Proceedings of the Eastern Asia Society for Transportation Studies, Vol.10, 2015

A New Concept to Evaluate Road Traffic Capacity based on Number of Passengers in Vehicle: Case Application of Tokyo Metropolitan Expressway

Hiroaki NISHIUCHI [a], Yasuhiro SHIOMI [b], Hiroshi WARITA [c]

[a] *Department of Civil and Environmental Engineering, Nagaoka University of Technology, Niigata, 940-2188, Japan*
[a] *E-mail: nishiuchi@vos.nagaokaut.ac.jp*
[b] *College of Science and Engineering, Ritsumeikan University, Shiga, 525-8577, Japan*
[b] *E-mail: shiomi@fc.ritsumei.ac.jp*
[c] *Maintenance and Traffic Management Department, Metropolitan Expressway Co. Ltd., Tokyo, 100-8930, Japan*
[c] *E-mail: h.warita1116@shutoko.jp*

Abstract: This paper proposes a new concept of road traffic capacity evaluation based on number of passengers in a vehicle. Currently road traffic capacity is evaluated by traffic volume based on number of vehicles. However the capacity based on number of vehicles does not always represent how the road is efficiently utilized from the point of view of road ability, especially when we compare it among different countries under different characteristics of the utilization of vehicles. Our concept showed the possibility that road capacity can be uniformly evaluated and compared for different roads and transport modes in the cities in South-Eastern Asian countries where the road situations are maintained under mixed several transport mode. The case study of road traffic capacity evaluation with installing High-Occupancy Vehicle Lane on Tokyo Metropolitan Expressway has been conducted. The results also showed the evaluation of delay time is different among the concepts of traffic capacities.

Keywords: Traffic Capacity, Number of Passenger, Mixed Traffic, Urban Expressway, High-Occupancy Vehicle Lane

1. INTRODUCTION

Road traffic in big cities where impressive grown Asian countries are heavily congesting. Transport mode in those cities is also mixed by passenger cars, motorcycles, buses and also locally specific vehicles. In addition to that, the proportion of those vehicles also has varied by each country and city. To improve traffic situations in Asian countries, it is necessary to evaluate suitable and sustainable transport plan for each Asian country, such as transport modal shift from motorcycle to passenger car and constructing new public transport systems (LRT, BRT) on the existing road space. In general, transport planning has been investigated using evaluation of the ability of road (traffic road capacity) that is an estimation based on number of vehicles. However, there is no existing study to evaluate road traffic capacity based on number of passengers in a vehicle as the principally, on the road is the space to travelling by people, not by vehicles.

This study proposes a new road traffic capacity evaluation index based on number of passengers in a vehicle, but not based on number of passing vehicles on the road as in the conventional way. Also this study aims to develop a suitable index that represents the actual use of vehicles, especially for evaluation of traffic capacity on the road where many types of vehicles are used in South-Eastern Asian countries. Through the proposed road traffic capacity index, contributions for investigating of transport infrastructure construction planning which exerts the highest performance considering rationality is expected.

This paper consists of following contents. Next sections, indices to evaluate road traffic capacity based on number of passengers in a vehicle are defined. And then, traffic road capacity based on number of passengers is calculated as a case study in an urban expressway, an intercity expressway and a national road in Japan. Calculated values are compared with public transport in Japan and the road in South-Eastern Asian countries (Phnom Penh and Bangkok) to see the efficiency of Japanese roads by number of passengers' point of view. In addition to that maximum road traffic capacity and the actual use of Japanese roads are compared to check how many Japanese roads still have surplus against maximum road capacity based on the number of passengers in a vehicle. After checking the usability of our proposed index, this paper investigates the effect of High Occupancy Vehicle (HOV) Lane introduction on Tokyo Metropolitan Expressway (MEX), and tests how the results of two investigations that are calculation based on number of passing vehicles as conventional way and number of passengers in a vehicle are different.

2. CONCEPT OF NUMBER OF PASSENGER BASED ROAD TRAFFIC CAPACITY

This section defines indices to be used for evaluating road traffic capacity based on number of passengers in a vehicle. This paper defines five indices to evaluate road traffic capacity as actual road usage based on the number of passengers in a vehicle as follows.

1) Passenger-based Road Capacity (PRC): number of passengers in a normal car in case seats of the vehicle are occupied by passengers under the assumption that all vehicles consist of passenger cars when the traffic volume approximates to road traffic capacity.
2) Maximum number of Passengers Under Current Situation (MPCS): number of passengers in a vehicle in case seats of the vehicle are occupied by the passengers for all transport modes if the proportion of transport mode on the road is given when traffic volume approximates to road traffic capacity. It can be an index to describe how many passengers can pass the study site considering the traffic situation by actual transport mode use.
3) Maximum number of Passengers Under Ideal Situation (MPIS): number of passengers in a vehicle if the proportion of transport mode on the road and actual number of passengers in each vehicle type are given when the volume traffic approximates to road traffic capacity. This index can describe the maximum number of passengers that is possible to measure on study site.
4) Passenger Equivalent Load Amount (PELA): the difference between PRC and MPCS. It describes the amount of load used against the road traffic capacity based on number of passengers.
5) Passenger Equivalent Surplus Amount (PESA): the difference between MPCS and "Measured Number of Passengers in a vehicle". It means the amount of empty space although more people can pass the study site.

