

## Defining Suitable Parking Controls to Minimize Negative Impacts of Road Traffic: A Case Study in Padang City

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**Abstract**—Although car usage is admitted to improving the efficiency of travel and productivity, it is also blamed for the widespread problems in urban areas. It demands an increasing amount of space for roads as well as for parking, especially within the Central Business District (CBD). Due to budget constraints and to minimize the negative impacts of road traffic such as fossil fuel crisis and increasing number of road traffic accidents- parking control becomes essential. This study attempts to define the parking behavior of motorists such as parking cost and duration, parking location distance, as well as pricing systems with a case study in Padang City, Indonesia. The findings from this study are expected could help the government in developing suitable parking controls inside the CBD and hence could contribute to minimizing the negative impacts of road transport. In addition, the government may also encourage the usage of public transport instead of private cars by using the recommended parking controls generated from this research. This is considerably important, especially for a country where a great amount of national petrol consumption is imported from overseas and mostly spent by private car and logistic transport.

**Keywords**— Parking Control; Road Traffic Impacts; On-Street Parking; Off-Street Parking; Willingness to Pay; Ability to Pay

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### I. INTRODUCTION

The negative impacts of road traffic such as energy crisis, congestion, air pollution and road accident in Indonesia is now considered at an alarming level. The consumption of un-renewable energy source such as petroleum is the highest compared to other sources of energy while its deposit was predicted lasting for only about 18 years from 2006 [1]. About one third of national petrol consumption was imported and subsidized [2]. Meanwhile, Morichi [3] suggested the cruise speed on particular road sections in Indonesia is not more than 20 Km/hour representing severe congestion level due to considerable unbalance growth rate between road length and automobile- about under 3% and above 10% respectively [4], [5]. These figures and trends must be controlled so that further negative impacts of road traffic can be minimized due to its outcomes towards a country's economy.

The potential financial losses due to congestion and road accident are estimated up to three per cent of Gross Domestic Product (GDP) and for developing countries like Indonesia the loss could be double as reported by Gwilliam [6] in Ma et

al. [7]. Road traffic negative impacts could be minimized by increasing transport supply facilities as well as controlling its demand [8] such as managing parking supply and increasing public transport shares. A previous research by Luatthep et al. [9] suggested that public transport share could be increased by introducing paid and limited parking facilities. It also demonstrated the CO<sub>2</sub> produced by road traffic could be reduced to 45.82%. Yet, scientific-based parking controls based on local conditions should be developed and hence it becomes applicable.

As an integral part of the public transport and road network, the parking facilities affect the commuter decision in choosing transport modes to use and hence contribute to the public transport patronage and congestion level. Parking control policy could be used to optimize the road transport, minimize congestion level and increase public transport share. Tsuboi [10] suggested the parking control could be used as an effective policy and hence understanding the traveler parking behavior becomes essential. It includes on-street and off-street parking in the CBD.

A study by Wijayaratna [11] demonstrated that on-street parking could reduce the road capacity to serve traffic up to 17% while short-term parking impacts road traffic more than long-term parking. It was also found that one-day parking reduced road capacity minimally. Alfaro [12] suggested the usage of road space for parking due to increasing demand contributes to the traffic congestion.

Meanwhile, un-controlled parking might encourage travelers to abuse the limited space for parking, double parking, improperly parked and parking on prohibited locations affecting traffic flow as well as road safety [13]. Therefore, parking should be controlled. These phenomenon are occurred not only in developed countries, but also in many developing countries such as in Malaysia [14] and Philippines [12], including in the CBD of Padang City-Indonesia. Although parking control studies have been undertaken in other places, yet it might not be applicable elsewhere. Therefore, developing parking control for Padang City becomes essential as it fits the local conditions.

