total number of parking spaces.

$$\textbf{Average Parking Turnover} = \frac{\text{Total number of Vehicles Parked}}{\text{Total number of Parking Spaces}}$$

5. ANALYSIS OF EXISTING PARKING SUPPLY AND USAGE AT PARK AND RIDE FACILITY

5.1 Existing parking supply

Terminal Putra park and ride facility provides a total of 538 parking spaces for cars and 4 of which were reserved for disabled users or RapidKL personnel. The parking facility is segregated into 3 lots, which are Lot A, Lot B and Lot C **(**Figure 2**)**.

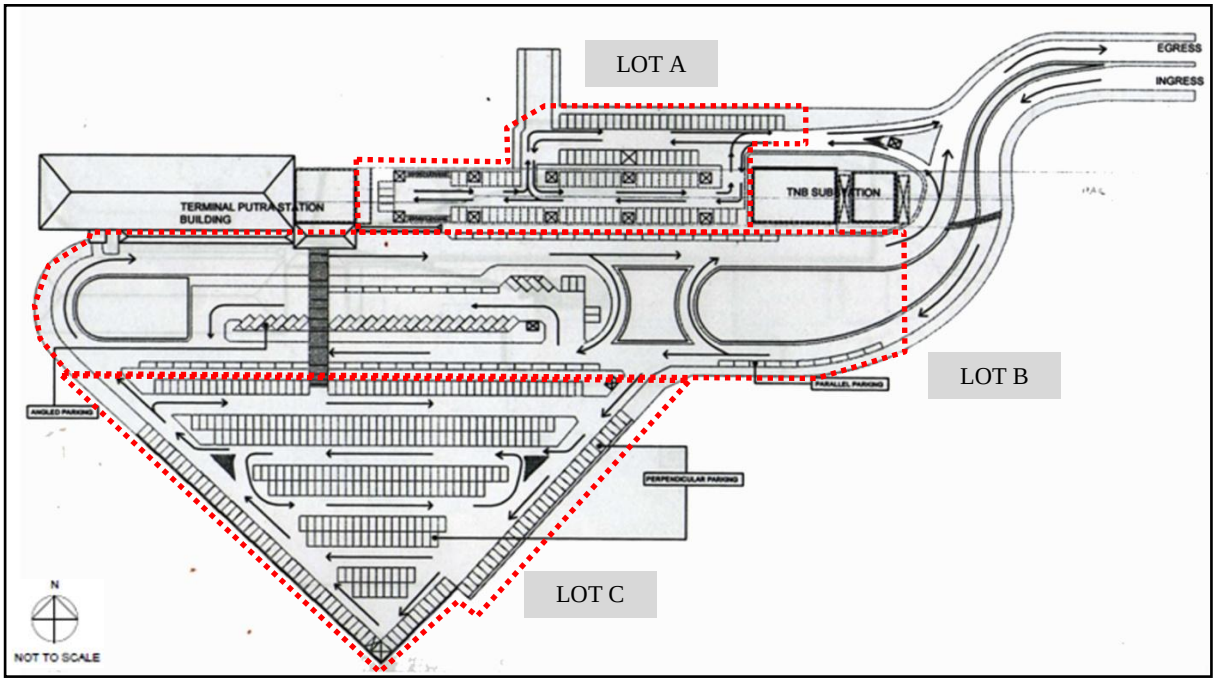

Figure 2. Parking provision at Terminal Putra LRT station

Whereas park and ride facility at Kelana Jaya station provides a total of 529 parking spaces for cars **(**Figure 3**)** including six parking spaces which were reserved for Prasarana personnel. The parking area is segregated into two zones, which are Zone A and Zone B. The number of parking spaces in each lot/zone and the average distance between each lot/zone to the station building is shown in Table 1.

