

RELOCATION OF PARKING AREA IN ORDER TO DELIVER BETTER PARKING CHARACTERISTICS

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Abstract

Indonesia with high number of population needs transportation, facilities, and motor vehicle. Indonesia Statistical Center Bureau Data indicated that number of motor vehicles increase around ten percent each year. Available and adequate number of parking area as one of facilities as well as good management is needed in order to reduce traffic congestion. Case study is carried out at a large shopping mall in Bandung, West Java. The aim is to examine whether relocation of off street parking area could deliver better parking characteristics. License plate observation method used in order to collect the data. Furthermore, hypothetical test and two sample t test method used to compare before and after relocation parking data set. Based on analysis, the results show increase in parking accumulation and parking duration, but decrease in parking index and parking turn over after relocation. Furthermore, parking accumulation during weekend is still higher than those during weekdays.

Key Words: *relocation, parking area, better parking characteristics.*

Abstrak

Indonesia yang memiliki jumlah penduduk yang tinggi, tentu memerlukan transportasi, fasilitas transportasi, dan kendaraan bermotor. Data Biro Pusat Statistik Indonesia menunjukkan bahwa jumlah kendaraan bermotor meningkat sekitar sepuluh persen per tahun. Keberadaan dan kecukupan jumlah area parkir sebagai salah satu fasilitas transportasi, disertai manajemen yang baik, diperlukan untuk mengurangi kepadatan lalu lintas. Studi kasus dilakukan di sebuah pusat perbelanjaan besar (mal) di Bandung, Jawa Barat. Tujuan penelitian adalah untuk mengkaji apakah relokasi area parkir (*off street*) dapat menghasilkan karakteristik parkir yang lebih baik. Metoda *License plate* digunakan untuk mengumpulkan data. Selanjutnya, uji hipotesis dan uji *two sample t* digunakan untuk membandingkan dua set data sebelum dan sesudah relokasi dilakukan. Hasil analisis menunjukkan bahwa akumulasi parkir dan durasi parkir meningkat, sedangkan indeks parkir dan *turn over* parkir menurun. Lebih lanjut, akumulasi parkir selama hari libur masih lebih tinggi dari akumulasi parkir selama hari kerja.

Kata-kata kunci: *relokasi, area parkir, karakteristik parkir yang lebih baik.*

INTRODUCTION

Data from Indonesia Statistical Center Bureau (BPS, 2013) indicated that number of motor vehicles including number of passenger cars is increasing year by year as presented in Table 1. Therefore, available and adequate number of parking area is needed to park the vehicle on street or off street safely and conveniently as well as to reduce traffic congestion. Tourism destination place is one of destination places that need parking area. Inadequate parking area leads to poor traffic congestion to surrounding area.

Case study in this study is in a large shopping mall in Bandung and the aim of the study is to examine whether relocation of parking area in the large shopping mall could deliver better parking characteristics i.e. parking accumulation, parking duration, parking turnover, and parking index during weekend and weekday. Observation using license plate is the method to collect the data. A number of solutions will be recommended based on analysis and existing conditions.

Table 1. Number and percentage of passenger car and motor vehicle (BPS, 2013)

Year	Passenger Car	Percentage of Passenger Car Increase	Number of Motor Vehicle	Percentage of Motor Vehicle Increase
1987	1,170,103		7,981,480	
1988	1,073,106	-9.04	7,771,019	-,71
1989	1,182,253	9.23	8,291,838	6.28
1990	1,313,210	9.97	8,889,022	6.72
1991	1,494,607	12.14	9,582,138	7.23
1992	1,590,750	6.04	10,197,955	6.04
1993	1,700,454	6.45	10,784,597	5.44
1994	1,890,340	10.5	11,928,837	9.59
1995	2,107,299	10.30	13,208,832	9.89
1996	2,409,088	12.53	14,530,095	9.09
1997	2,639,523	8.73	16,555,119	1.13
1998	2,769,375	4.89	17,611,767	6.11
1999	2,897,803	4.43	18,224,149	3.36
2000	3,038,913	4.84	18,975,344	3.96
2002	3,403,433	6.79	22,985,183	8.98
2003	3,792,510	10.26	26,613,987	13.63
2004	4,231,901	10.38	30,541,954	12.86
2005	5,076,230	16.63	37,623,432	18.82
2006	6,035,291	15.89	43,313,052	13.14
2007	6,877,229	12.24	54,802,580	20.97
2008	7,489,852	8.18	61,685,063	11.16
2009	7,910,407	5.32	67,336,544	8.39
2010	8,891,041	11.03	76,907,127	12.44
2011	9,518,866	6.89	85,601,351	10.16
2012	10,432,259	8.47	94,373,324	9.29
2013	11,484,515	9.16	104,118,969	9.36

