INTERNATIONAL COMPARISON STUDY ON ROAD TRAFFIC FLOW*

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1. Introduction

The purpose of this research is to find the characteristics which affect traffic flow capacity especially in developing countries and compare these with those characteristics observed in developed countries in order to

(a) help solve various traffic problems,
(b) contribute to the development of highway capacity manuals for developing countries, and
(c) determine which characteristic flow changes with the level of economic development of the country.

The metropolitan capitals of the countries of Japan, South Korea and the Philippines are compared in terms of measured saturation flow rates of intersections. The following characteristics of traffic flow which affect the capacity are compared in this study:

(a) frequency of lane-changing of vehicles,
(b) start-up lost time, and
(c) effect of certain vehicle types such as jeepneys on traffic flow.

2. Intersection Data Collection

Intersections containing at least one exclusive through-traffic flow lane were chosen for the purpose of comparison of straight-through saturation flow rates which is the focus of the study. Traffic flow at these intersections was observed by videotaping. Video footages were taken at selected intersections where there are access facilities such as pedestrian bridges in order to have a clear view of the discharge of vehicles and the traffic signal lights. Video surveys were conducted in the morning and afternoon peak periods of flow (see Table 1) where the flows are saturated (with more than 5 vehicles in queue) but not congested due to the presence of obstructions downstream of the traffic flow.

Table 1 Survey Sites and Periods

Metropolis	Location	No. of Lanes	Time
Tokyo	Route 20	2	1750-1920
	Meiji Ave	1	1630-1820
Seoul	Daebang Rd	1	740-840
	Mia Avenue	2	700-900
Manila	España Ave	2	1540-1710
	Aurora Ave	2	700-900

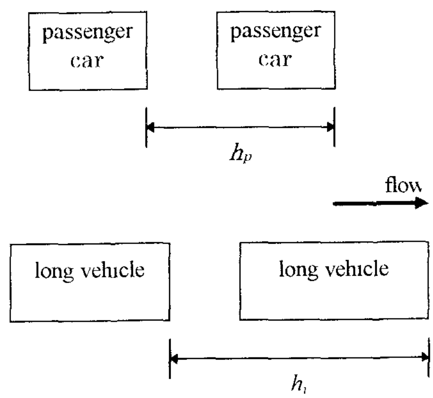

Figure 1: Measurement of headway

3. Calculation of Passenger Car Equivalent Factors

By viewing of video footages, time headways were measured with the aid of the computer. In this study, the leading headway was considered which is the time difference of passing between the front axles of vehicles across the stopline. Based on the measured headway, the passenger car equivalent factors (PCEF's) for various types of vehicles such as jeepneys in Manila and long vehicles such as trucks and buses were estimated based on microscopic approach using the simplified PCE equation obtained from Krammes and Crowley[1]

$$PCEF_i = h_i / h_p$$

where h_i = headway of vehicle type i
h_p = headway of passenger car

The headways are measured as shown in Fig. 1 and are taken from the saturated portion of the green interval

* Keywords: traffic flow, capacity, saturation flow rate
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4. Saturation Flow Rate

In the assessment of performance of signalized intersections, the capacity of an intersection approach is based on a number of variables, namely, the cycle length, allocated green time, and saturation flow rate(defined as the flow rate per lane at which vehicles can pass through a signalized intersection in such a stable moving queue), and can be expressed as

$$Capacity = g/c * s$$

where g = effective green

c = cycle time

s = saturation flow rate

In this study, saturation flow rate is expressed in terms of passenger car units per hour of green per lane so the passenger car equivalents calculated previously are multiplied to the corresponding vehicle types. The saturation flow rate is estimated based on the cumulative graph of vehicles vs time as shown in Fig 2. The slope of the straight line in the saturation period corresponds to the saturation flow rate. It is noted that this paper does not attempt to obtain the basic or ideal saturation flow rate and to provide basis for comparison, the resulting value is the adjusted saturation flow rate, adjusted only to account for traffic composition such as the presence of jeepneys and other heavy vehicles, similar to the computation done in the paper of Teply[12], where it is stated that it is convenient to represent saturation flow in terms of homogeneous entities, suggesting the conversion of all volumes of individual vehicle categories to passenger-car units (pcu). Therefore, as much as possible, the factors which affect saturation flow varying from different urban conditions and various geometric and traffic conditions are minimized in the process of selecting intersections for the study. If other effects are minimized, the values computed for saturation flow therefore include the existing local driver behavior such as lane-changing and the general performance of passenger cars. These factors therefore are that local special characteristics which are present in the traffic flow.