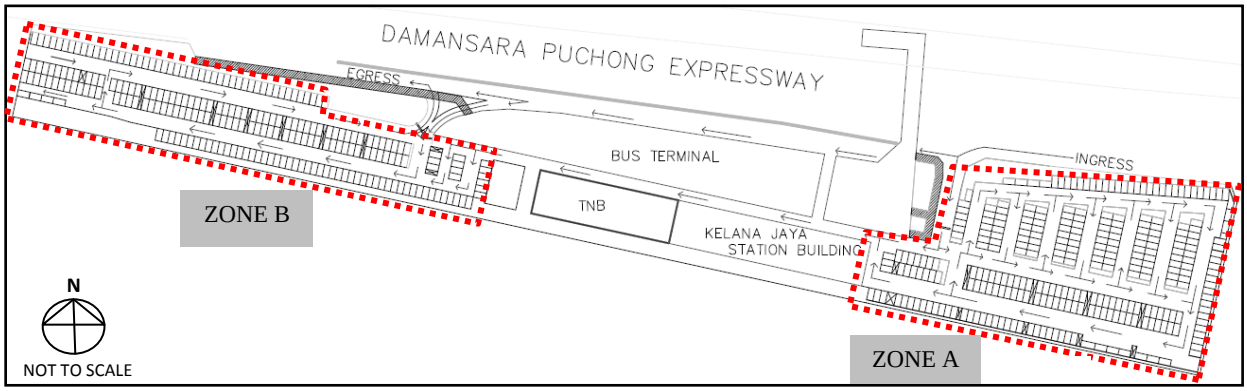

Figure 3. Parking provision at Kelana Jaya LRT station

Table 1. Number of Parking Spaces and Average Distance between Parking Lot and Station Building

	Terminal Putra station			Kelana Jaya station	
Lot/Zone	Lot A	Lot B	Lot C	Zone A	Zone B
Number of parking spaces	100	97	341	287	241
Average distance from station building (m)	75	80	90	-	-
- Nearest	-	-	-	7	133
- Intermediate	-	-	-	90	245
- Farthest	-	-	-	136	324

The types of parking spaces provided in the Terminal Putra park and ride facility were perpendicular (90º), parallel and angled. While at Kelana Jaya station, only two types of parking spaces namely perpendicular (90°) and parallel parking were provided. The number of parking spaces according to type of parking is shown in Table 2**.** The measurement of each type of parking is shown in Table 3. The majority of the parking spaces provided were mainly for public uses. Table 4 shows the number of parking spaces according to use.

Table 2. Number of Parking Spaces According to Type of Parking

Type of Parking	No. of Parking Spaces Provided	
	Terminal Putra	Kelana Jaya
Perpendicular	446	511
Parallel	65	18
Angled	27	-
TOTAL	538	529

Table 3. Parking Measurement According to Type of Parking

Type of parking	Measurement (length x width)	
	Terminal Putra	Kelana Jaya
Perpendicular	5m x 2.5m	5m x 2.5m
Parallel	5m x 2.0m	5m x 2.5m
Angled (45°)	5m x 2.5m	-

Table 4. Number of Parking Spaces Provided According to Use

Category	No. of Spaces Provided	
	Terminal Putra	Kelana Jaya
Public	534	523
Reserved	4	6
TOTAL	538	529

The internal circulation of vehicles at Terminal Putra park and ride facility is both one-way and two-way movement. At Lot A, the circulation was two-way and it includes a dead-end aisle, where the reserved parking spaces are located. The vehicle flow into and out of the parking lot is channelled by a chevron marking and traffic island. One-way circulation system was applied in Lot B and C which is considered ideal with the provision of angled parking as

the drivers can drive straight into the parking spaces, and vehicle movement was continuous from the entrance to the exit.

The Kelana Jaya park and ride facility is accessed by Damansara-Puchong Expressway (LDP) and internal circulation system was one-way with two entrances, one each at Zone A and Zone B. Zone A is accessed directly from LDP, being linked with a service road. The access to Zone B is from both LDP and from Zone A. A bus terminal is also provided near the entrance to Zone B parking area. The one-way circulation system in the facility facilitates both perpendicular and parallel parking spaces, as the drivers can drive straight into the parking spaces and enable a continuous movement of vehicle from the entrance to the exit.