Padang is the capital city of West Sumatra. With the total population above one million individuals, it is categorized as one of newly emerge big cities in Indonesia. Figure 1 shows the Padang city map consisting of 11 counties, where the CBD is located not far from the west coast. It is a dense business area with a mixed land use including major shopping centers, automobile spare parts stores, construction material, and furniture stores and also the largest traditional market in Padang City (see Figure 2).



Fig. 1 Padang city map

Meanwhile, there are two major collector roads crossing the Padang CBD from East to West and from South to North. Those are (1) M. Yamin Road and (2) Hiligoo Road-Pasar Raya Road and Permindo Road where both are one-way roads

(see the sketch on Figure 3). Both major roads are congested, especially during working days. On-street parking lots are provided along these roads where Figures 4-7 represent the existing on-street parking condition and behavior.

Some vehicles were parked in the prohibited area contributing to the decrease in the road capacity. Car parked with different angles on the same side of the road resulted in inconvenience for the traveler to enter and exit the parking lots. Meanwhile, not all provided on-street parking provided are marked with clear markings as well as clear signs whether on-street parking is allowed or prohibited along that road section. Yet, some vehicles were parked improperly despite the parking lot is marked clearly (see Figures 4-7 respectively for more details).

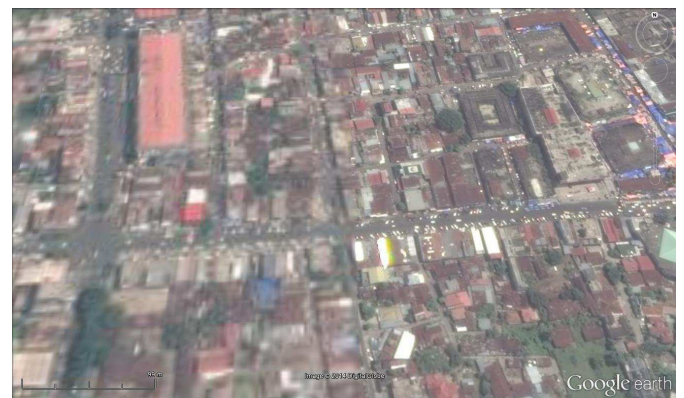


Fig. 2 A dense and mix land use of Padang CBD

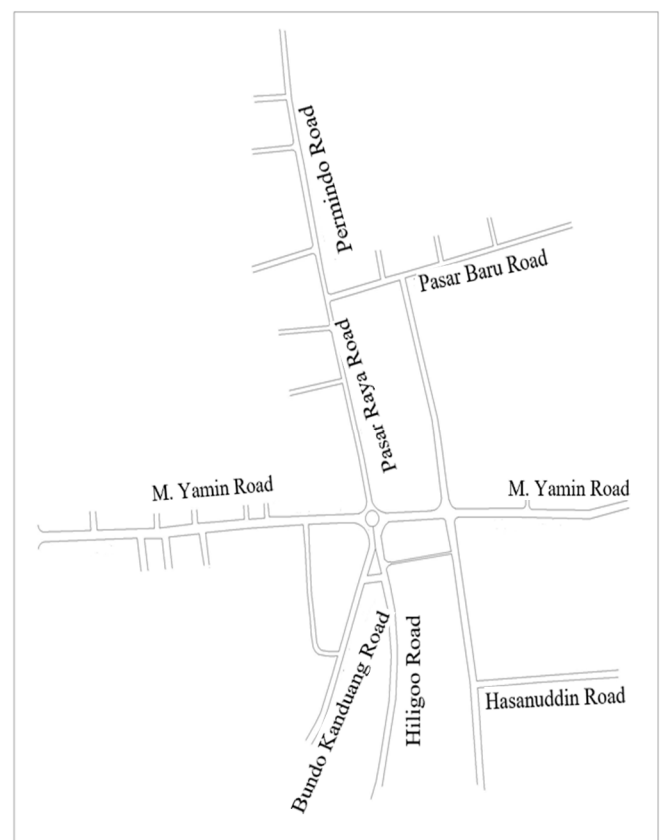


Fig. 3 Major roads in Padang CBD





Fig. 4 Parking in a prohibited area



Fig. 5 Different parking angles on the same side of the road



Fig. 6 On-street parking without parking mark

## II. MATERIALS AND METHOD

The demand for on-street parking varies during the day ranging from 17 to 102 parking lots. In average, the parking demand is about 60 lots where the highest demand belongs to M. Yamin Road followed by Permindo Road and Hiligoo Road. Figure 8 depicts the on-street parking demand in Padang CBD. Figure 9 displays mode shift trends in Padang City suggesting more travelers shifted from public transport (PT) to private vehicles (PV). It resulted in more traffic loaded to the city roads, especially inside the CBD. It was described by Yaldi [15] that congestion occurs mainly inside CBD and