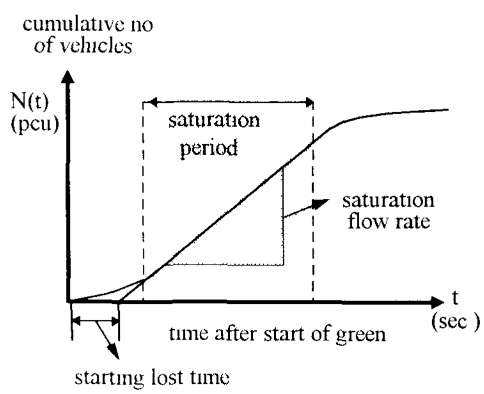

Figure 2: Estimation of the saturation flow rate using the cumulative curve

In order to calculate the basic or ideal saturation flow rate, it is better to choose a road facility which has few jeepney traffic where the effect of geometric and traffic conditions are minimized.

5. Computation of Lost Time

The saturation headway h_s, defined as the mean headway starting from a specific queue position where saturation flow rate is assumed to commence, can be computed from the relation

$$h_s = \frac{3600}{s}$$

The start-up lost time as defined by the US HCM is measured from the start of green up to the time when the saturation flow is observed. It is given by the equation

$$l = \sum_{i=1}^{N} t_i$$

where l total start-up lost time

t_i lost time for the ith vehicle in queue

N number of vehicles that passed the stopline before saturation flow starts

On the other hand, the so-called starting lost time l_s, which is useful in the computation of signal timing, is estimated as the time interval from the start of green up to the extension of the saturation flow line(Fig 2). By performing regression analysis on the saturation flow line, the saturation flow rate and starting loss can be computed. Obviously, the starting lost time is always less than the start-up lost time.

The starting lost time or the start-up lost time greatly affects the effective green g(effective green equals actual green plus portion or whole of amber period less starting lost time, i.e., $g = G + Y - l_s$), and as a consequence, reduces the capacity of the approach.

6. Results of Lost Time

Compared to Tokyo, the start-up lost time for the initial vehicles in Manila is 75% more. In the study of

Tonaki[5], the causes of large start-up lost time were observed from the videos of the intersections surveyed
(a) in general, Manila has inferior vehicle performance compared to the vehicles in Seoul and Tokyo,
(b) vehicles are not in their proper positions inside their lanes,
(c) crossing pedestrians and vehicles of the crossing street after the change of signal from red to green,
(d) public vehicles stopping at the intersection approach, and,
(e) passengers of jeepneys and buses waiting at the outer lanes of the main arterial street

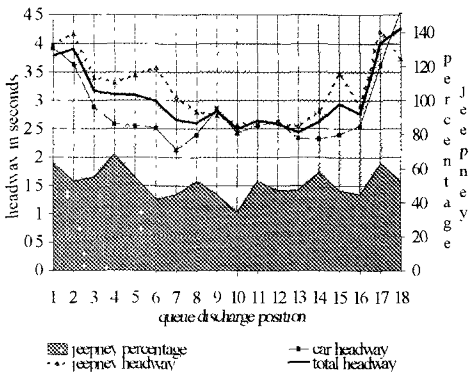

Figure 3: Variation of headway with jeepney traffic

7. Results of Saturation Flow Rate

The measured values for the saturation flow rate are shown in Table 2. It is indicated that the values are significantly higher in Tokyo and Seoul compared to those of values computed in Manila. The reasons for this outcome were mainly due to the following factors observed in Manila

(a) high frequency of lane-changing of vehicles, and,
(b) effect of public vehicles such as jeepneys

Despite the observed frequent lane-changing of drivers of jeepneys which affects the saturation flow rate which would be discussed in Section 9, the values computed would still be saturation flow rates (not basic or ideal) accounting for the behavior of drivers and general vehicle performance in Manila. This may be explained by the result in Fig. 3 that there is no significant correlation between the percentage of jeepneys and the total headway(for all vehicle types) per queue position. Computations yield an r^2 of 0.46 covering from position 3, the start of the saturation period, until the average queue which is position 18. A series of paired t-tests from position 3 to position 18 showed that there is no significant difference between total headway values of successive queue positions indicating the stability of the headway regardless of the relative proportion of jeepneys in the traffic flow. It is stressed here that the high proportion of jeepneys present in the arterial roads of Metro Manila has a negative effect on saturation flow rate not in terms of the stability of headway but in terms of the average headway values maintained by passenger cars and jeepneys which are relatively larger compared to Tokyo (to be discussed in Section 9)