The park and ride facility was equipped with other related facilities to ensure convenience and safety for the users. The other related facilities provided are; pedestrian walkways, marked curbs and lampposts. The width of pedestrian walkways at Terminal Putra was between 1 and 6 metres with the provision of either zebra crossings or raised pathways. At Kelana Jaya station, the pedestrian walkway provided includes both covered and uncovered walkways. The covered pathway provided at Zone A is to connect users from the parking lot to the entrance of the station building. At Zone B, only uncovered pedestrian walkway was provided which has eventually led to inconveniences to the users especially during extreme weather conditions. Moreover, the distance from the parking area at Zone B to the station building is considered far. The parking area is well illuminated by street lights at both stations. However, at Lot A in Terminal Putra station, adequate lighting arrangement was provided only in the area not covered by the railway tracks. The parking areas, which are covered by railway tracks, are often dark at night exposing safety concerns.

5.2 Existing parking usage

The parking usage at park and ride facilities was measured by parking *accumulation, occupancy, volume, turnover and duration*. A 13-hour parking usage survey at Terminal Putra and Kelana Jaya park and ride facility shows almost similar parking usage pattern. The parking accumulation curve at three lots at Terminal Putra station shows a steep rise in the number of cars parked between 7.00 am to 9.00 am due to continuous arrival of users taking LRT for work purposes (Figure 4). This trend was identified as similar to the 142 parking spaces at Shah Alam park and ride facility where a high number of in and out-vehicle flow from 5.30 am to 6.30 a.m on a weekday was observed (Hamid, 2009). The parking demand at Terminal Putra station from 9.00 am to 4.30 pm was high and remains fairly constant at high level. The accumulation curve then started to gradually decline from 4.30 pm onwards as users were found leaving the parking spaces indicating their travel to home from workplaces. This scenario reflects the regular weekday morning and evening rush hour for commuters and were being consistent with the trip patterns of those on compulsory trips namely to work and school/college (Hamid, 2009).