also some areas located in outside CBD but still in the city of Padang. Further, severe congestion levels causing a considerably low Level of Service (LoS) had occurred in some spots and could reach as low as F.



Fig. 7 Improperly parked vehicles

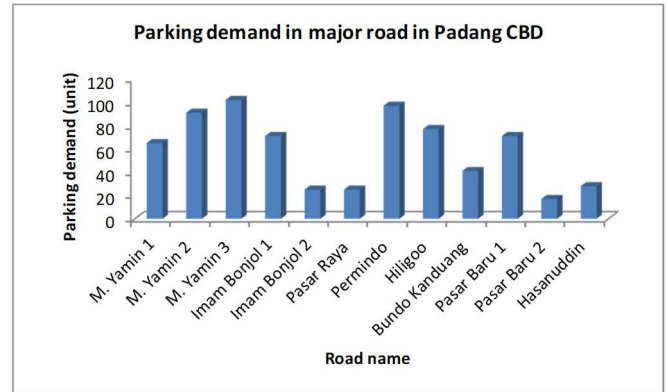


Fig. 8 Hourly on-street parking demand

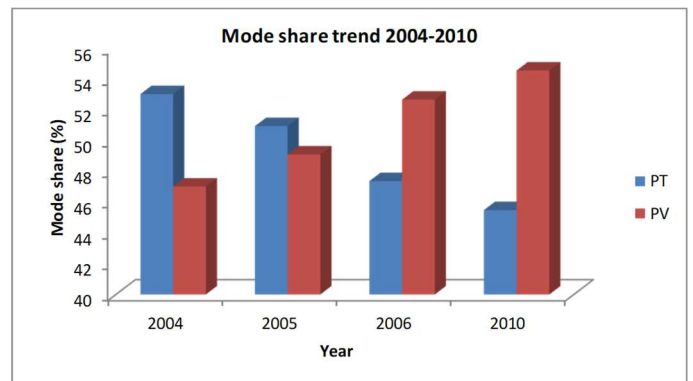


Fig. 9 Mode share and trend in Padang city

The potential loss due to congestion for Padang City would reach above IDR900 Billion or 3% of the 2012 Gross Domestic Regional Product (GDRP). This number is significantly higher than the budget allocated by the local government for the transport sector. It is even higher than all sector budgets combined together. Therefore, strategic efforts must be undertaken immediately to prevent further damage to urban economic and social life by optimizing the transport supply facilities as well as strengthening the transport demand management, including parking systems.

In order to minimize the impact of road traffic by means of parking controls, it is important to investigate the variable considered essential in optimizing the existing parking supply. It is also expected that it could reduce private car usage and hence mode shift from private cars to public transport occurred. It can be achieved by understanding the existing parking behavior.

Thus, identifying the value for variables considered important for the traveler such as parking cost, parking location, parking distance to the activity center, Willingness to Pay (WTP) as well as Ability to Pay (ATP) are necessary. These data are commonly obtained by conducting a series of surveys, including Stated Preference (SP) survey [10]. Therefore, a combination of Revealed Preference (RP), Stated Preference and Parking Occupancy surveys have been undertaken in Padang CBD aimed at defining the best proposed scheme of parking control.