These results indicate the necessity of developing the local highway capacity manual due to the large difference in saturation flow rates. There is an increasing necessity to use values of traffic parameters and variables affecting them which are specific to the location. Earlier in Section 4 in Manila, not only driver behavior but also the vehicle performance affects the saturation flow rate which could be quantified in terms of headway between passenger cars

passenger cars following passenger cars
Metropolitan Manila = 2.20 seconds
Tokyo Metropolitan Area = 1.73 seconds
Seoul City = 1.82 seconds

The preceding results indicate the low vehicle performance even for passenger cars in Manila which is one of the local characteristics of traffic flow which naturally affects capacity and saturation flow rate. This higher headway means lower number of vehicles could flow through the intersection in a given signal green time

8. Lane-changing Observations

In this study, the rate of lane-changing of vehicles is quantified in terms of number of times or frequency per hour of green time per lane over a specified road section approximately 50 meters in the intersection approach, based on the studies of Sigua[4] conducted for the development of the Philippine HCM

It can be noted from Table 2 that in Manila, more than 80% of the frequency was due to the jeepneys. Tonaki[5], in his study, observed from the video data some factors which affect the decision of drivers to change lanes
(a) gap between the average speeds of the vehicles of two adjacent lanes,
(b) difference in magnitudes of the leading headway between adjacent lanes,
(c) length of vehicle queue of each lane at the intersection approach,
(d) patience and attitude of drivers,

Table 2 . Comparison of traffic flow characteristics

Characteristics	Tokyo	Seoul	Manila
straight-through saturation flow rate (pcu/hour/lane)	1950-2150	1900-2100	1450-1800
start-up lost time	12 0	no value*	16 0-19 0
starting loss	0 72	no value*	3 77
PCE values	medium/large truck -- 1 35	bus -- 2 00	jeepney -- 1 44-1 7
lane-changing rate (no /lane/hour)	2 0	1 5	jeepney = 35 0 others = 8 0

* in Seoul. the first vehicle would start to move even before the start of greentime

(e) proportion of public utility vehicles in traffic flow.
(f) existence of a designated lane for public vehicles. and
(g) type of leading vehicle

In Manila. where the observed lane-changing is excessive. the significant factor contributing to this is the behavior of drivers of vehicles specifically those of jeepneys. They are observed to cut through other lanes quite frequently in a not so gradual manner which disrupts the smooth flow of traffic through intersections This flow is characterized by sudden stops and accelerations which decrease the saturation flow at intersections There were observed lane-changing occurrences in Tokyo and Seoul but they were not as significant and when there was. it is done in a gradual manner minimizing disruptions in traffic flow It was further observed in Tokyo that most of the time. the drivers give way to each other even if a vehicle shifts lanes. the other vehicles provide ample headway and adjust gradually to accommodate the vehicle

Therefore. it can be stated there is a problem of behavior of drivers in the streets of Manila

9. Effect of Jeepneys on Traffic Flow

As shown in the graph in Fig 4. the high percentage of jeepney traffic and its grouping at the first position in the queue contributed to the large headway and consequently to the large start-up lost time in Metro Manila This result reaffirms the low acceleration capability of vehicles which are made up mostly by jeepneys traveling along the arterial roads of Metro Manila The relatively high percentage of jeepney traffic compared to the public vehicle traffic observed in Tokyo and Seoul contributed to the lower saturation flow rate in Manila

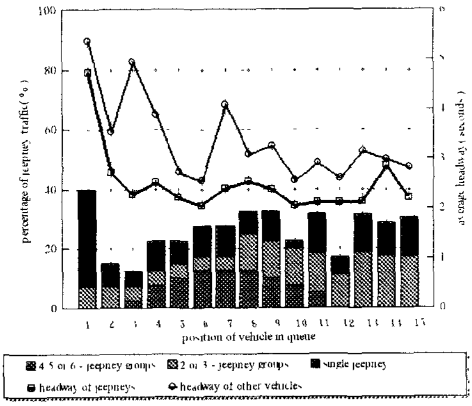

Figure 4: Variation of jeepney traffic, headway and grouping behavior

Another observation is that the average headway of other vehicles fluctuates and relatively is lesser stabilized compared to the headway curve for the jeepneys. as shown in Fig 4 This is due to the leading vehicle factor where other vehicles maintain a slightly longer headway from jeepneys because of their unpredictable movements on the roads caused mainly by observed drivers' behavior Below are the computed average headway values between passenger cars and jeepneys in Manila and passenger cars and trucks in Tokyo