This paper also defines the road traffic capacity, MPCS for each transport mode, number of passengers in a vehicle by road types and proportion of transport mode by each road types to calculate above indices 1) to 5). Followings a) to d) introduce used data and survey method in this paper.

a) Road traffic capacity: Table 1 shows the value of road traffic capacity used for calculations in this paper. The capacity of urban expressway was decided using vehicle detector data measured from 1st to 31st March 2014 at inbound direction on route no. 4 of Tokyo Metropolitan Expressway. Especially, the maximum traffic flow rate at bottle neck section of the road was used as the representation of the capacity on urban expressway in Japan. In case of the intercity expressway, maximum traffic flow rate at the bottleneck (near to Takarazuka tunnel) on Chugoku Intercity Expressway was chosen as the representation of traffic capacity. For road traffic capacity on the arterial road, value that was written on Manual on Traffic Signal Control (JSTE, 2007) is used. The capacity on arterial road in South-East Asian countries (Phnom Penh and Bangkok) was set from survey by existing study (Yoshii *et al*, 2004). In addition to the value of traffic capacity on arterial road, impact of traffic signal control was defied as 0.5 in all countries (Japan, Phnom Penh and Bangkok).

Table 1. Road traffic capacity by road type

Road Type	Traffic Capacity [veh/1hour*2lane]
Urban Expressway	3600
Intercity Expressway	3600
National Highway	2000
Arterial Road (Phnom Penh)	1800
Arterial Road (Bangkok)	1800

b) MPCS for each transport mode: The value of maximum number of passengers for each transport mode should be different by each vehicle individually. Therefore this paper employs the values from Guidebook of automobile (JAMA, 2013) as a representation as in Table 2.

Table 2. Maximum number of passengers for each transport mode

	Passenger Car	Small Truck	Large Truck	Bus	Motorcycle
Maximum number of Passengers	5	2	2	29	2

c) Number of passengers in a vehicle by vehicle type and road types: Table 3 shows the used values of number of passengers by vehicle type and road types which is the fundamental information of proposed road traffic capacity evaluation. A census survey results by metropolitan expressway on 2011 (MEX, 2011) was used for the case study in this paper as the values for not only in urban expressway but also in the intercity expressway since authors could not find official survey for number of passengers in intercity expressway. The one of arterial roads was used for the data of census survey conducted by Ministry of Land, Infrastructure, Transport and Tourism. However it was not shown about motorcycle. Therefore this paper uses same value with urban expressway for number of passengers on a motorcycle. The data about South-Eastern Asian countries has been used based on survey by an existing study (Yoshii *et al*, 2004). This study has conducted the survey of number of passengers for passenger cars and motorcycles as well.

Table 3. Number of passengers in a vehicle by vehicle type and road types

Road Type	Passenger Car	Small Truck	Large Truck	Bus	Motorcycle
Urban Expressway	1.82	1.50	1.26	20.74	1.16
Intercity Expressway	1.82	1.50	1.26	20.74	1.16
National Highway	1.32	1.20	1.26	13.82	1.16
Arterial Road (Phnom Penh)	1.60	-	-	-	2.20
Arterial Road (Bangkok)	1.50	-	-	-	1.20

d) Proportion of transport mode by road type: The proportions for each road type were set by data measured by authors. Survey for urban expressway has been conducted from 11:30am to 11:45am on route no. 4 of Tokyo Metropolitan Expressway. The one for intercity expressway has been conducted from 16:15 to 16:30 on Chuo National Expressway, and for arterial road has been conducted from 07:30am to 07:45am on route no.8 of national highway in Nagaoka City. Proportion for South-Eastern Asian countries has been decided from the paper by Yoshii *et al.* (2004) for both passenger car and motorcycle. Table 4 shows the details.

Table 4. Proportion of transport mode by road type

Road Type	Passenger Car	Small Truck	Large Truck	Bus	Motorcycle
Urban Expressway	0.62	0.14	0.21	0.02	0.00
Intercity Expressway	0.66	0.13	0.19	0.01	0.00
National Highway	0.75	0.16	0.09	0.01	0.00
Arterial Road (Phnom Penh)	0.30	-	-	-	0.60
Arterial Road (Bangkok)	0.67	-	-	-	0.33

The next section shows the evaluation of road traffic capacity based on number of passengers whose passing the each road through comparison between PRC and MPIS for all road types. In addition to that this paper investigates how people still can travel the roads from point of view of transport ability of the roads focusing on urban expressway, intercity expressway and arterial road (national highway in Japan).

3. Comparison of Traffic Capacity based on Number of Passengers

3.1 Comparison of Traffic Capacity by road type

This section shows the relationship between PRC and MPIS on a selected urban expressway, intercity expressway, and the National Highway in Japan, and two more cities in South-Eastern Asian Countries. To check its level, maximum number of passengers of the public transport (Light Rail Transit and subway) was also plotted based on repot by Ministry of Land, Infrastructure, Transport and Tourism (2014).