### III. RESULTS AND DISCUSSION

The results can be seen in Figures 10-12 and also reported by Table 1. It was found that the average parking duration was about 85.8 minutes or nearly 1.5 hours per vehicle. The longest parking duration was higher than three hours while it is 30 minutes or less for the shortest ones. The RP survey indicates the majority of the motorists parked within 1-2 hours. From Figure 10 it can be assumed 72% of travelers parked for more than one hour and the rest is not more than an hour.

In order to optimize the parking facilities, it then could be assumed that 28% of parking spaces should be allocated for 60-minute parking while 36% of parking lots are provided for 120-minute and >120-minute each. Yet, long-term parking lots are preferred as the impact of short-term parking to the road capacity is more obvious [11].

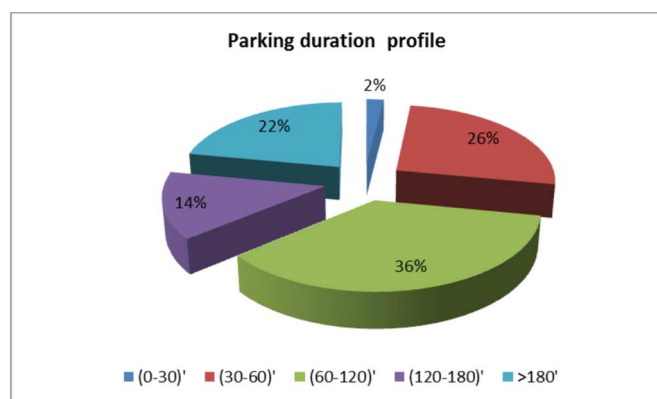


Fig. 10 Parking duration profile in Padang CBD

Further, about 96% of motorists parked in paid parking lots, including on-street and off-street parking locations suggesting mostly all of parking lots in CBD are paid parking. It is estimated that about 4% of respondents used unpaid parking lots as shop owners. The average parking cost paid by the motorist to park is IDR3000 (USD1 equals approximately IDR15000) and the same amount was paid by the majority of the motorist as depicted by Figure 11. It was obtained from the RP survey that about 38% of respondents used off-street parking, suggesting the majority of motor vehicles are parked on roadsides interrupting the traffic flow. In some countries

like Japan, on-street parking is basically prohibited due to its impact towards road capacity [10].

TABLE I  
PARKING DURATION DISTRIBUTION IN PADANG CBD

No.	Parking duration (minutes)	% Respondent
1	<60	28
2	60-120	36
3	>120	36

Meanwhile, it was found the motorist desires to park in on street and off-street parking with equal percentage. This preference is considerably different compared to the existing figure where more motorists parked along the on-street parking facilities (see Tables 2 and 3). This finding suggests that currently more on-street parking facilities are available than the off-street parking. Thus, it is recommended that the transport authority to provide more off-street parking facilities as desired by the motorists-yet with specific constraints such as its location from the activity centers.

In average, the motorist parked 77.5 meters from activity centers while the desired distance is much longer namely 179 meters. Tables 4 and 5 and Figure 12 show there is a huge gap between the existing and desired parking distances. Thus, the transport authority could reduce the on-street parking supply and provide more off-street parking facilities with the average distance from the activity center is longer than 179 meters and the parking price higher than IDR 3000.