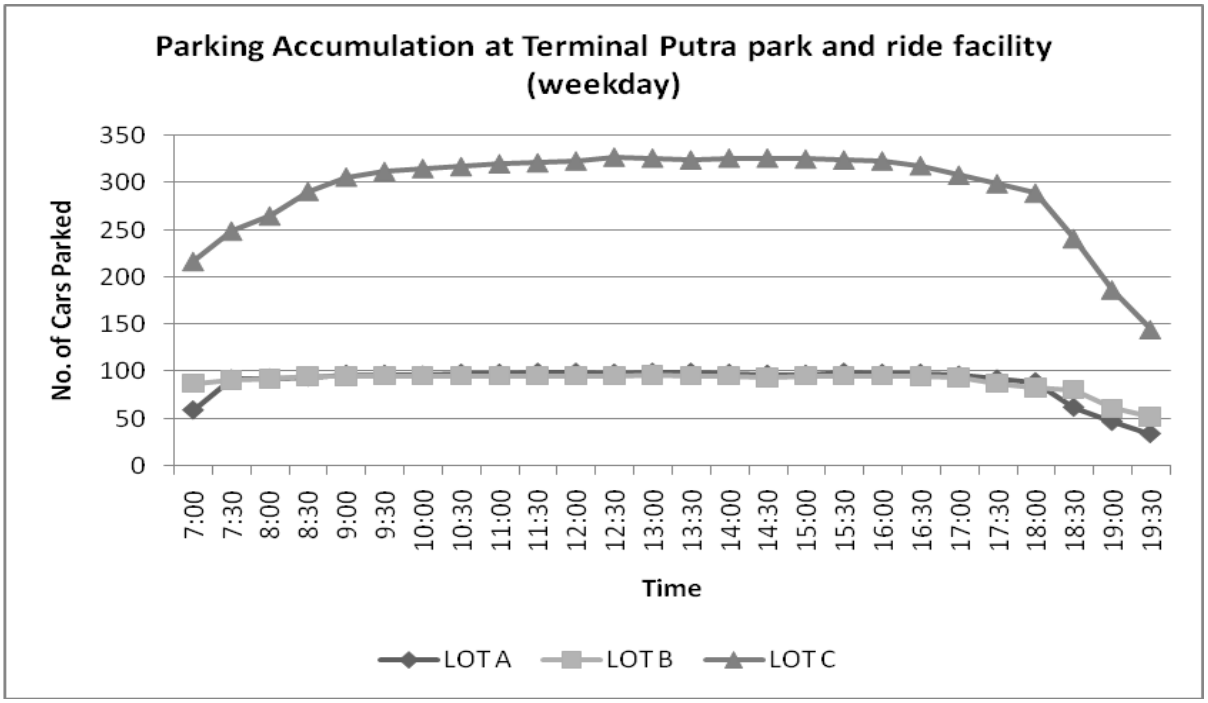

Figure 4. Parking accumulations at Terminal Putra park and ride facility

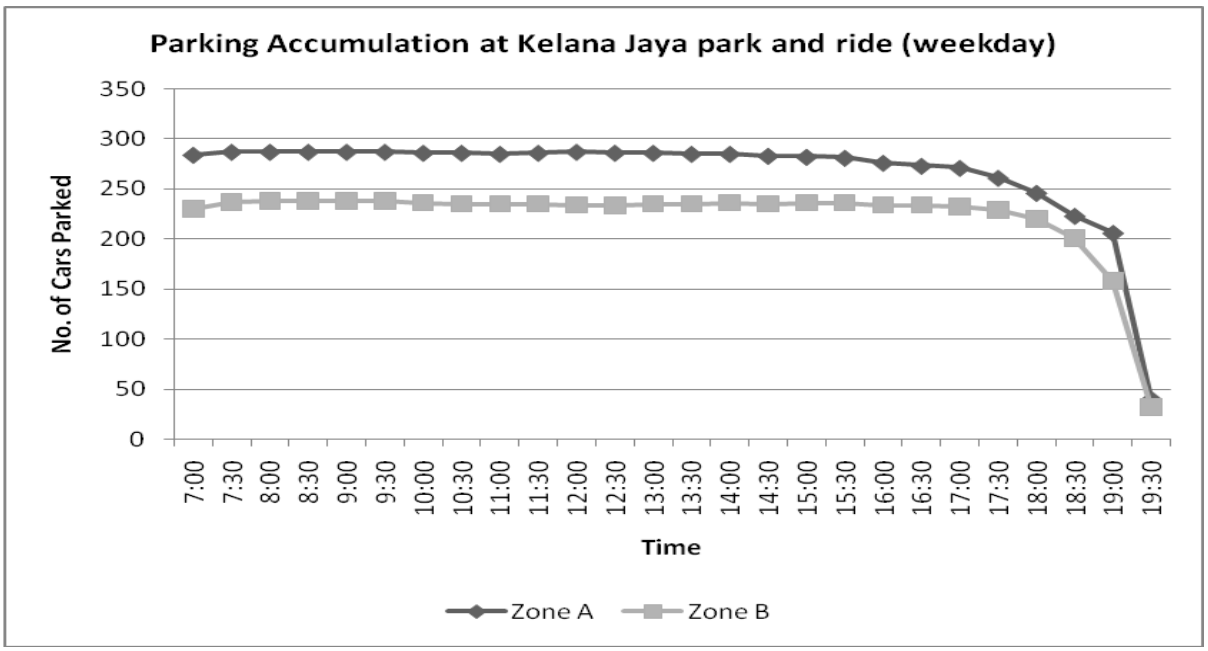

Figure 5. Parking accumulations at Kelana Jaya park and ride facility

The Kelana Jaya park and ride facility provides 529 parking spaces, slightly less than Terminal Putra. The parking accumulation curve at this station shows almost similar pattern to that of Terminal Putra station **(**Figure 5**)** reaching maximum capacity in the morning rush hours. However, the arrival of vehicles at Terminal Putra station was progressive before reaching its peak capacity at 10 a.m. Whereas, the number of vehicles parked at the Kelana Jaya station was found reaching its capacity as early as 7.00 a.m. and remain constant at high level until 3.30 p.m. One of the likely reasons for this trend is due to intense concentration of residential activities near the Kelana Jaya station as compared to Terminal Putra station. This pattern of early morning peak accumulation was also seen in Hong Kong, where the cars entering the park and ride facility reaches its highest morning peak period between 7:00 am and 9:00 am (Lam *et al.* 2001).