Figure 1 shows the comparison of traffic capacity based on the number of passengers by transport mode and road types. From figure 1, the traffic capacity based on number of passengers in a vehicle of public transport is the highest capacity compared to another mode. In the second place, the capacity for urban expressway and intercity expressway in Japan is the highest. In the point of view of MPIS, the capacity of road in Phnom Penh is the highest. The reason of this tendency describes the situation of South-Eastern Asian countries that both of the proportions of motorcycle in Phnom Penh and its number of passengers in a motorcycle are higher when compared to other cities in this paper. Therefore figure 1 show that transport mode shifts to passenger car is not always efficient situation in the point of view of road's effective utilization (number of passing passengers on the road) although the transport mode shifts from motor cycle to automobile is growing in some Asian countries due to economic growth. In case of Taipei City, proportion of motorcycle does not become lower and road traffic infrastructure and policy of its control is also developed by premising the traffic situation in the city although economic condition is also growing up in Taiwan (Shiomi and Nishiuchi, 2011). Therefore the results can indicate the necessity to consider rationality such as utilization characteristics of current transport system as distinct from simply introducing transport system of developed countries by analyzing traffic capacity in the point of view of number of passengers.

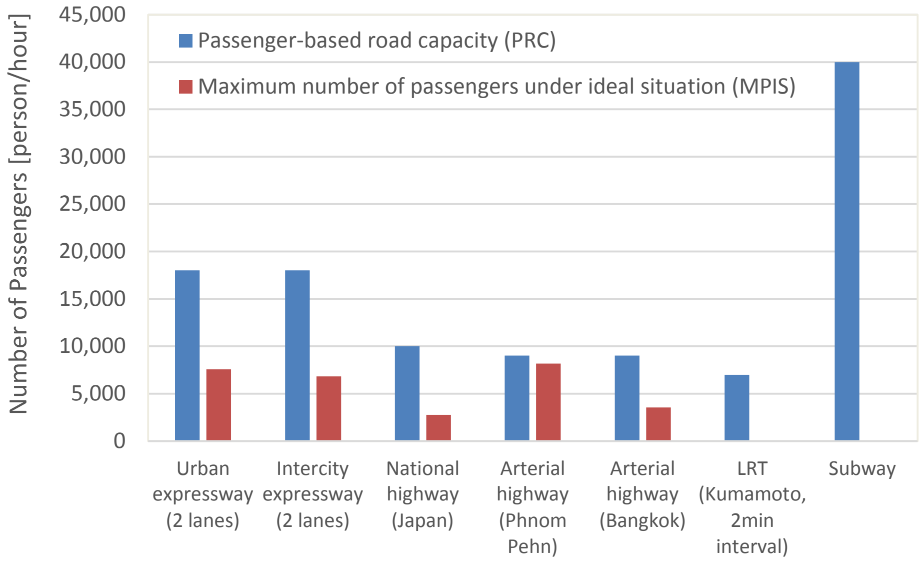

Figure 1. Comparison of traffic capacity based on the number of passengers by transport mode and road types

3.2 Relationship between Traffic Capacity based on number of passengers and the actual condition

This section investigates how many roads have surplus of traffic capacity based on the number of passengers focusing on urban expressway, intercity expressway and National Highway in Japan.

Figure 2 shows the relationship of indices defined by this paper related to traffic capacity based on number of passengers for three types of roads. Figure2 indicates that proportion of PELA on both urban expressway and intercity expressway is higher than national highway. In addition to that, proportion of PESA against PRC for all roads is in a higher level as 44% for urban expressway, 48% for intercity expressway and 61% for National Highway. The reason of the highest one for National Highway is considered the passenger cars used by just one person for short trip on arterial road in Japan. Therefore the results indicate that there are still needs to improve road utilization in the point of view of increasing traffic capacity based on the number of passengers. And then the next section shows an example of evaluation of traffic efficiency based on the number of passengers based traffic capacity through the introduction of HOV lane to urban expressway.

