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INTERNATIONAL COMPARISON STUDY ON ROAD TRAFFIC FLOW*

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1. Introduction

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

(a) assist in the solution of various traffic problems,

(b) contribute to the development of highway capacity manuals for developing countries, and

(c) determine which characteristic of traffic flow changes with the level of economic development of the country.

The capital cities of the countries of Japan, South Korea and the Philippines are compared in terms of saturation flow rate through intersections on arterial roads. The following characteristics of traffic flow which affect the saturation flow rate and intersection capacity in the three capital cities are compared in the 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.

The bus traffic flow in the three capital cities and Fukuoka City in Japan is also compared in this study.

2. Intersection Flow

All the roads containing the intersections chosen for this purpose are classified as arterial roads originating from the capital city center or heart of the metropolis and traversing outward to the outlying suburban areas of each country of study. The method of video survey is preferred because it would need lesser number of surveyors and lesser time and money at the same time preserving the important events on tape. The research relied mainly on video data. Video footage was taken on selected intersections in Tokyo, Seoul and Manila as illustrated in Figure 1 in the morning and afternoon peak hours of flow.

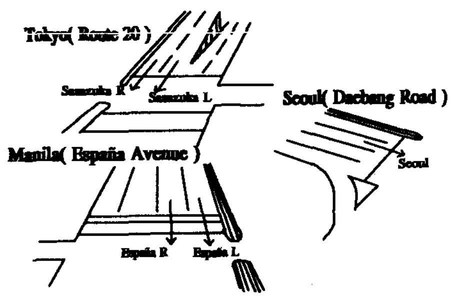

Figure 1: Intersection flow survey areas

(1) Determination of Passenger Car Equivalent Factors

The research employed the method of weighted average determined by proportions of various vehicle types and these traffic composition adjustment factors were applied to the average headway values corresponding to each position in queue. The adjustment factor for passenger cars is therefore equal to 1.0 and the adjustment factors for other vehicles are the passenger car equivalents(PCE).

(2) Adjustment of Average Headway

The PCE factor computed in the preceding section is then used to adjust the average headway corresponding to each position in queue. The revised computation is similar to the weighted average computation with the adjustment factor acting as the weight of a vehicle category multiplied to the number of vehicles of this category. They are then totalled and divided by the total number of vehicles surveyed for every position. These calculations result to the adjusted average headway values shown in the graph of Figure 2.

In Manila, the headway of the first vehicle is the highest in contrast to the headway graphs in Tokyo and Seoul wherein the second vehicle had the maximum headway. For the cases of Tokyo and Seoul, the shape of

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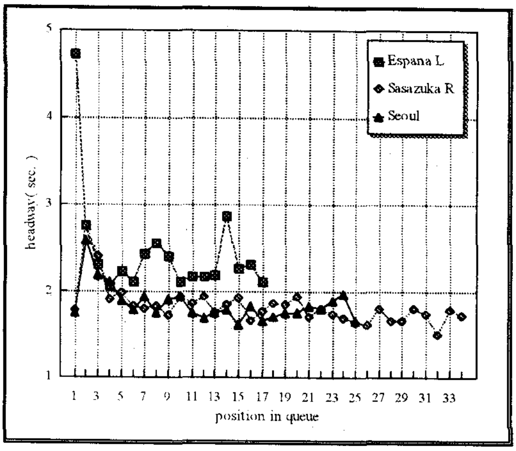

Figure 2: Variation of average headway with the position in queue

the graph follows the theoretical headway curve wherein the criterion for discharge used is stopline and front bumper. However, viewing the España(Manila) graph, they differ from the established relationship. It can also be noticed that the headway values at the last positions in queue are low, which are supposed to be higher since these positions are usually vehicles joining the initial queue at a later portion of the discharge, thus at larger headway. The primary reason for these differences was that the large start-up lost time due to traffic obstructions in the Manila intersection at the start of green enables the vehicles upstream to join the movement of the initial queue through the intersection. The paper of Teply and Jones[1] confirms the difference in shape of the Manila headway graph and stated that such patterns, where the highest value of headway is on the first position in queue, were observed in intersections with high degrees of red signal violations and therefore, high start-up lost time, which would be discussed in detail in Section (6).