PARKING CHARACTERISTICS AND STATISTICAL METHOD

Parking needs, parking stall, parking generate rates as well as parking peak number are close related to the type of land use for example: residential area, central business district, shopping mall, industrial area, hospital, hotel, restaurant, bank, and public building. The parking facilities could be on street or off street parking, whereas parking position could be parallel parking or at angle of 30⁰, 45⁰, 60⁰, 70⁰, or 90⁰ with single, internal or external design (Roess, Roger P., 2004; Hill, Jim, 2005).

Parking Characteristics

There are a number of parking characteristics (Institute of Transportation Engineers, 1994; Urban Land Institute, 1999; Roess, Roger P., 2004; Hill, Jim, 2005), for example: parking

capacity, parking accumulation, parking duration, parking turn over, and parking index. In more detail, the explanation is as follow:

- Parking capacity is measured in term of how many vehicles can be parked during the period of interest within the study area. The formulation is $P = \left(\frac{\sum nNT}{D} \right) \times F$ with P is parking supply (veh), N is number of spaces of a given type and time restriction, T is time that N space of a given type and time restriction are available during the study period (hrs), D is average parking duration during the study period (hrs/veh), and F is insufficient factor to account for turn over (0.85 – 0.95) and increase as average duration increase.
- Parking accumulation is defined as the total number of vehicle parked at any given time. The formulation is $N_T = N_{\text{enter}} - N_{\text{exit}} + N_{\text{before}}$ with N_T is number of parked vehicle, N_{enter} is number of vehicle enter the parking area, N_{exit} is number of vehicle exit the parking area, and N_{before} is number of vehicle parked before observation.
- Parking duration is the length of time that individual vehicles remain parked. The formulation is $D = \frac{\sum x(N_x \times X \times l)}{N_T}$ with D is average parking duration (h/veh), N_x is number of vehicle parked for x intervals, X is number of interval parked, l is length of observed interval (h), and N_T is total number of parked vehicles observed. Parking accumulation and parking duration is closed related to city size.
- Parking turn over rate indicates the number of parkers that, on average, use a parking stall over a period of one hour. The formulation is $TR = \frac{N_T}{N_S \times T_S}$ with TR = parking turnover rate (veh/stall/h), N_T is total number of parked vehicles observed, N_S is total number of legal parking stalls, and T_S is duration of study period (h).
- Parking index or occupancy is percentage of available parking space used. The formulation is $P_i = \frac{N_T}{N_S} \times 100\%$ with P_i is parking index, N_T is parking accumulation, and N_S is total number of legal parking stalls.

Statistical Method

Statistical method used in this study is hypothetical test and two sample t test (Ott, R. Lyman, 1993) in order to compare before and after relocation parking data set. Comparison of two independent data sets using hypothetical test is presented in Table 2 with μ_1 is the first population mean and μ_2 is the second population mean. Whereas Table 3 presents t statistical test while using small and large sample data.

Table 2. Hypothetical test of two independent population data sets

Null hypothesis	Alternative	Rejection Region
$H_0: \mu_1 - \mu_2 = D_0$	$H_a: \mu_1 - \mu_2 \neq D_0$	$ t > t_{\alpha/2}$
$H_0: \mu_1 - \mu_2 = D_0$	$H_a: \mu_1 - \mu_2 > D_0$	$t > t_\alpha$
$H_0: \mu_1 - \mu_2 = D_0$	$H_a: \mu_1 - \mu_2 < D_0$	$t < -t_\alpha$

Table 3. Statistical test for small and large sample data

Null hypothesis and Standard deviation	t test for small sample data and z for large sample data
$H_0: \mu_1 - \mu_2 = D_0$	$t = \frac{(\bar{x}_1 - \bar{x}_2) - D_0}{s \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$
$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 + n_2 - 2)}}$	$z = \frac{(\bar{x}_1 - \bar{x}_2) - D_0}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} = \frac{(\bar{x}_1 - \bar{x}_2) - D_0}{\sigma \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$
Legend: \bar{x}_1 = first sample mean \bar{x}_2 = second sample mean σ = population standard deviation	n1 = first sample size n2 = second sample size s = sample standard deviation

METHOD AND ANALYSIS

Previous study at the large shopping mall in 2008 indicated that queue length was more than 30m at 7pm up to 11pm during weekends but less than 30m, during weekdays (Kanigara, A., 2008). Another previous study showed that in the parking area before relocation, parking turn over during weekends was 6.074 (rounded to 6) while during weekdays was 2.943 (rounded to 3) and parking accumulation was 1,368 vehicles, more than available parking stall i.e. 1,300 (Pradana, A., 2009). The results indicated that parking needs at shopping mall during weekends is significantly larger than during weekdays.