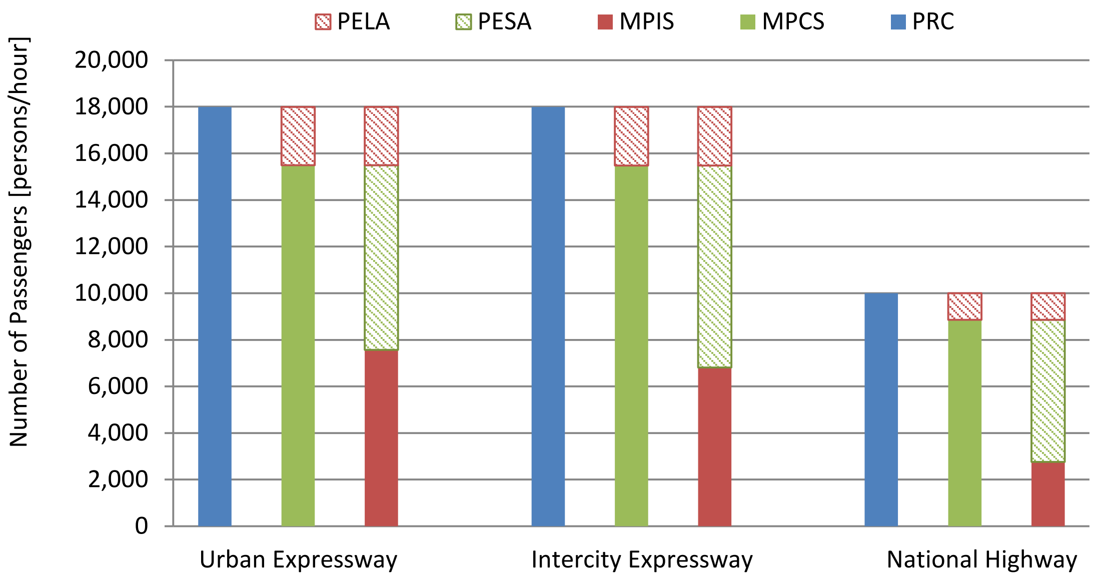

Figure 2. Relationship of indices related to traffic capacity based on number of passengers for three types of roads

4. Application of Traffic Capacity Evaluation based on Number of Passengers

This section shows the examination of effect by introducing High Occupancy Vehicle (HOV) on the intercity expressway in Japan as example of application of road traffic capacity evaluation based on the number of passengers that differs from number of passing vehicles based traffic capacity evaluation.

Tokyo Metropolitan Expressway is discussing introduction of Olympic Lane to keep smooth traffic for coming Tokyo Olympic on 2020. There is not a detailed plan how Olympic lane will be introduced until now, however by examining the propriety of traffic lane management on urban expressway has no small significance. Therefore, this section shows the evaluation difference of total delay time not only for the number of vehicles (Total Delay = Delay Time * Number of Vehicle), but also number of passengers (Total Delay = Delay Time * Number of Passengers) on the urban expressway in case introduced HOV lane with assuming the bottle neck is existing at downstream of the road section on 2 lane and 3 lane highway.

4.1 Scenario of HOV Lane Operation

To evaluate HOV Lane operation by proposed road traffic capacity concept, assumes that the following vehicles can use HOV Lane but not others.

1) Motorcycles
2) Passenger cars and small freight vehicles with more than one passenger
3) Buses more than 20 passengers

The purpose of introducing HOV lane is to keep smooth traffic by passing higher priority vehicles and that can be promoted to increase the number of passengers in a car. Therefore this study also assumes traffic jam will not occur on HOV lane. This also assumes that over traffic demand will use conventional traffic lane if the demand for HOV lane becomes higher than road traffic capacity by increasing HOV lane use demand.

This paper examines the total delay time in case one lane will be used as HOV lane on two lane expressway and three lane expressway respectively with the above assumptions.

4.2 Calculation of Delay Time

The delay time T related to bottleneck can be described as equation (1) using relationship between arrival curve $A(t)$ that is arrival pattern of traffic demand from upper stream and departure curve $D(t)$ that is pattern of traffic volume from the bottleneck of the road section.

$$T = \int_{t_{ini}}^{t_{end}} \{A(t) - D(t) - t_f\} dt \qquad (1)$$

Where t_{ini}, t_{end} represents starting time and finishing time of target time period of the evaluation, t_f is free flow travel time from the arrived traffic survey point to bottleneck. Followings are not considered tf to be simplified and real demand pattern to arrive bottleneck is given as $A(t)$.

4.2.1 Delay Time in case without HOV Lane Operation

In case HOV lane is not installed i.e. all lanes are opened for all traffic demands, only less traffic demand than the traffic capacity in the bottleneck. Here, time derivative values of $a(t)$, $d(t)$ from $A(t)$, $D(t)$ are defined, then $d(t)$ can be written by following.

$$d(t) = \min(a(t), C_{BN})$$

Where C_{BN} describes the traffic capacity of bottleneck, the departure curve $D(t)$ can be written as the equation (2).

$$D(t) = \int_{t_{ini}}^{t} d(x)dx \qquad (2)$$

Thus delay time T based on the number of passing vehicles can be examined by substituting equation (2) to equation (1). Then delay time is based on the number of passengers can be defined by using the relationship with average number of passengers for all the passing vehicles n_{ave}, that is

$$n_{ave} = \sum_i \sum_j p_i \cdot r_{ij} \cdot j$$

Then,

$$T_p = n_{ave} \cdot T$$

Where, p_i is mixed rate of vehicle type i, r_i is ratio of the car that is riding, j passengers in vehicle type i.

4.2.2 Delay Time in case with HOV Lane Operation

This section defines the traffic operation in case HOV lane is operating by using one lane on N lane traffic. Now demand pattern of arriving vehicles on HOV lane $A_{HOV}(t)$ can be described as following equation.

$$A_{HOV}(t)=\int_{t_{ini}}^{t} a_{HOV}(x)dx,$$

Here,

$$a_{HOV}(t)=\min\left(a(t)\cdot\sum_{i}\sum_{j\geq c_i} p_i\cdot r_{ij},\ {C_{BN}}\big/{N}\right)$$

is minimum number of passengers of vehicle type that can be permitted to use on the HOV lane. Then demand pattern of conventional lane is written as below.

$$A_{nor}(t)=A(t)-A_{HOV}(t)$$

On the other hand, departure curve for HOV lane $D_{HOV}(t)$ and conventional lane $D_{nor}(t)$ are shown as follows.