<u>Metropolitan Manila</u>
jeepneys following passenger cars = 3 61 seconds
jeepneys following jeepneys = 2 94 seconds
passenger cars following jeepneys = 2 68 seconds
<u>Tokyo Metropolitan Area</u>
trucks following passenger cars = 2 26 seconds
passenger cars following trucks = 2 08 seconds

It can be said that in the preceding analyses that a relatively high proportion of jeepneys had a reductive effect on the measured saturation flow and capacity of intersections observed in Metro Manila Based on the average headways, this even has a greater effect than the high proportion of trucks in Tokyo

10. Conclusion and Recommendations

The results of this study, based on the analysis of video data, suggest that there is little difference in the characteristics of traffic flow at intersections between Tokyo and Seoul However, when these cities were compared with Manila, there is a significant difference The lower measured saturation flow rates and the higher start-up lost times in the observed intersections in Manila are mainly due to the observed high frequency of lane-changing of vehicles mostly by jeepneys This behavior is attributed to the observed lower performance of jeepneys, poor road traffic behavior of drivers as well as the pedestrians Results have also shown that capacity and saturation flow may not be directly related to the level of economic development of the country The realization that there is a significant difference in the traffic flow characteristics indicate the need to establish a local highway capacity manual which takes into account the some factors which are found in that specific country The results of this study could contribute to the development of the capacity manual in developing countries such as the Philippines Adopting a local manual would make the planning, design and analysis of road networks and signalized intersections more effective and more responsive to the traffic demand

This study introduced characteristics of traffic flow which are already known but usually taken for granted It is recommended that the behavior of lane-changing be studied in more detail for the case of Metro Manila The observation of traffic flow in this study did not include flow on other conditions such as on rainy weather, weekend traffic and off-peak hours More intersections should be surveyed to identify more special characteristics of traffic flow in different cities The change in the traffic flow in the future should be studied in terms of future modal split, general vehicle performance and many other factors considering the economic development of the country These are very important elements which are needed to be included in the development of the highway capacity manual in developing countries

Acknowledgment

The authors would like to thank professors, experts and students in Japan, South Korea and the Philippines for their valuable contribution in this international comparison study Firstly, the authors deeply appreciate the very important and helpful comments of Professor Hiroshi Inoue of Okayama University, and Dr Kuwahara of the University of Tokyo The study was made possible through the coordination with Dr Sigua of the University of the Philippines, Dr Ieda of the University of Tokyo who was then visiting professor of the University of the Philippines, Mr Kwon of the Korea Transport Institute, the Fukuoka City Transportation Office and Mr Seiya Matsuoka of Fukuyama Consultants

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道路の交通流に関する国際比較研究

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本研究の目的は、独自の道路設計方針が確立されていない発展途上国において、その確立のため、道路の交通容量に影響を及ぼす特性を掴むことにある。日本、韓国、フィリピンを対象に、飽和交通流率、発進損失時間、進路変更回数等を計測したところ、飽和交通流率は東京とソウルとの間で差異は認められなかった。また、発進損失時間はマニラにおいて東京より大きい値が得られている。以上の結果から、道路設計方針を確立する際、このような差異を考慮する必要性が示唆されている。

International Comparison Study on Road Traffic Flow

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The purpose of this research is to find the characteristics which affect traffic flow capacity especially in developing countries and compare with the developed countries in order to solve traffic problems and contribute to the development of highway capacity manuals for developing countries such as the Philippines The countries compared for this study are Japan, South Korea and the Philippines The saturation flow rate, starting lost and start-up lost time, lane-changing and passenger car equivalents of certain vehicles are calculated for each country The saturation flow rates of Tokyo and Seoul did not differ significantly while the rate for Manila was considerably lower The start-up lost time and starting lost time were also determined to be higher in Manila than in Tokyo These differences indicate the need to develop a highway capacity manual which takes into account the characteristics of traffic flow in order to effectively analyze and design intersections and roads in developing countries