35. ANALYSIS OF INTERSECTION'S TRAFFIC FLOW CONSIDERING INTERACTION BETWEEN PEDESTRIANS AND VEHICLES FLOW USING MICROSIMULATION MODEL

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I. INTRODUCTION

Traffic simulation has increasingly become popular to both practitioners and researchers. This is largely due to its ability to illustrate in graphical form the traffic condition as well as its effectiveness for quantifying benefits and limitations of the different possible alternatives.

The study selected the intersection of Etchujima-Kiyosumi roads as study area. This intersection is walking path of commuters of Etchujima JR Keio line train station, residents of nearby condominiums, as well as most staff and students of Tokyo University of Mercantile Marine. It is supported by elevated pedestrian refuge making the roads convenient for motorists. Elevated pedestrian system is very common in the streets of Tokyo as response to high number of accidents involving pedestrians from early 1950's up to early 1970's due to lack of traffic safety infrastructure and the rapid growth of private motor vehicle ownership. Although the elevated pedestrian system brings considerable benefits to the road traffics and the pedestrians, aged and handicapped persons are observed to be inconvenient. Moreover, bicycle users have to find nearest other pedestrian refuge to cross since it would be difficult for them to carry their transport equipment. In general, the present design of the elevated pedestrian system is perceived not suitable if serving all clusters of pedestrian users is to be valued.

II. STUDY OBJECTIVES AND ANALYSIS APPROACH

There have been considerable numbers of studies analyzing traffic flow and road capacity using simulation; however, it is uncommon to include pedestrians' flow which affects the vehicles flow as general. Tanaka et al [(1)] analyzed traffic flow and road capacity using tiss-net at the intersection without pedestrian flow while Kawasima et al [(2)] focuses on observing the level of SPM and NO_x using VISSIM microsimulation model.

This paper will analyze the characters of traffic flow of the intersection at its current traffic condition which is aided by elevated pedestrian infrastructure as its first objective. Its second objective is to evaluate what type of pedestrian system is perceived suitable between elevated and non-elevated. In order to meet these two objectives, several cases and scenarios were tested such as taking into account the: a) present situation, b) adding non-elevated pedestrian lane without changing the traffic signals setting, and c) optimize the traffic signals. Further test were done by increasing the volume of vehicles by 10 and 20 percent which could be seen as most likely to happen given the rapid growth of vehicle ownership. These different cases and scenarios were tested to evaluate the changes to the traffic characters such as travel time and delay (Table 1). Having many cases and scenarios allowed to ensure the stability of the output of simulation thus leading to good recommendations.

Table 1. Cases and traffic volumes for traffic simulation

Scenario/Case	Case 1 (present volume)	Case 2 (10% increase)	Case 3 (20% increase)
Present situation	2775	3052	3330
With added pedestrian lane	2775	3052	3330
Optimization of traffic light	2775	3052	3330

Survey

The survey using video and digital camera for the intersection of Etchujima-Kiyosumi roads was conducted on 3 April 2002. A total of 4 hours and 30 minutes was recorded with the break down of 1 hour in the morning, 1 hour and 30 minutes noon time and 2 hours in the afternoon. The recorded video was then aggregated to 30 minutes so to have more flexible combinations of time. Table 2 shows the summary of peak hours for each time period of the day. A comparison among the peak hours suggested that the afternoon peak

Table 2. Number of observed vehicle, pedestrian, bicycle

Time of the day	Actual time	Vehicle	Pedestrian	Bicycle
Morning	08:30~09:30	2680	285	150
Noon	12:00~01:00	2175	230	108
Afternoon	05:00~06:00	2775	285	194

hour has more numbers of vehicle and bicycle while there are equal numbers of pedestrian during the morning and the afternoon. The detail analysis of the study utilized the afternoon peak hour for the above reason.

VISSIM Modeling Process

VISSIM 3.5 was used as tool for analysis which provides good presentation regarding the effects of pedestrians into the traffic flow. It has an excellent modeling capability and graphic presentation. It is a microscopic, time step and behavior based simulation model developed to analyze the full range of functionality classified roadways and public transport operations. It is one of the newest micro simulation models distributed by PTV Planung Transport Verkehr AG in Germany.