$$D_{HOV}(t)=\int_{t_{ini}}^{t}\min\left(a_{HOV}(x),{C_{BN}}\big/{N}\right)dx\ ,\quad D_{nor}(t)=\int_{t_{ini}}^{t}\min\left(\frac{dA_{nor}(x)}{dx},\frac{N-1}{N}C_{BN}\right)dx$$

Therefore the total delay time based on the number of passing vehicles can be defined as equation (3).

$$T=\int_{t_{ini}}^{t_{end}}\{A_{nor}(t)-D_{nor}(t)\}dt + \int_{t_{ini}}^{t_{end}}\{A_{HOV}(t)-D_{HOV}(t)\}dt \qquad (3)$$

Here, the second term on the right side in equation (3) will be zero by assumption of HOV lane operation.
On the other hand, the delay time based on the number of passing passengers T_p can be written as follows with the assumption of average number of passengers in the vehicles on conventional lane n_{ave}^{nor}.

$$T_p=n_{ave}^{nor}\cdot\int_{t_{ini}}^{t_{end}}\{A_{nor}(t)-D_{nor}(t)\}dt$$

Then n_{ave}^{nor} can be also defined by equation below.

$$n_{ave}^{nor}=\left.\left\{\begin{array}{l}\left(A_{HOVp}-A_{HOV}(t_{end})\right)\sum_{i}\sum_{j\geq c_i}p_i r_{ij}\, j\\ +\left(A_{nor}(t_{end})-A_{HOVp}\right)\sum_{i}\sum_{j<c_i}p_i r_{ij}\, j\end{array}\right\}\right/A_{nor}(t_{end})$$

However A_{HOVp} has meaning of possibility of HOV usage and it is written as follows.

$$A_{HOVp} = A(t_{end}) \cdot \sum_i \sum_{j \geq c_i} p_i r_{ij}$$

4.3 Definition of Arrival Pattern and Traffic Capacity of Bottleneck

Traffic detector data collected at inbounds of route no. 4 on Tokyo Metropolitan Expressway is analyzed to define arrival pattern of traffic demand to the bottleneck and traffic capacity of the bottleneck. The section measured is two lane expressways for a direction where traffic jam is occurring on a daily basis at a specific bottleneck (Miyakezaka junction in this study site). Hence the measurement of traffic flow without impact of traffic jam at upper stream of the bottleneck is used with the traffic jam starting from the bottleneck. This study traffic flow data are measured on 12nd March 2014 on study site. Figure 3 shows time series profiles of the measured traffic volume and speed at 3.5km upper point from the bottleneck. The figure indicates that traffic flow does not affect the impact of traffic jam from the bottleneck, even if traffic jam occurred at bottleneck. Therefore the traffic demand arrival pattern to the bottleneck is defined based on the profile of measured traffic flow at 3.5km upper section.

In addition to above, traffic capacity on the bottleneck defined 95.6 [pcu/5min/lane] as mean value of traffic volume in case average speed becomes smaller than 60[km/h] at the bottleneck.

4.4 Proportion of Transport Mode and Distribution of Number of Passengers

Proportion of transport mode on the road and distribution of number of passengers for each transport mode is required to calculate the delay time. Proportion of transport mode is defined shown as Table 5 by using mixed rate for passenger cars, motorcycles, buses, small trucks and large trucks based on the survey results from previous section. Distribution of number of passengers for each transport mode is used by referring to Origin-Destination census survey conducted by Tokyo Metropolitan Expressway (MEX, 2010) as shown on Table 6.

4.5 Comparison of Delay Time; Number of Vehicle based and Number of Passengers based

4.5.1 Delay Time in case two lane expressway

Figure 4 shows the departure and arrival curves of without HOV lane operation for two lane expressway. Figure 5 shows departure and arrival curves of conventional lane HOV lane operation and HOV lane. From those figures, mixed rate of the vehicles of higher number of passengers that can use HOV lane is not enough, and then the traffic volume on HOV lane becomes lower values. On the other hand, most of the traffic tends to use conventional traffic lane and it can be indicated that traffic congestion occurs.