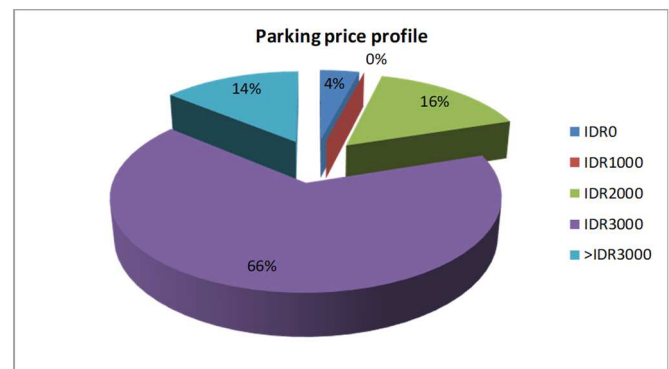


Fig. 11 Parking cost profile in Padang CBD

It is expected longer distance of off-street and on-street parking facilities towards the activity centers would cause fewer travelers using private cars and would shift to public transport, reducing fuel consumption, congestion and traffic accident numbers. Furthermore, limited parking supply as well as expensive parking cost would encourage the motorist to park in the remote area [16]. Thus, it is expected to be less traffic on the CBD road and congestion could be avoided, especially during peak time. Yet, this expectation must be further investigated. Thus, an SP survey was conducted assessing motorist behavior towards the virtual parking facilities scenarios as depicted by Figure 13.

TABLE II  
EXISTING PARKING LOCATIONS

No.	Parking location	% Respondent
1	On-street	66
2	Off-street	34

TABLE III  
THE PREFERRED PARKING LOCATIONS

No.	Preferred parking location	% respondent
1	On-street	50
2	Off-street	50

TABLE IV  
EXISTING PARKING DISTANCE TO THE ACTIVITY CENTER IN PADANG CBD

No.	Existing parking distance (meter)	% Respondent
1	<50	46
2	50-100	40
3	100-150	4
4	150-200	6
5	200-250	4

TABLE V  
PREFERRED PARKING DISTANCE TO THE ACTIVITY CENTER IN PADANG CBD

No.	Preferred parking distance (meter)	% Respondent
1	<50	18
2	50-100	12
3	100-150	4
4	150-200	50
5	200-250	66

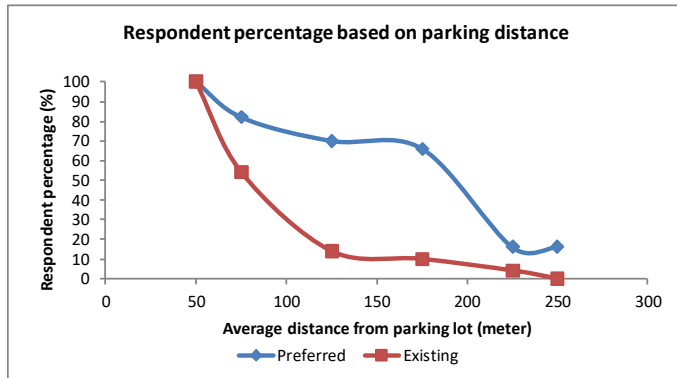


Fig. 12 Existing and preferred parking distance

In order to investigate the behavior of travelers in selecting virtual parking facilities based on particular characteristics, an SP survey has been undertaken and designated for three different scenarios based on RP survey outputs as can be seen in Figure 13. The purpose is to determine the behavior of the travelers towards the proposed parking scenarios including parking locations (on-street or off-street) and parking price system (fix or progressive) with specific security and convenience devices.

The expected results are the WTP of the travelers for each parking scenario and also the ATP based on the traveler monthly income could be figured out and hence could be used to develop a suitable parking control policy. The results are reported in Table 6 and Figures 14-16. The SP survey output reported in Table 6 suggests the motorists have the same preference for parking scenarios for short-time parking. However, more motorists seem to prefer the first parking scenario once the parking price increased to IDR4000 – IDR5000 as reported by Table 6.