The first step in modeling VISSIM is to import aerial photo or schematic drawing of the study area into simulator. Next is by building the networks and applying its attributes (i.e., lane widths, speed zones, priority rules, etc). Links are generally straight or follow the curvature of the road. Connectors, which are used to connect links, are typically used to model turning areas and lane expansion and contractions.

III. TRAFFIC SIMULATION MODEL CALIBRATION

The vehicle directions and pedestrian routes are illustrated in Figure 1 while Figure 2 depicted the proposed non elevated pedestrian lane. The non elevated pedestrian lane, a 3-meter wide, will serve the pedestrians of direction 1 and 2. As for pedestrians coming from direction 3 and 4, they can use the existing non elevated pedestrian lane which is estimated to be 40 to 50 meters away from the intersection (not shown in the Figures).

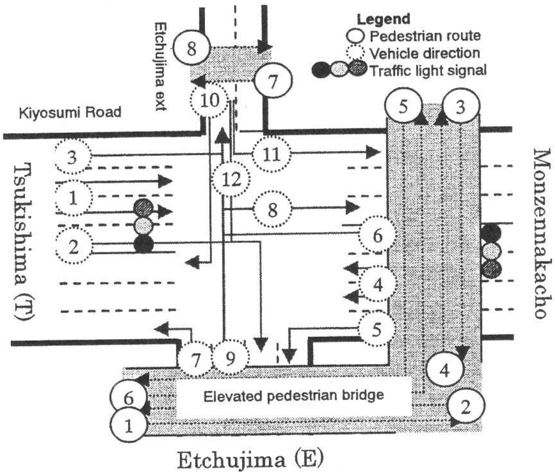

Figure 1. Etchujima-Kiyosumi intersection showing traffic directions and the elevated pedestrian routes

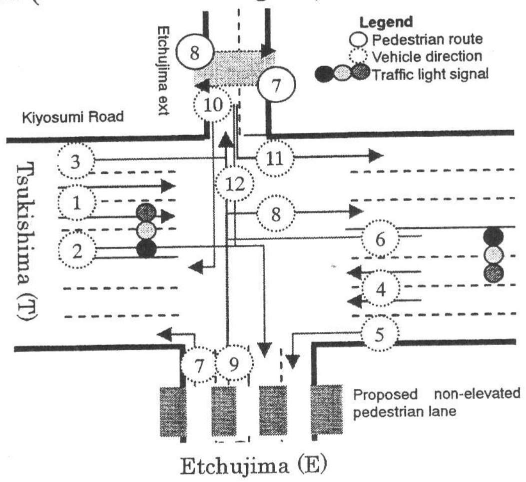

Figure 2. Etchujima-Kiyosumi intersection showing the proposed pedestrian lane

Table 3. Number of vehicles per road direction(afternoon peak)

Code	Road Name	Actual count	10% increase	20% increase
E->M	Etchujima to Monzennakacho	292	321	350
T->E	Tsuksihima to Etchujima	324	356	389
T->M	Tsukishima to Monzennakacho	924	1016	1109
M->T	Monzennakacho to Tsukishima	700	770	840
M->E	Monzennakacho to Etchujima	275	303	330
E->T	Etchujima to Tsukishima	245	270	294
	Total Vehicles	2760	3036	3312

The different road directions will be represented by their respective codes shown in Table 3 for the succeeding discussions. The values of 10 and 20 percent increases to the vehicle numbers are shown in Table 3. These 3 different total numbers of vehicles were used for the simulation representing different scenarios to observe the changes to the traffic speed and delay. Most of the vehicles, as presented in Figure 3, are composed of car, followed by truck, and bus. The distributions of vehicle numbers into the different roads meeting at the intersection are also presented in Table 3. It can be observed that road direction T to M has the highest volume followed by road direction M to T. These two directions having high numbers are both through traffic. Vehicles coming and going to Etchujima extension, which counted for 15, were considered into the simulation for exact representation of the intersection; however, its results were not shown in this research for brevity and convenience.