Number Plate Method

Number Plate Method is used to collect number and duration of enter and exit vehicles as primary data during weekend and weekday. Whereas secondary data i.e. area of large shopping mall with 50,000 m², location of parking area before and after relocation, available of previous parking stall (1,300 stall), available of existing parking stall (1,750 stall), and historical parking data of location of previous parking area. Secondary data obtained from the shopping mall building organizer.

Analysis of Parking Characteristics

Parking characteristics used in this study are parking accumulation, parking duration, parking turn over, and parking index, using available parking capacity, with attention of safe and convenient design layout. Figure 1 and Figure 2 present location A of parking area at the shopping mall before and after relocation, respectively. Whereas, Figure 3 and Figure 4 present location of parking area B at the shopping mall before and after relocation, respectively.

Data collecting use number plate method during weekends and weekdays presented in Table 4. Furthermore, the results of parking characteristics count and using of two sample t test method, for large sample, to compare before and after relocation parking data set, during weekends and weekdays, are presented in Table 5. In more detail, results in Table 5 indicated as follow:

- Parking accumulation after relocation is increases 31 percent during weekend and reduces 33 percent during weekday.
- Parking duration after relocation is increases 64 percent during weekend and increases 45 percent during weekday.
- Parking index after relocation is reduces 1 percent during weekend and reduces 33 percent during weekday.
- Parking turn over after relocation is reduces 33 percent during weekend and reduces 33 percent during weekday.
- Parking capacity after relocation is increases 35 percent during weekend and increases 35 percent during weekday.

Based on detail explanation of results in Table 5, follow up recommendation are as follow:

- Relocation of parking area lead to better parking characteristics, especially during weekend wherein number of visitors and shoppers are higher than those during weekdays.
- Parking turn over after relocation of parking area is 3.648. The value is less than 3.97 as the value of parking turn over as result of 141 case studies at shopping center (Roess, 2004).
- In order to reduce parking duration, parking ticket fee can be free for drop off only or parking duration less than 30 minutes.

Further study recommended is that the relocation is not only increase number of stall but also pay attention to parking demand based on existing and relevant data. For example, regarding size of activity measured, portion of destination, proportion of people arriving by car, average auto occupancy, proportion of persons with primary destination at the design of the large shopping mall (Roess, 2004).

CONCLUSIONS

This study examines a number of parking characteristics i.e. parking accumulation, parking duration, parking turn over, and parking index, using available parking capacity in order to find out whether relocation of parking area could better serve to the visitors and shoppers.

Result indicated that parking characteristics studied are better after relocation of parking area. Based on analysis and existing conditions, solutions could be recommended are inexpensive parking ticket fee. Moreover, further study recommended is that the relocation is not only increase number of stall but also pay attention to parking demand based on existing and relevant data.

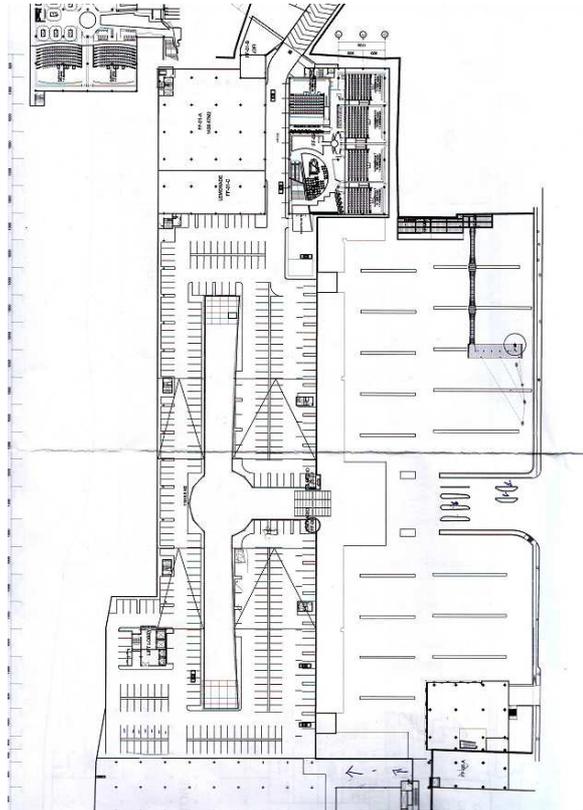


Figure 1. Location of parking area A before relocation (Dhanesworo, D. R., 2015)