(3) Determination of Saturation Headway

The saturation headway is computed as the mean of the average headway starting from a specific queue position, determined from the graph of the time difference between consecutive vehicles against the queue position. This specific position is chosen as starting position for stabilization of headway, that is the start of saturation period, when the time difference of headway between two positions become very small or when the headway stabilizes. From the graphs of adjusted average headway due to traffic composition, the saturation headway is derived.

2.4 Comparison of Saturation Flow Rates

The saturation flow rates of the five sample sets from the cities are computed in this section based on the determination of the saturation headway. Equation 1-6 of the US HCM[2] was used for this purpose. In the assessment of signalized intersections, the capacity of an intersection is derived from the saturation flow rate. The comparison of saturation flow rate values are shown in Table 1. It shows significantly higher saturation flow rates for Tokyo and Seoul compared to the rate of Manila. Compared to that of Tokyo, the values in Manila are about 20-25 % less. These results indicate the necessity of a local highway capacity manual due to the large difference in saturation flow rates and more important, this traffic flow parameter is mainly used in the planning and design of roads, the number of lanes to be allotted for a road and therefore, the capacity. The reasons for this outcome are mainly due to the following factors:

(a) high frequency of lane-changing of vehicles in Manila,
(b) large start-up lost time in Manila, and
(c) effect of public vehicles such as the jeepneys.

(5) Lane-Changing

In this study, the rate of lane-changing behavior of vehicles is quantified in terms of the number of times or frequency per hour of green time per lane over a specified road section of approximately 50 meters in the intersection approach, based on the studies of Sigua[3] in the study conducted for the Philippine HCM.

It could be noted from Table 1 that in Manila, more than 80% of the frequency accounted for the jeepneys. Tonaki[4] observed from the video several factors that affect the decision of drivers to change lanes :

(a) gap between the average speeds of the vehicles of the 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,
(e) proportion of public utility vehicles in traffic flow,
(f) existence of a designated lane for public vehicles, and
(g) type of the leading vehicle.

In Manila where the observed lane-changing was excessive, the significant factor contributing to this is the patience and attitude of drivers specially that of jeepneys. They were observed cut through other lanes very frequently in a not so gradual manner thereby disrupting the smooth flow of traffic. This flow is characterized by sudden stops and accelerations which decrease the saturation flow and capacity of intersections. There were observed lane-changing occurrences in Tokyo but they are very few and done on a gradual manner minimizing the disruptions in traffic flow. It was observed in Tokyo that the drivers give way to each other even if a vehicle shifts lane, the other vehicles provide ample headway and adjust in order to accommodate that car. It could be stated here that the attitude of drivers are better than that of Manila.

(6) Start-up Lost Time

Comparing to Tokyo, the start-up lost time in Manila is 75% more. In the plot below, a consistent trend could be seen where the start-up lost times for the initial vehicles discharging through the intersection in the outer and inner lanes of España Avenue are greater than those of Tokyo and Seoul. In between Tokyo and Seoul, it was surprising to note that after a same initial value, the plots deviate that resulted to a little higher start-up lost times for the two lanes Route 20 in Tokyo than the lane of Daebang Road observed in Seoul.

In the research of Tonaki[4], he found out the causes of large value of start-up lost time in Manila based on the analysis of video data:

(a) in general, Manila has inferior vehicle performance to that of the vehicles in Tokyo and Seoul,
(b) vehicles not in their proper positions inside lane,
(c) crossing pedestrians and vehicles of the intersecting 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 lane of the road.

(7) Effect of Jeepneys on Traffic Flow

From the graph in Figure 3, the high percentage of jeepney traffic and its grouping at the first position in queue contributed to the large headway and consequently to the large start-up lost time in Manila. This result reaffirms the low acceleration capability of vehicles which are composed of mostly jeepneys in the arterial roads of Manila. The relatively high percentage of jeepney traffic compared to the public vehicle traffic in the lanes observed in Tokyo and Seoul contributed to the lowering of the saturation flow rate as a result of frequent lane-changing mostly done by jeepney drivers as explained earlier. Another thing is that the average headway of other vehicles fluctuates and is not stabilized relative to the curve for the jeepneys. This is due to the leading vehicle factor where other vehicles keep distance from jeepneys because of its unpredictable movements caused mainly by the drivers' behavior. It can be said based in the preceding analyses that the relatively high proportion of jeepneys in the traffic flow has a