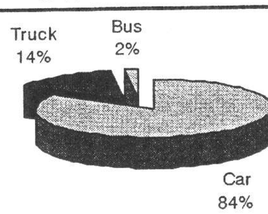

Figure 3. Traffic composition

IV. TRAFFIC SIMULATION MODEL VALIDATION AND RESULTS

The comparison between the actual count and simulated count is shown on Figure 4. The actual count recorded 2,775 vehicles for one hour while the VISSIM simulation program utilizes 2,630 for the same span of time. The actual count was graphed relative to the simulated count to check their relationship. The pedestrian lane was assigned to handle 354 for both directions with 50 percent share of pedestrian and 50 percent share of bicycle. This number was based on the highest actual pedestrian observed from direction 8 and 9 (Figure 1).

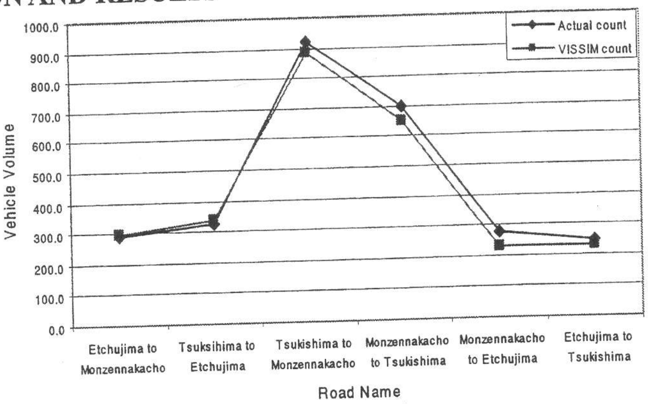

Figure 4. Actual count vs VISSIM count

Assessment of Traffic Signals and Possible Provision of Non-elevated Pedestrian Lane

The travel time of vehicles crossing the intersection was assessed using 100 meters section defined in the VISSIM network. The result of simulation shows that providing pedestrian lane without modifying the traffic lights would prolong the travel time of vehicles to direction E to T. To maintain the present of traffic flow while serving the pedestrian's interest, there is a need to modify the traffic signals settings. First modification to be made is to add 10 seconds to the green light to the road direction T to E resulting to 31 seconds for the first phase of green signal while retaining the second green signal which is 47 seconds (Figure 5). Second modification is to align the signal lights of road direction M to E to the signal lights of road direction E to T to avoid conflict between the pedestrians crossing and vehicles. These adjustments to the traffic signals setting would almost retain the present traffic flow. The 2 seconds red signal present to all the traffic signals allowed all motorists to stop for safety measure before another signal will be given. The observed amber time is 3 seconds.

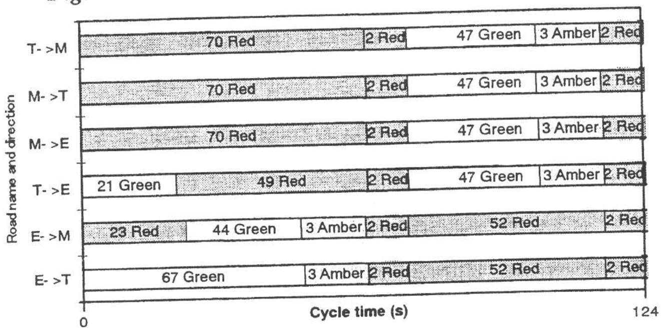

Figure 5. Traffic signals setting

Impact of Increasing Traffic Volume and Modifying the Traffic Signals Setting to Vehicles' Average Travel time and Delay

The case 1 (Figure 6) shows the impact of putting non elevated pedestrian lane to the traffic flow taking into account the present volume of vehicles. The highly affected traffic direction is T to E. Prior to the provision of pedestrian lane, the average travel time is at 36.5 seconds, and then moved to 38.5 seconds before reduced to 29.7 seconds as a result of traffic signals modifications. Other road directions show no changes to its average travel time indicating that its flow were not affected by the changes made to the settings of traffic signals and to the provision of non elevated pedestrian lane.