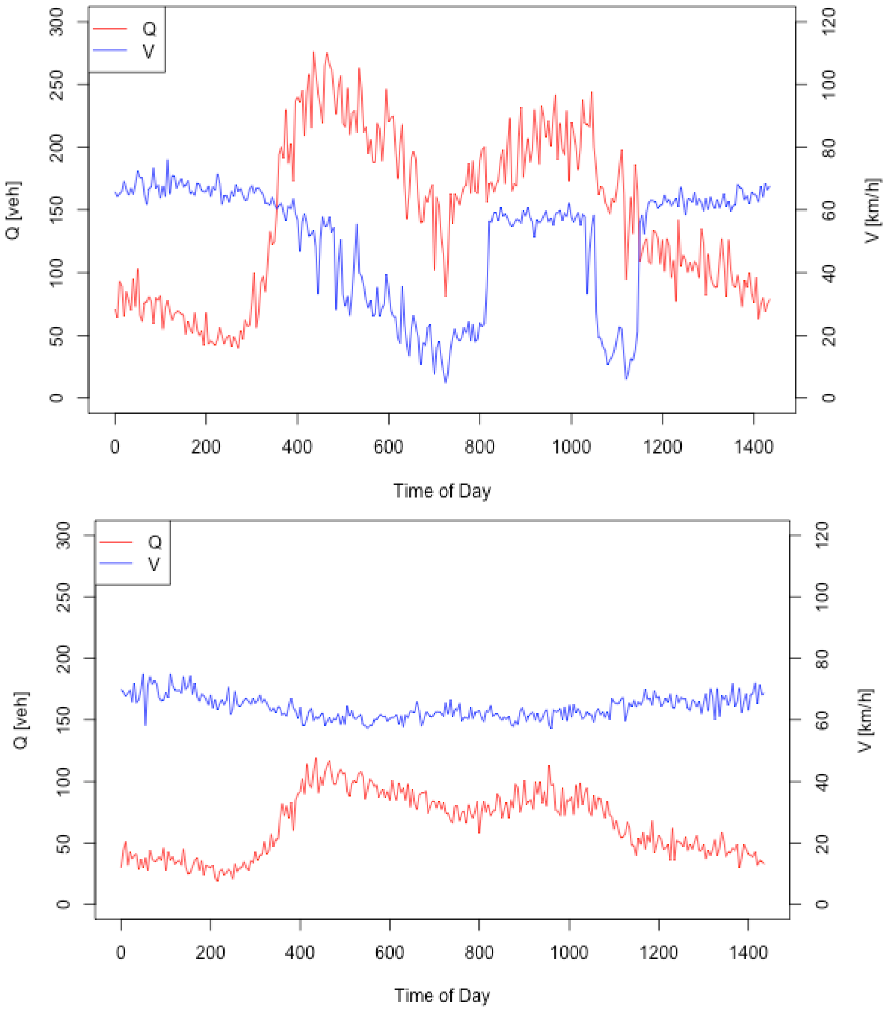

Figure 3. Profile of traffic volume and speed at bottleneck (top) and 3.5km upper section from bottleneck(bottom)

Table 5. Proportion of transport mode for examination

Passenger Car	Small Truck	Large Truck	Bus	Motorcycle
62.4	13.5	20.6	2.36	0.43

Table 6. Distribution of number of passengers for each transport mode

Passenger Car	1	2	3	4 ≦
	50.4	32.7	9.3	7.5
Motorcycle	1	2		
	83	17		
Bus	1	2 to 6	7 to 20	21≦
	5.6	20.7	43.6	30.1
Small Truck	1	2	3	4 ≦
	73.6	18.3	5.1	3
Large Truck	1	2	3	4 ≦
	81.5	13.6	3.1	1.8

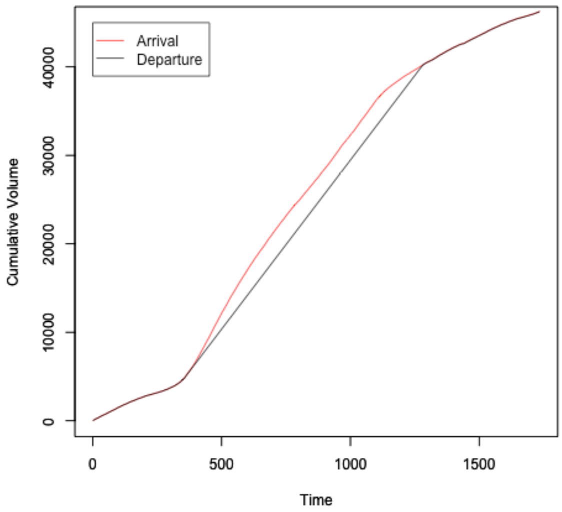

Figure 4. Departure and arrival curves of without HOV lane operation for two lane expressway

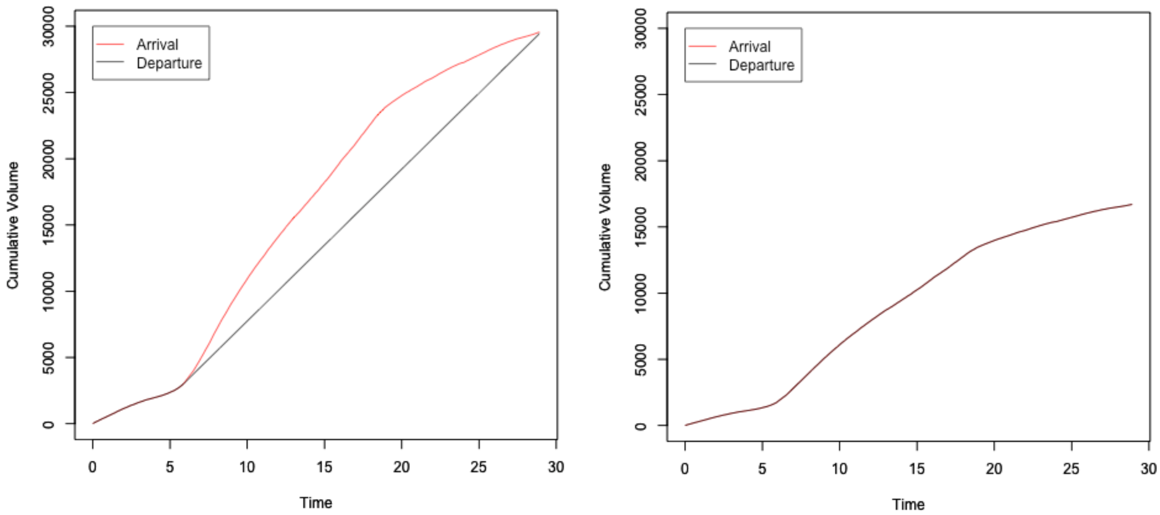

Figure 5. Departure and arrival curves of conventional lane on HOV lane operation (left) and HOV lane (right) for two lane expressway