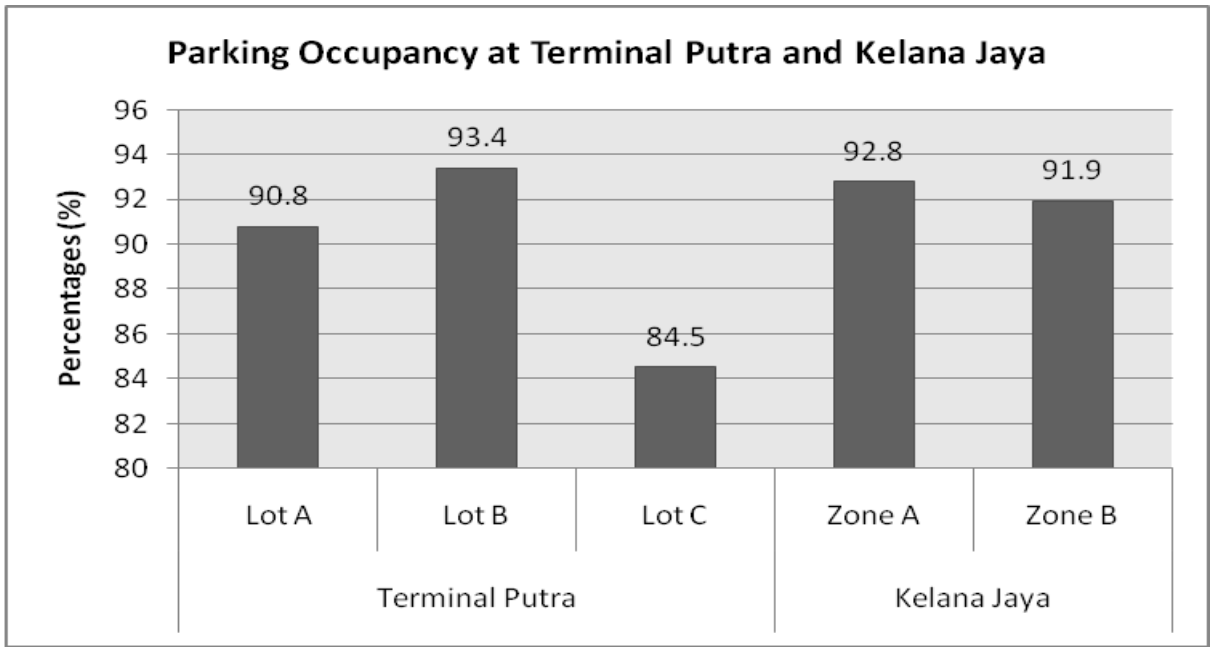

Figure 6. Parking occupancy at Terminal Putra and Kelana Jaya park and ride facility

The analysis on ***parking occupancy*** showed that more than 80% of parking spaces at Terminal Putra park and ride facility were occupied. Figure 6 shows Lot B was the most preferred parking area at Terminal Putra station with about 94% occupancy rate. Despite, Lot A is located nearest to the station in terms of distance, the location of Lot B which is directly in front of the station's entrance has made it more strategic and most preferred parking location. Furthermore, the analysis on parking occupancy showed that occupancy rate at Lot B at Terminal Putra station has reached more than 90% as early as 7 in the morning. On the other hand, Lot A and Lot C has taken longer time to reach 90% occupancy rate. It showed that the parking location in front of the railway station is normally more attractive and preferable.

The average parking occupancy rate at Kelana Jaya park and ride facility was similar to that of Terminal Putra station **(**Figure 6**)** where it also reaches more than 90%. The analysis further showed that parking occupancy at Zone A at Kelana Jaya station has reached 100% between 7:30 am and 9:00 am. The parking load was maintained at high level (over 90%) during day time which obviously reflects majority of those who parked at this area were travelled to work. Moreover, Zone A parking area is located nearer to the station than Zone B which creates higher parking demand.