SCENARIO 1			P	
	Base parking price (IDR)	Answer		
- On-street parking	3500	Yes No		
- Clear parking sign	4000	Yes No		
- Unlimited parking time	4500	Yes No		
- On-site parking machine	5000	Yes No		
- Fix parking price (see Table)	5500	Yes No		
	6000	Yes No		

SCENARIO 2			P	
	Base parking price (IDR)	Answer		
- On-street parking	3500	Yes No		
- Clear parking sign	4000	Yes No		
- Unlimited parking time	4500	Yes No		
- On-site parking machine	5000	Yes No		
- Parking ranger	5500	Yes No		
- Progressive parking price	6000	Yes No		
- 1 <sup>st</sup> hour parking price (see Table)				
- Additional parking price after the 1 <sup>st</sup> hour is IDR1000/hour				

SCENARIO 3			P	
	Base parking price (IDR)	Answer		
- Off-street parking	3500	Yes No		
- Located in the city centre	4000	Yes No		
- Clear parking sign	4500	Yes No		
- Unlimited parking time	5000	Yes No		
- Parking machine	5500	Yes No		
- Parking operator	6000	Yes No		
- Equipped with CCTV Camera				
- Progressive parking price				
- 1 <sup>st</sup> hour parking price (see Table)				
- Additional parking price after the 1 <sup>st</sup> hour is IDR1000/hour				

Fig. 13 Proposed virtual parking scenarios

TABLE VI  
RESPONDENT PERCENTAGE FOR DIFFERENT PROPOSED PARKING SCENARIOS

	% respondent					Total (%)
Parking duration (minutes)	<30	(30-60)	(60-120)	(120-180)	>180	
<b>Scenario 1</b>						
Parking price 1	0	10	10	2	2	24
Parking price 2	2	12	24	10	18	66
Parking price 3	0	4	2	2	2	10
<b>Scenario 2</b>						
Parking price 1	0	8	12	4	6	30
Parking price 2	2	12	18	8	12	52
Parking price 3	0	6	6	2	4	18
<b>Scenario 3</b>						
Parking price 1	0	6	8	2	4	20
Parking price 2	2	10	22	8	12	54
Parking price 3	0	10	6	4	6	26

Parking price 1= IDR3000-IDR3500, Parking price 2= IDR4000-IDR5000, Parking price 3= IDR6000