Based on the results, Figure 6 shows the calculation results of the total delay time based on the number of passing vehicles and passengers. The figure indicated that the total delay time tends to increase from the calculation of both indices. In case HOV lane operation on two lane expressway, therefore, it can keep higher level of services for higher priority vehicles. However it also indicates that the possibility of increasing of delay time for all road users.

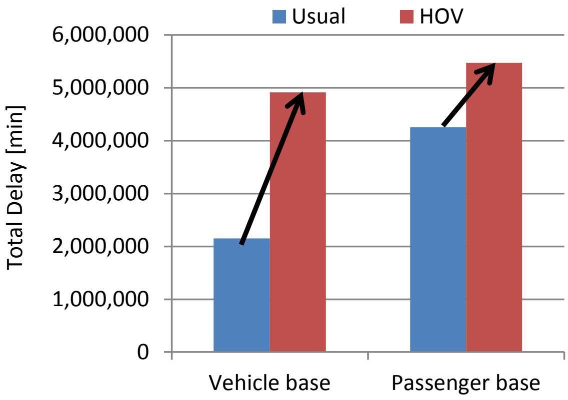

Figure 6. Total delay time based on the number of passing vehicles and passengers for two lane expressway

4.5.2 Delay Time in case three lane expressway

Figure 7 shows the departure and the arrival curve of without HOV lane operation for three lane expressway. Figure 8 shows the departure and the arrival curve but the conventional lane under HOV lane operation and HOV lane. From the figures, traffic jam at conventional lane can be confirmed under HOV lane operation, but the level of the congestion is much smaller than the one under the two lane expressway (above section). In addition to that arrival and departure curve at HOV lane becomes a linear arrangement that means the same amount of traffic demand to traffic capacity is arriving to the bottleneck. Figure 9 shows the examination of delay time based on the above results, and it shows that the total delay time for all passing passengers makes decreasing by operating HOV lane on three lane expressway, although total delay time is increases by introducing HOV lane based on evaluation of delay time by the number of passing vehicles. The number of people who uses HOV lane is higher than conventional lane. Therefore the evaluation of the delay time by introducing traffic control scheme by considering the actual usage of each vehicle should also be employed in addition to conventional way of the evaluation. Otherwise results of this study indicate that it is possible to make misunderstanding of the decision making if always the decision maker follows the conventional way without considering the actual usage of transport systems.

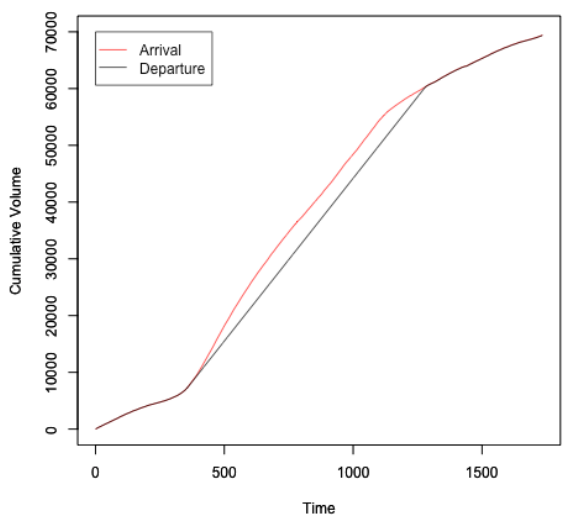

Figure 7. Departure and arrival curve of without HOV lane operation for three lane expressway