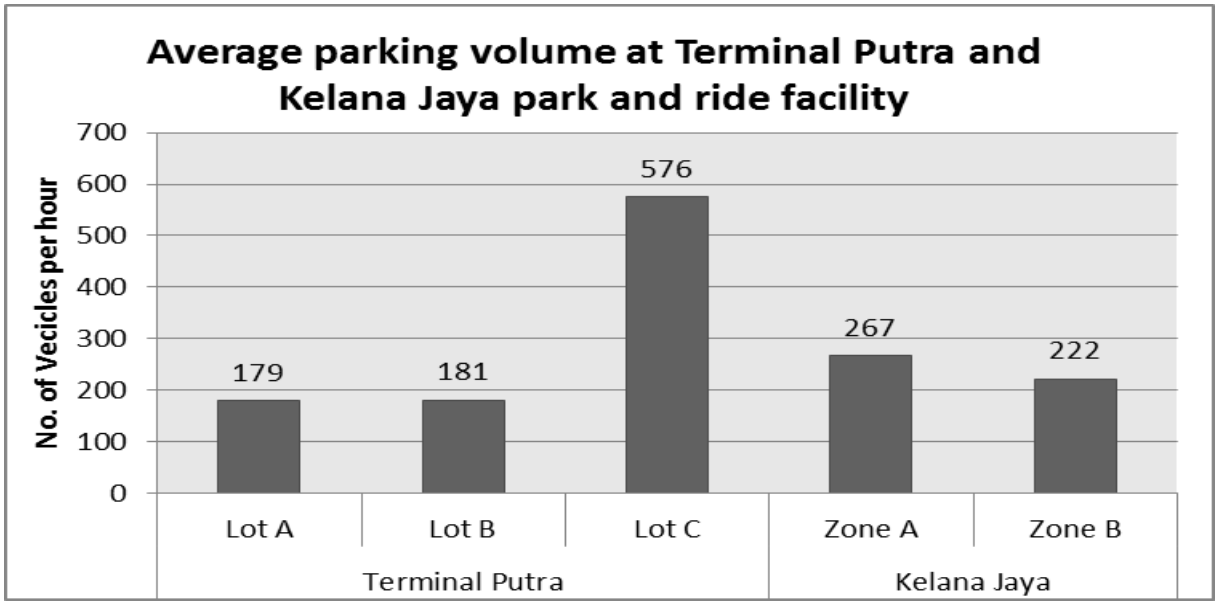

Figure 7. Average parking volume at Terminal Putra and Kelana Jaya park and ride facility

The ***average parking volume*** at both stations shows dissimilarities recording high volume at Lot C at Terminal Putra station than other parking lots (Figure 7). The difference in the volume was due to the differences in the number of parking spaces at each lot; the number of parking spaces at Lot C exceeds that of Lot A and Lot B by more than 200 spaces.

A slight variance on parking volume between Zone A and Zone B in Kelana Jaya facility was observed. It also influenced by the different number of parking spaces provided in each zone; Zone A has 287 parking spaces while Zone B 241 parking spaces. Logically, Zone A could accommodate more cars than Zone B.

