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Parking and Queue Analysis

(Case study : New Sport Center in Kepanjen, Malang Regency)

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Abstract:- The construction of new facilities in urban areas will increase to the trip generation, as will the plan to build a Sports Center (GOR) by the Malang Regency Government located in the Kanjuruhan Stadium Area, Kepanjen. Travel in urban areas especially in developing countries is dominated by private vehicles. Problems will arise when visitors come to the GOR with private vehicles and the parking facilities that provided by the GOR are not able to accommodate the vehicles. If the parking capacity insufficient, there will be a lot of illegal parking on the side of the road (on street parking) or even on the pedestrian. Long queues of vehicles that get into GOR can also cause traffic disturbances on the surrounding roads. The purpose of this research is to predict the parking volume and make a parking capacity plan according to the availability of land. Aside from that, it also calculates the queue of vehicles, especially when going into the GOR so that the queue does not interfere with traffic on the surrounding roads. The analysis used is comparative analysis, regression and parking index to predict the number of vehicles that will park, then queue analysis to predict the queue length of vehicles entering the GOR. The results of the study can be used as a reference for the government in planning parking in the Kepanjen GOR area, Malang.

Keywords:- Demand Parkir; Queueing Introduction; Sport Center.

I. INTRODUCTION

With rapid growth of the metro cities all over the world, the parking generation rate goes on increasing very quickly which creates major problems of parking in most of the urban areas [1]. Increasing demand for parking spaces, insufficient parking space planning, and low standards of parking facilities, which has become the main obstacle to the development of urban transportation at this stage. How to improve the efficiency of parking space utilization and urban parking has become an important content of urban traffic management [2].

There is a general problem of finding free space for parking vehicles in crowded cities, particularly at shopping centres, theatres, sports venues, wedding places, hospitals and other tourist destinations [3]. There is a great complexity for the beginners to park a vehicle in peak hours, such as holidays, weekends etc. The problem of parking occurs due to inadequate space for parking which in turn leads to congestion and people often gets frustrated because of not finding available space for parking. Meanwhile, the problem of parking becomes worst as more population is migrating from towns to cities [4].

The coordination between parking policies and traffic management revealed how parking is becoming a barrier to the through-traffic operation. Also, it is responsible for the inefficient use of available resources, even the decisions are made on an ad-hoc basis while making policy. Hence, it is necessary to understand the parking choice behaviour and actual demand of parking space. In the last three decades, ample studies have been done to evaluate parking characteristics, to estimate the demand for parking and on driver's behaviour while choosing the parking space [5].

The drivers of private vehicles usually want to leave their vehicle as close as possible to their destination. However, the parking slots are limited and may not be enough to sustain the demand, especially when the destination pertains to an attractive area. Thus, individuals looking for a place to park their vehicle contribute to increasing traffic flow density on roads where the parking demand cannot be satisfied [6].

Such a motorcycle-dominated culture has resulted in a number of parking issues in Asian developing countries. Transport users are having a unique parking behavior regarding parking duration, parking searching time and walking distance. The number of private vehicles has been increased while the available space on the roads has remained unchanged, leaving a huge gap between parking supply and demand. Illegal parking occurs frequently in many urban areas, especially central business districts [7].

The need to improve sports infrastructure and facilities to the community has made Malang Government taken policy steps, one of which is the construction of new GOR infrastructure and provide its facilities. Therefore, the Malang Government carried out the construction of a new GOR located in the Kanjuruhan Stadium area which is located in Kepanjen, Malang. The construction of the GOR with a capacity of 3000 spectators is predicted to raise large trip generation, especially when the GOR is operating. To anticipate negative impacts, it is necessary to predict and provide parking needs for visitors, so as not to cause disturbances in security, safety, order, and smooth traffic in the area around the Kanjuruhan Sports Complex, Kepanjen Malang. [8]

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II. LITERATURE REVIEW

[9] have carried out the comprehensive survey and analysis of parking facilities in old community in Jinan, China and used the parking supply model based on livable environment to determine the suitable scale of parking supply. The selection of appropriate car parks could be influenced by multiple factors, e.g.. the walking distance to destination, driving and waiting time, parking prices, availability, and accessibility [10].