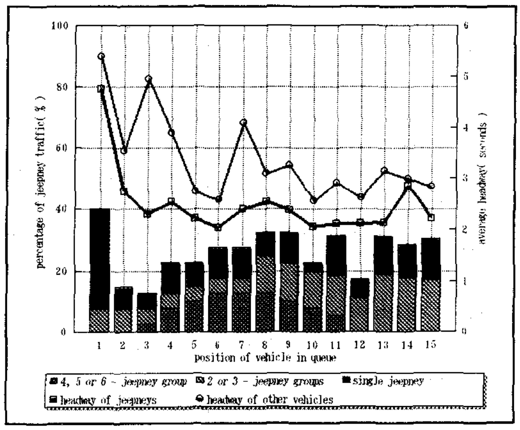

Figure 3: Variation of jeepney traffic, headway and grouping behavior

reductive effect on the saturation flow rate and the capacity of an intersection.

3. Comparison of Bus Flow

The numbers of buses passing a reference point at five-minute time intervals for Kawasaki are higher than in Fukuoka. Comparing the flow of buses in the two Japanese cities and that of Seoul, results(Table 1) show that the values in Seoul are greater. The major reason is that bus is still the major mode of urban transportation in Seoul and its railway network is still in the process of developing. In Japan, the network for rail is already in place so commuters have alternatives.

Results of bus flows in Table 1 show the highest flow rates in EDSA Avenue in Metropolitan Manila in comparison to the cities in Japan and in Seoul. Most of the buses are plying this road. The rail-based mass transportation system network is still at the initial stage. Furthermore, there is only one LRT line operating inside Metropolitan Manila and the old intercity commuter lines of the Philippine National Railways(PNR).

4. Conclusion

Based on the results of this study from video data analysis, there was little difference in the values of the characteristics of traffic flow between Tokyo and Seoul. However, comparing these two cities with Manila, there was significant difference. The lower saturation flow rates and the higher values of start-up lost time and time for flow stabilization in Manila are mainly due to the observed high frequency of lane-changing done mostly by jeepney drivers. These problems are due to the observed lower performance of vehicles, specially the jeepneys, and the observed poor road traffic behavior of motorists. Results also have shown that the capacity and saturation flow are not related to the level of economic development of the country. The realization that there are significant differences in traffic flow characteristics indicates the need for the establishment of a local highway capacity manual which takes into account the characteristics of traffic flow specific to that country. The results of this study could contribute in the current development of the capacity manual specially to developing countries such as the Philippines. These local manuals would make the planning and design of roads and road networks more effective and responsive to the traffic demand. The high volume of buses and the future modal split should be considered also in the development of the capacity manual since buses reduce the road capacity especially in the vicinity of bus stops. This study introduced many characteristics of traffic flow which are already known but usually taken for granted. It is recommended that the phenomenon of lane-changing which is very high in Metropolitan Manila must be studied in more detail. The observation conducted in this study was limited which did not include traffic flow on other days of the week, on rainy weather and on off-peak hours. More intersections should be surveyed to identify more special characteristics and behavior of traffic in the different cities. The change in traffic flow in the future should be studied in terms of future modal split, general vehicle performance and many others considering the economic development of the country. These are very important elements which are needed to be incorporated in the development of the local highway capacity manual.

Table 1: Comparison of traffic flow characteristics

Characteristics	Tokyo	Seoul	Manila
saturation flow rate(pcu/hour-green/lane)	1950 - 2150	1900 - 2200	1450 - 1700
start-up lost time	4.0 sec.	3.5 sec.	7.0 sec.
time for flow stabilization	12.0 sec.	11.0 sec.	16.0 - 19.0 sec.
P.C.E. for certain types of vehicles	large/medium vehicles = 1.35	———	jeepneys = 1.7
frequency of lane-changing	2.0/lane/hr.	1.5/lane/hr.	jeepneys = 35/lane/hr. others = 8.0/lane/hr.
peak bus flow (buses/hr.)	Kawasaki = 144 Fukuoka = 144	264	576

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