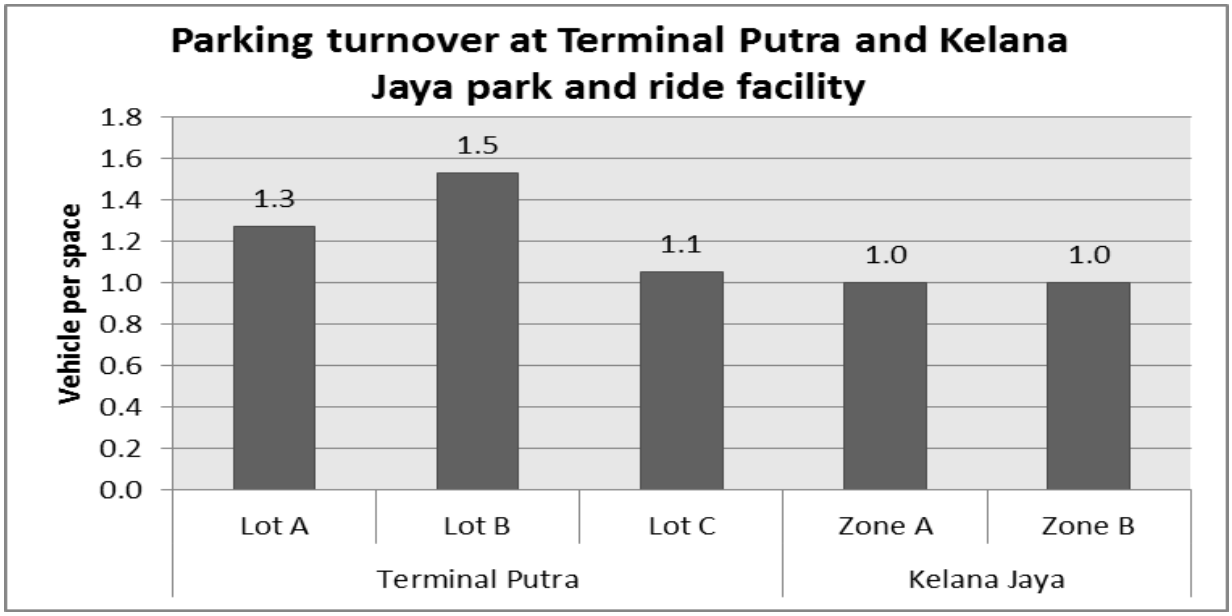

Figure 8. Parking turnover at Terminal Putra and Kelana Jaya park and ride facility

The analysis on ***parking turnover*** showed a low parking turnover at each station, which was not more than 1 vehicle per space (Figure 8). It shows that the park and ride

facility at both stations were mainly used to travel for work and school purposes. The low turnover rate means less vehicle movement at individual parking space. It also indicates that the vehicles were parked for long duration. The highest turnover was in Lot B (1.5 vehicles per space) at Terminal Putra station. The study also found that once the parking spaces were emptied in the evening hours, they were taken up by the people who park at these spaces (for a very short period) to pick up their relatives and friends at the stations. Furthermore, as Lot B was located right in front of the station building's entrance, it makes the parked cars easier to spot. Also, no parking fees were charged to these drivers. However, these cars were still taken into count during the survey which has resulted in a higher turnover at the lot.

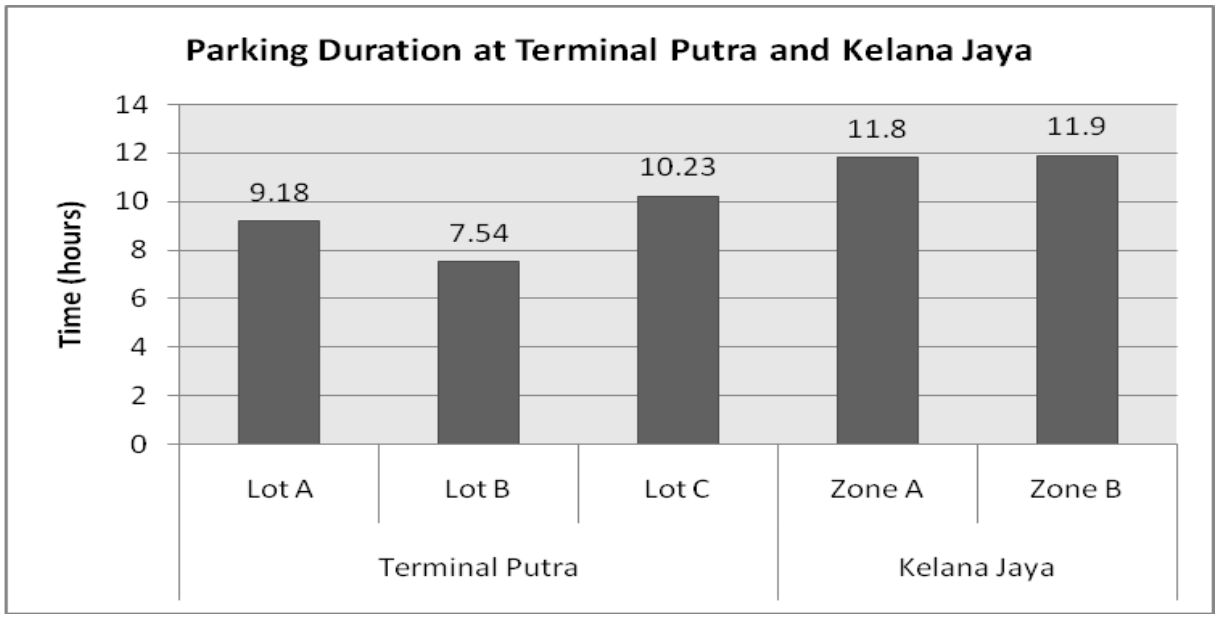

Figure 9. Parking duration at Terminal Putra and Kelana Jaya park and ride facility.