A framework for delivery spaces location and evaluation is suggested. It consists in gathering real and up-to-date information about cartography, delivery parking demand and existing delivery spaces. It quantifies the generated flow of loadings and deliveries for each business with a statistic-based estimation or with a local survey. It determines the location of new delivery spaces based on an optimization model that considers real distances, influence radius and physical constraint [11].

Queues at parking entry are of primary importance since it affects directly the external traffic [12]. The queuing theory is an operational research technique that models systems allowing queue, calculates its performances and determines its properties in order to help managers in decision making [13].

Parking volume is the total number of vehicles parked through a given time duration or survey period. It is noteworthy that it doesn't account repetition of the same vehicle. So, it only reckoned the number of vehicles entered during the survey period. Capacity is the total number of parking space/bays available for parking at a particular parking lot. Occupancy factor or parking index for particular parking facility is the total number of parked vehicles at a specified duration, i.e., accumulation divided by the capacity. It is also obtained by dividing the parking load by the capacity for a given time interval. It is a measure of efficiency of parking lot that how effectively it is being utilized [5]. Peak parking saturation is the number of vehicles parked at peak time to the total number of parking space available (i.e., capacity). Peak parking ratio is the ratio obtained by dividing number of vehicles parked at peak time to average number of vehicles parked at each time interval [14].

III. METHOD

The location for the construction of the New GOR Type B is on Trunojoyo Street, Kanjuruhan Stadium Complex, Kedungpedaringan Village, Kepanjen District, Malang Regency. The following is a picture of the study area taken from google maps in 2019 (Figure 1)

Fig. 1 Study Area in Kepanjen, Malang

Analysis of parking demand is based on calculations with regression and using a parking index. Regression modeling use data released by the Ministry of Transportation, the Director General of Land Transportation which includes parking demand data and parking index. In these guidelines, GOR is included in the category of temporary activities in the form of sports activities [15].

The analysis of parking needs is divided into 2 types of vehicles, namely cars and motorcycles based on the assumption of mode choice from the results of a comparative analysis with the mode choice used by spectators at Ken Arok Sports Center, Malang City.

Queueing theory really needs to be studied to recognize the behavior of the movement of traffic flows, both humans and vehicles. There are 3 main components in queuing theory that must be known and understood, namely: arrival rate (λ), service level (μ); and queuing discipline [16]. There are 4 (four) main parameters that are always used in analyzing queues, namely [17]:

- Number of vehicles or people in the system (n);
- Number of vehicles or people in the queue (q);
- Time of vehicles or people in the system (d); and
- Time of vehicles or people in queue (w).

With FIFO (First In First Out) queue discipline, the equation for each parameter is as follows [17]:

$$n = \frac{\lambda}{(\mu-\lambda)} \quad (1)$$

$$q = \frac{\lambda^2}{\mu(\mu-\lambda)} \quad (2)$$

$$d = \frac{1}{(\mu-\lambda)} \quad (3)$$

$$w = \frac{\lambda}{\mu(\mu-\lambda)} \quad (4)$$

IV. DISCUSSION

A. Prediction of Trip Generation and Modal Split

Traffic generation is predicted from the analysis of the proportion of vehicles at Ken Arok Sports Center. Ken Arok Sports Center is used as a comparison because the capacity of the Ken Arok Sports Center is similar from the New Sport Center Kepanjen. The capacity of Ken Arok Sports Center is 6000 people, while the capacity of the New Sport Center Kepanjen is 3000 people. In addition, Ken Arok Sports Center is located in the Malang City area which has almost the same characteristics as the Kepanjen area. The distance between the two sport center is approximately 30 Km or 45 minutes driving. The following is the proportion of vehicles based on the results of a comparative survey at Ken Arok Sports Center. (Table 1)

TABLE I. COMPARATIVE SURVEY RESULTS OF VEHICLE PROPORTION IN GOR KEN AROK

No	Vehicle	Amount (unit)	Percentage (%)
1	Motorcycle	2279	74
2	Car	678	22
3	Mini bus/Bus	123	4
Total		**3080**	**100**

In predicting parking needs, there are 2 categories of calculation of the Parking Space Unit (SRP), that is cars and motorcycle. In this case, the types of vehicles in the form of cars and minibuses/buses are included in the car category. The assumption is that the number of vehicles used is 74% for motorcycles and 26% for cars.