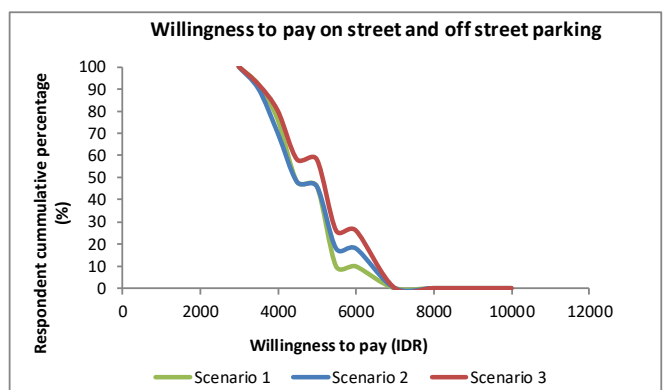


Fig. 14 WTP for different parking scenarios



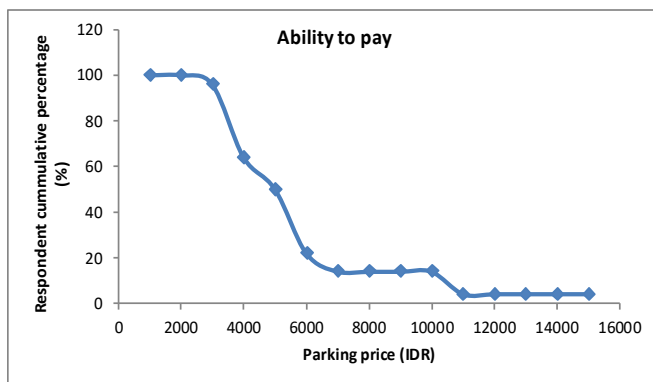


Fig. 15 Motorist ATP for parking

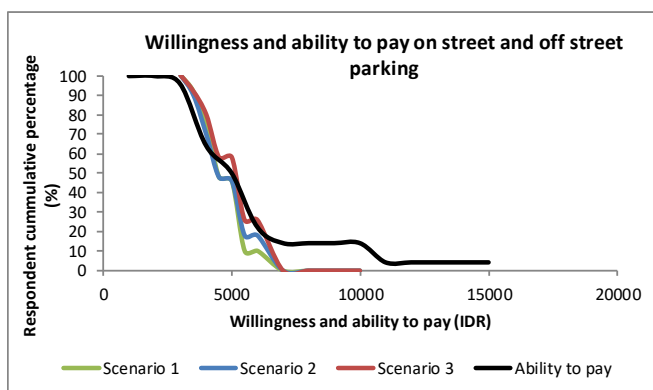


Fig. 16 WTP and ATP for different parking scenarios

Meanwhile, more motorists choose Parking Scenario 3, a once-based parking fee that reaches IDR6000. Thus, parking price IDR4000 – IDR5000 is considered as the boundary where motorist preference moves from on-street parking to off-street parking. Yet, the motorists prefer the first parking scenario rather than others although more motorists have WTP IDR6000 for parking scenario 3. It suggests a better parking facility is worthwhile a higher parking cost. These findings demonstrate the motorist decisions are affected by the parking prices, parking time limits and parking locations as well as parking facilities.

It also can be seen in Table 6 and Figure 14 where in average more than a half of respondents are willing to pay the parking prices for all of proposed parking scenarios not more than IDR4000 – IDR5000. In general, the motorists would use parking facilities charged up to IDR5000 with a percentage of 92%, 82%, and 74% for parking scenarios 1, 2, and 3 respectively. Thus, it can be assumed that motorists prefer on-street parking with fixed prices more than other scenarios. In the meantime, the ability to pay for parking is reported to reach IDR6000 although some motorists are able to pay up to IDR15000. Once the WTP and ATP are superimposed, the WTP and ATP motorists for parking facility are estimated above IDR4000 but not more than IDR5000 as represented by more than 70% of the motorists. The summary of the findings from this study is then reported in Table 7.

The transport authority is recommended to develop its local parking control policy based on these findings depending on which scenario is to be applied. Thus, the government could provide more off-street parking facilities, yet with a based

parking price above IDR6000 and paid progressively. Meanwhile, the on-street parking facilities should be minimized where more long-term parking lots are recommended with a based parking price above IDR4000 and paid progressively.

TABLE VII  
THE PROPOSED PARKING CHARACTERISTICS FOR PARKING CONTROL AND MANAGEMENT SCHEMES

Parking location	On-street parking	Off-street parking
Price scenario	Progressive pricing	Progressive pricing
Based on parking price (IDR/hour)	4000	6000
Parking distance-activity center (m)	>179	>179
Provided parking lots (%)*		
- Maximum 60 minutes	27	38
- 60-120 minutes	35	24
- >120 minutes	38	38
Future parking development locations		√

\* More one-day parking spaces are recommended

#### IV. CONCLUSION

The main findings from this study suggest the transport authority could control road traffic so that its negative impacts could be reduced by controlling the existing parking facilities. The existing parking supply provides on-street parking more than the off-street parking. This situation could lead to severe traffic congestion during peak hours due to road space usage for parking. It is recommended the supplied on-street parking lots be re-assessed and optimized by applying progressive pricing and limited parking duration based on Table 6.

The average on-street parking should be located not less than 179 meters from the activity center where 73% of parking lots are provided for parking duration longer than one hour-preferred for one-day parking and more expensive price. Meanwhile, the transport authority could also manage the parking supply by providing more off-street parking facilities with progressive pricing. The based parking price should be not less than IDR6000 with an average distance from the activity center >179 meters where only 38% of parking lots are for parking duration less than one hour. Although applying the parking control policy based on the findings from this study is probably considered as difficult, unpopular and politically sensitive, the government are encouraged to persuade the public and implement the policy gradually and also by engaging the community for the sake of future economic and generation.

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