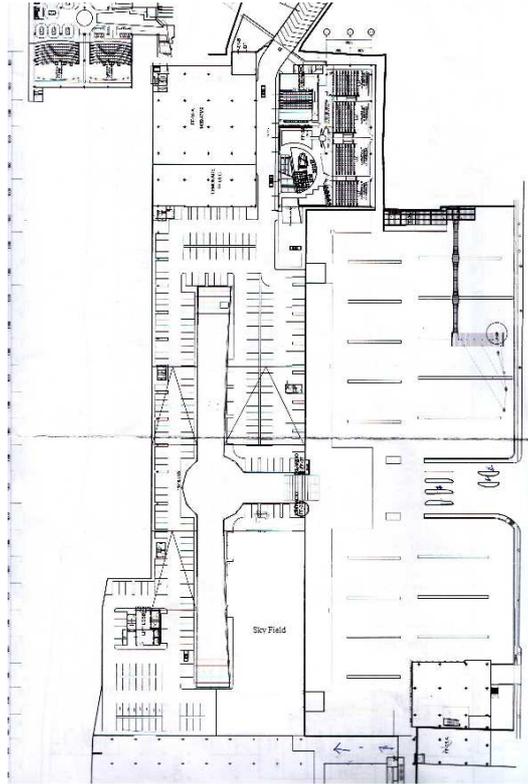


Figure 2. Location of parking area A after relocation (Dhanesworo, D. R., 2015)

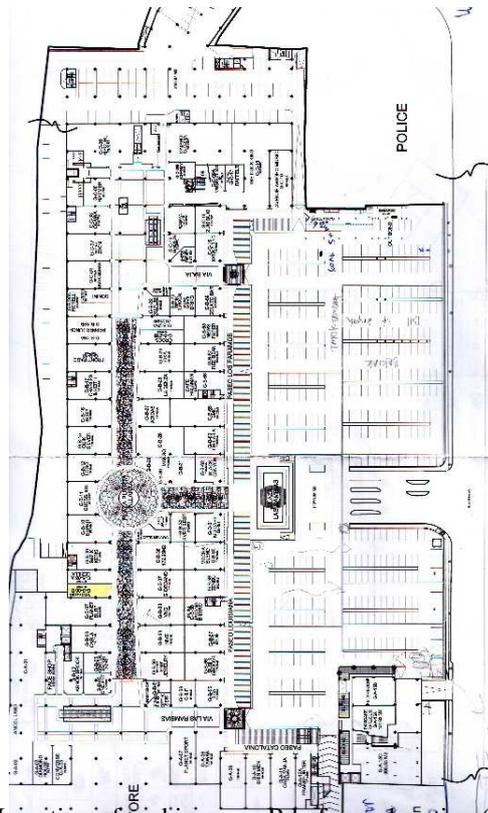


Figure 3. Location of parking area B before relocation (Dhanesworo, D. R., 2015)

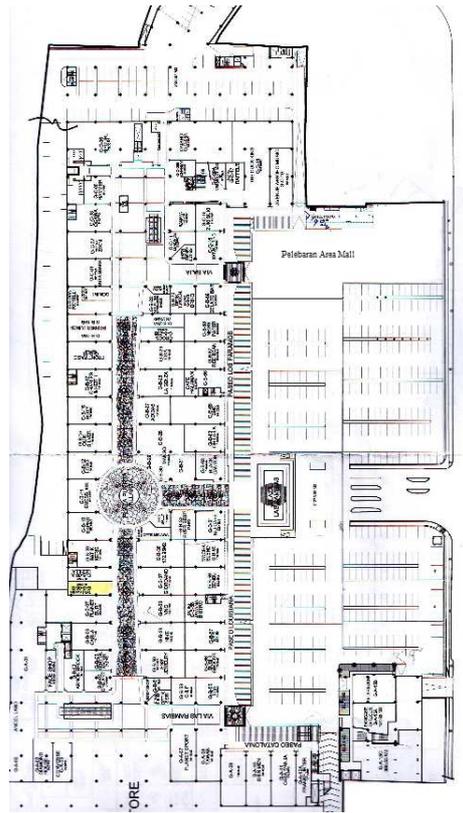


Figure 4. Location of parking area B after relocation (Dhanesworo, D. R., 2015)