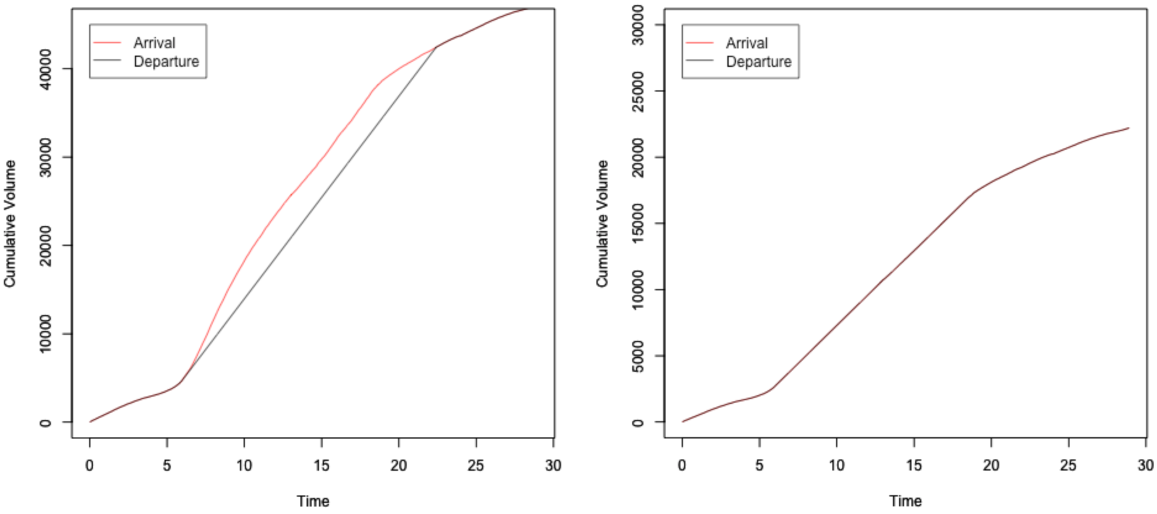

Figure 8. Departure and arrival curves of conventional lane on HOV lane operation (left) and HOV lane (right) for three lane expressway

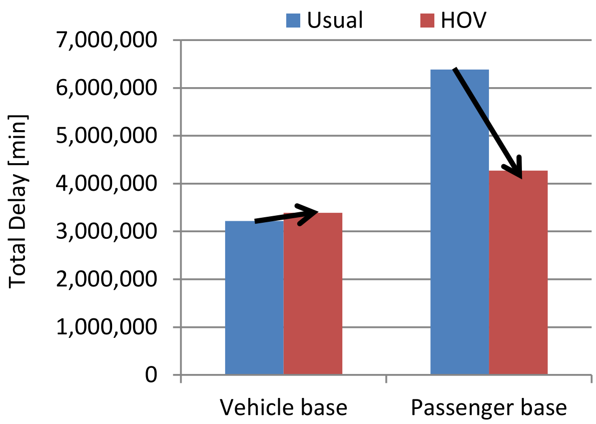

Figure 9. Total delay time based on the number of passing vehicles and passengers for three lane expressway

5. Conclusions

This paper proposed road traffic capacity evaluation concept based on number of passengers in a passing vehicle to consider the actual utilization of each transport modes instead of the conventional way that is the one based on the number of passing passenger cars on the road. In addition to that this paper showed comparison of road traffic capacity by proposed way for each transport mode, and road traffic capacity based on the passenger fall short of capacity of subway, however it can have advantages compared to other transport modes. Moreover, number of passengers on arterial road in Phnom Penh and Bangkok based on measured data was also evaluated. The comparison with Japanese road showed MPIS on the road in Phnom Penh is in a higher capacity than the one of Japanese road. The results indicated the importance of comparison of traffic capacity by integrated evaluation scheme for both of transport modes and road types, especially in the cities in South-Eastern Asian countries where there exist various transport modes on the road. This study showed also the possibility of still having surplus of road capacity to improve the efficiency of number of passing passengers, because the estimated surplus of road capacity based on the number of passengers is still half of the limit of road traffic capacity. To show how the surplus can be utilize to contribute for the road capacity, the difference of total delay time by difference of evaluation scheme of road traffic capacity between number of passing vehicles based and number of passengers was investigated by assuming traffic condition with introducing HOV lane on urban expressway in Japan. The difference indicated the examination of traffic lane control policy from a different point of view according to the purpose of introducing traffic control plan is important, especially when considering the actual utilization for existing transport mode should be considered to discuss about future traffic control policy.

The study recommended evaluating road traffic capacity by using real data of number of passengers to in the study site. Because data of number of passengers used in this paper was employed the representative values from census survey, and it does not include the characteristics of roads in study site and also statistical characteristics. Therefore data collection should be improved. In addition to that by considering the value of load amount is also recommended especially in case proposed concept of traffic capacity into the transport policy evaluation.

REFERENCES

City and Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism (2014): http://www.mlit.go.jp/road/ir/ir-data/data_shu.html, in Japanese

Japan Automobile Manufacturers Association, Inc. (2013) Guidebook of Automobile (2013-2014), Japan Automobile Manufacturers Association, Inc. , in Japanese

Japan Society of Traffic Engineers. (2007) Manual on Traffic Signal Control, Japan Society of Traffic Engineers, Japan, in Japanese

Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (2014): http://www.mlit.go.jp/road/ir/ir-data/data_shu.html, in Japanese

Tokyo Metropolitan Expressway Co. Ltd. (2011) Report of 27th MEX Origin-Destination Survey, Tokyo Metropolitan Expressway Co. Ltd., in Japanese

Tokyo Metropolitan Expressway Co. Ltd. (2010) Report of 26th MEX Origin-Destination Survey, Tokyo Metropolitan Expressway Co. Ltd., in Japanese

Yoshii, T., Shiomi, Y. and Kitamura, R. (2004) Capacity Analysis of Mixed Traffic Flow with Motorcycles, IATSS Review, 29 (3), 22-31., in Japanese

Shiomi, Y. and Nishiuchi, H. (2011) Evaluation of Spatial Motorcycle Segregation at Isolated Signalized Intersections Considering Traffic Flow Conditions， Journal of the Eastern Asia Society for Transportation Studies, 9, 1644-1659.