The ***average parking duration*** of the vehicles being parked at both Terminal Putra and Kelana Jaya park and ride facilities were long-term parking, considering vehicles parked more than 3 hours as long-term parking (Hamsa, 2005). On average, vehicles were parked more than 7 hours at each of the three parking lots at Terminal Putra station (Figure 9). The majority of the users, especially during weekday, who parked their vehicles at these stations, were found to traveling for work purposes by using public transportation.

The average parking duration at Kelana Jaya park and ride facility was 11 hours and 9 minutes, indicating a long-term parking facility (Figure 9). The long-term parking at this facility has lead to low parking turnover. Again, most of the parkers at this facility were using public transportation for work purposes. The long-term parking duration at this facility was identical with that of parking users at Shah Alam and Seremban park and ride facility. About 56% of parkers at Shah Alam station were parked for more than 8 hours whereas at Seremban park and ride facility, about 82% of total parkers were long term parkers (Hamid, 2009). The spatial factor of the stations and the travel pattern of the users are the likely causes for this trend.

6. DISCUSSION AND RECOMMENDATION

Two park and ride stations were selected to identify the demand patterns of the parking users especially during weekday. Normally, parking demand during weekday is higher than weekend because of school trips and work trips. The findings showed that parking accumulation has started to increase as early as 7 in the morning and remain high (more than 80%) till 4.30 in the evening at both facilities. The parking duration showed that users parked their vehicles for long duration (more than 7 hours) at these facilities indicating that most of the parkers were using public transportation for work purposes. A number of studies has shown that parking location which are nearer to the station's entrance were normally in high demand. Lot B at Terminal Putra station showed a high parking demand because it was located very close and in front of the entrance to the railway station building. Thus, it also allows shorter walking distance to the station. The findings showed that the location of the parking spaces with respect to the station building is one of the major determinant factors to maximize the utilization of parking areas.

The findings also showed that the selected park and ride facilities were found to have high parking demand which indicates that the existing parking area should be expanded to cater for both existing and future parking demand. To encourage more commuters to use public transportation, parking availability at park and ride stations is very crucial and critical. However, the land availability for expansion at these stations is limited. To overcome this shortcoming, the existing parking area should be expanded vertically allowing for a multi-storey parking facility. An alternative to structure parking, which could cost four times as much as surface parking lot (Institute of Transportation Engineers, 1999), is the provision of automatic mechanical parking facility. This system is considered to be a cost effective measure because of the elimination of structured building and ramps. Parking fee is another important consideration for the users to park their vehicles at these stations and use public transport. An affordable and attractive parking charge should be imposed to further increase the parking demand at the park and ride stations, but more importantly would increase the usage of public transportation system.

7. CONCLUSIONS

The provision of adequate parking spaces at park and ride facility is very important and crucial for the success of the facility. It encourages users to shift from private vehicles to public transportation to travel to central part of the city for various trip purposes. The parking demand pattern at the selected park and ride facilities showed that most of the parkers, who parked their vehicles at these facilities especially during weekday, were traveling for work purposes. The parking data collected on the day of survey showed high parking demand at both Terminal Putra and Kelana Jaya park and ride facility. The parking spaces were fully occupied as early as 7 a.m. and remain fully occupied until 4.30 p.m. Thus, it eventually leads parkers who did not find parking spaces to park their vehicles at undesignated locations near to the station. The location of the parking area which faces the Terminal Putra station was the most preferable choice of the parkers due to its nearness to the station as well as provides direct access from the road to the station. Vehicles were usually parked for longer duration (more than 7 hours, on average) at both stations as most of the users who parked their vehicles were traveling for work purposes. The high parking demand at both these facilities showed that the facilities should be expanded to accommodate more parking users. However, due to unavailability of land at these facilities to expand it horizontally, a multi-storey parking

facility should be considered to increase the number of parking spaces. Thus, it allows parkers to shift from private vehicles to public transportation which obviously would help relieve the level of congestion and its associated problems at the central area of a city.

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