Table 4. Data collecting use number plate method before and after relocation during weekends and weekdays (veh)

Time	Weekend		Weekday	
	Before Relocation	After Relocation	Before Relocation	After Relocation
12:01 - 12:10	575	527	132	160
12:11 - 12:20	612	557	145	153
12:21 - 12:30	644	597	154	147
12:31 - 12:40	668	635	171	161
12:41 - 12:50	696	677	188	157
12:51 - 13:00	710	707	200	157
13:01 - 13:10	718	725	229	168
13:11 - 13:20	743	765	255	174
13:21 - 13:30	760	799	276	202
13:31 - 13:40	780	815	303	203
13:41 - 13:50	806	844	331	207
13:51 - 14:00	831	861	347	220
14:01 - 14:10	841	895	352	223
14:11 - 14:20	845	927	377	230
14:21 - 14:30	862	961	407	247
14:31 - 14:40	876	970	427	249
14:41 - 14:50	897	1,005	442	263
14:51 - 15:00	920	1,020	463	261
15:01 - 15:10	932	1,046	484	270
15:11 - 15:20	958	1,082	505	269
15:21 - 15:30	984	1,123	527	279
15:31 - 15:40	1,009	1,169	549	280
15:41 - 15:50	1,040	1,199	562	295
15:51 - 16:00	1,067	1,248	582	321
16:01 - 16:10	1,096	1,294	610	319
16:11 - 16:20	1,125	1,308	625	344
16:21 - 16:30	1,152	1,344	647	364
16:31 - 16:40	1,172	1,364	676	375
16:41 - 16:50	1,198	1,387	664	382
16:51 - 17:00	1,223	1,409	673	408
17:01 - 17:10	1,246	1,428	689	418
17:11 - 17:20	1,263	1,464	718	437
17:21 - 17:30	1,286	1,501	744	448
17:31 - 17:40	1,308	1,524	773	461
17:41 - 17:50	1,333	1,540	816	489
17:51 - 18:00	1,349	1,559	838	507
18:01 - 18:10	1,362	1,571	868	528
18:11 - 18:20	1,368	1,589	886	548
18:21 - 18:30	1,364	1,622	916	583
18:31 - 18:40	1,363	1,655	942	611
18:41 - 18:50	1,361	1,664	985	635
18:51 - 19:00	1,354	1,694	1,034	666
19:01 - 19:10	1,349	1,712	1,067	706
19:11 - 19:20	1,342	1,736	1,102	746
19:21 - 19:30	1,334	1,742	1,136	777
19:31 - 19:40	1,320	1,758	1,168	808
19:41 - 19:50	1,303	1,769	1,184	839
19:51 - 20:00	1,293	1,794	1,209	884
20:01 - 20:10	1,279	1,842	1,222	932
20:11 - 20:20	1,254	1,860	1,229	970
20:21 - 20:30	1,224	1,868	1,224	1,000
20:31 - 20:40	1,183	1,887	1,215	1,017
20:41 - 20:50	1,145	1,932	1,198	1,013
20:51 - 21:00	1,123	1,929	1,172	1,009

Table 5. Parking characteristics and results of two sample t test method during weekends and weekdays

Characteristics	Weekend		Weekday		Two sample t test ($\alpha=0.05$)	
	Relocation		Relocation		$H_0: \mu_1 - \mu_2 = 0$	$H_a: \mu_1 - \mu_2 > 0$
	Before	After	Before	After	Weekend	Weekday
Parking Accumulation (veh)	1,060	1,385	668	448	$t_{value}=5.44$ $P_{value}=0.002$ $P_{value}<\alpha$ H_0 rejected	$t_{value}=-3.62$ $P_{value}=0.998$ $P_{value}>\alpha$ H_0 accepted
Parking Duration (minute)	31.0	50.9	26.5	38.5	$t_{value}=1.35$ $P_{value}=0.094$ $P_{value}>\alpha$ H_0 accepted	$t_{value}=0.92$ $P_{value}=0.184$ $P_{value}>\alpha$ H_0 accepted
Parking Index (%)	105.2	104.4	86.8	58.1		
Parking Turn Over (veh/stall/hr)	6.074 (rounded to 6)	3.648 (rounded to 4)	2.443 (rounded to 3)	1.445 (rounded to 2)		
Parking Capacity (veh/hr)	578	778	867	1167		

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