B. Analysis of Supply and Demand Parking

Parking demand analysis is based on calculations with regression and using a parking index. The regression model use data released by the Ministry of Transportation, the Director General of Land Transportation, in the form of a Technical Guidelines for the Implementation of Parking Facilities which contains data on parking demand and parking index. In these guidelines, GOR is included in the category of temporary activities, that is places for sports activities.

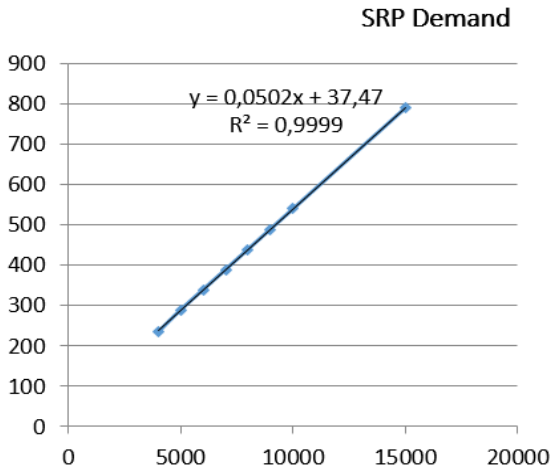

Fig. 2 Modeling Graph of Parking Demand Sports Competition Venue

TABLE II. REGRESSION MODEL OF PARKING DEMAND SPORTS COMPETITION VENUE

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	37,470	1,590		23,559	,000
	Capacity	,050	,000	1,000	272,637	,000

a. Dependent Variable: Parking_Demand

Besides regression modeling (Figure 2 and Table 2), calculations are also carried out using the parking index withh assumption parking index 1 and 1.3 and using 2 scenarios, that is with a capacity of 1,000 spectators and 3,000 spectators.. The results of the calculation of the parking demand for the New Sport Center Kepanjen construction are as follows.

TABLE III. CALCULATION OF PARKING DEMAND FOR THE NEW SPORT CENTER KEPANJEN

Model	Indeks/ Konstanta	Proportion of Vehicle Type (unit)	
		car	motorcycle
		26%	74%
Regression Parking 1000	87,70833	25,43	62,27
Regression Parking 3000	188,1845	54,57	133,61
Index 1 1000	1000	290	710
index 1 3000	3000	870	2130
index 1,3 1000	1300	377	923
index 1,3 3000	3900	1131	2769

TABLE IV. CALCULATION OF PARKING DEMAND FOR THE NEW SPORT CENTER KEPANJEN (2)

Model	Parkir Demand (SRP)		Rounding Off (unit)	
	car	motorcycle	car	motorcycle
	11,5	1,5		
Regression Parking 1000	2,21	41,51	3	42
Regression Parking 3000	4,74	89,07	5	90
Index 1 1000	25,21	473,3	26	474
index 1 3000	75,65	1420	76	1420
index 1,3 1000	32,78	615,3	33	616
index 1,3 3000	98,34	1846	99	1846

Based on several parking calculation scenarios above (table 3 and 4), the parking demand taken are index 1 with a capacity of 3000 spectators which results in parking requirements of 76 cars and 1420 motorcycles. When compared with the parking capacity based on the drawing plan (figure 2), the calculation of parking availability is as follows.

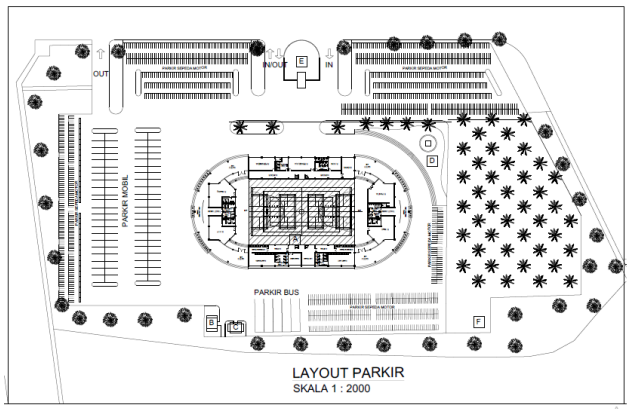

Fig. 3 New Sport Center Kepanjen Parking Layout Plan

From the picture above, it can be seen that the number of parking available is 5 unit for bus/minibus, 88 units for car and 1468 units for motorcycle. The above data will be assumed to be a supply parking. (Figure 3)

TABLE V. COMPARISON OF SUPPLY-DEMAND PARKING IN KEPANJEN SPORT CENTER

No.	Vehicle	Parking Supply (unit)	Parking Demand (unit)
1.	Bus	5	4
2.	Car	88	76
3.	Motorcycle	1468	1420

From the table 5, it can be seen that the availability of parking has been able to accommodate the number of parking demand for the construction of the New Sport Center Kepanjen.

C. Queueing analysis

The number of vehicles that are estimated to get into the New Sport Center Kepanjen is divided into four times, that is 3 hours before the match, 2 hours before the match, 1 hour before the match, and when the event starts. Based on survey results, the highest arrivals occurred 1 hour before the match, which was 42.5%. At the New Sport Center Kepanjen, it is planned to withdraw parking tickets at the parking queue entrance counter. The following is the average service time for distribution withdrawals at the parking queue entry counter and the number of vehicle arrivals for motorcycle and car parking gate plans at New Sport Center Kepanjen assuming the number of spectators occupancy is 100% (maximum). (Table 6)

TABLE VI. NUMBER OF ARRIVALS AND MAXIMUM PARKING GATE SERVICE TIME

Vehicle	Arrival (vehicle/hoour)	Service Time (second/vehicle)
Motorcycle	559	12
Car	68	25

Based on the number of vehicles and the length of service time, the queue length is calculated, which is presented in the following table 7:

TABLE VII. PREDICTING AND QUEUEING ANALYSIS ON 100% AUDIENCE OCCUPANCY

Numbers of Gate (N)	$\bar{n}$ (vehicle)	$\bar{q}$ (vehicle)	$\bar{d}$ (second)	$\bar{w}$ (second)
Motorcycle				
1	-2	-4	-14	-26
2	14	13	176	164
Car				
1	1	0	47	22
2	1	0	33	8

Queue counting show that motorcycle parking with 1 gate will not be able to serve the arrival of 559 motorcycle/hour so a minimum of 2 motorcycle parking gate is needed. At 2 motorcycle parking doors with distribution withdrawals at the parking queue entry counter there will be 13 motorcycle queues, with 13 vehicles queuing assuming 1 motorcycle has a length of 2 meters, a parking queue length of 26 meters is required. In the car park there is only 1 car in line so there is no problem.

V. CONCLUSION

The supply parking capacity is predicted to still be able to accommodate the volume of vehicles that will park even though the occupancy rate is maximum or 100%. Parking demand for buses are four (4) units, while the availability of parking capacity is five, parking demand for cars are 76 units while the number of availability of parking capacity is 88, as well as motorcycle, there are 1,468 parking units available, while parking demand are only 1,420 units. In planning the gate for ticket withdrawal, the results of the queueing analysis show that for motorcycle requires 2 gates, while for cars only requires 1 gate. The queue length caused by the existence of this gate is 26 meters, where the distance between the gate and Trunojoyo road is approximately 100 meters so that the queue will not interfere with traffic on the road.

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