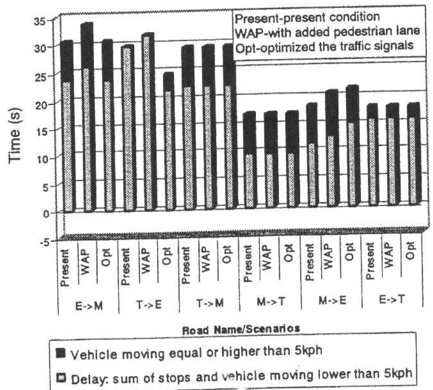

Figure 6. Case 1 travel time and delay

Increasing the volume of vehicles into the network is one way of testing the stability of policies running in place. The present volume of vehicles stands at 2775 then increased by 10 and 20 percent resulting to 3036 and 3312 respectively. Figure 7 (case 2) shows the effect of 10 percent increase to the average travel time and delay. Noticeable effect is the increase of average travel time of direction T to E and M to E. Vehicles from other directions almost kept their previous average travel time and delay. In case 3 (Figure 8), the network is handling 3312 number of vehicles heading to different directions. The capacity of road direction T to E was overwhelmed and congestion was observed resulting to high number of average travel time and delay. Without the pedestrian lane, the average travel time is recorded at 42.3, then increased to 43.7 after the presence of the pedestrian lane, and then lowered down to 38.6 after the optimization to the traffic signals. Taking another look

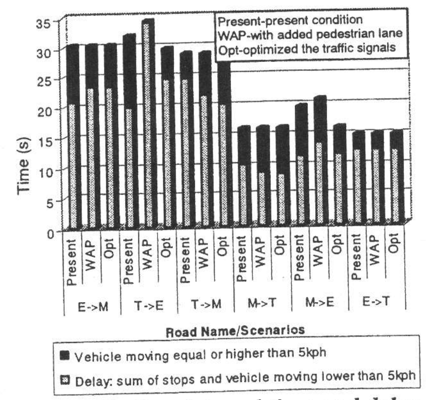

Figure 7. Case 2 travel time and delay

into Figure 8 suggested that that despite the method employed to reduce the average travel time of direction T to E, their average speed is still relatively high compared to other directions, i.e., 30.6 seconds for E to M, 28.1 seconds for T to M, 15.5 seconds for M to T, 18.4 seconds for M to E seconds and 23.9 seconds for E to T.

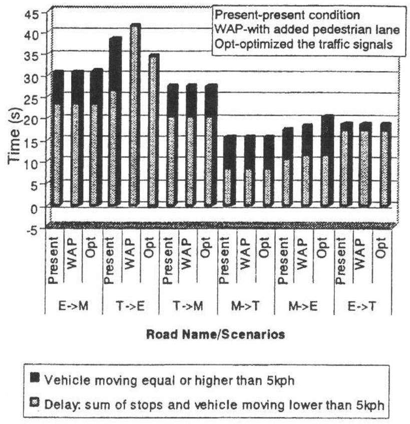

Figure 8. Case 3 travel time and delay

The total one hour travel times for all vehicles per direction using the present volume, i.e. 2775 vehicles, was calculated as shown in Figure 9. Direction T to M has the highest time mainly due to its high number of vehicles. The directions affected by the non elevated pedestrian lane shows reduction of total time as results of traffic signals modifications. To illustrate, the total travel times of direction T to E before the provision of pedestrian lane is 1022 seconds, increased to 10772 seconds, and reduced to 5111 seconds after the modifications of traffic signals. Figure 10 shows the average travel time of vehicles which includes delay and vehicle in motion. In this study, delay is defined as the total waiting time plus vehicle time while its speed is lower than 5 kph. The average travel time of the vehicles are mostly composed of delay while only small amount of time where the vehicles have the chance to speed up to 5 kph or higher.

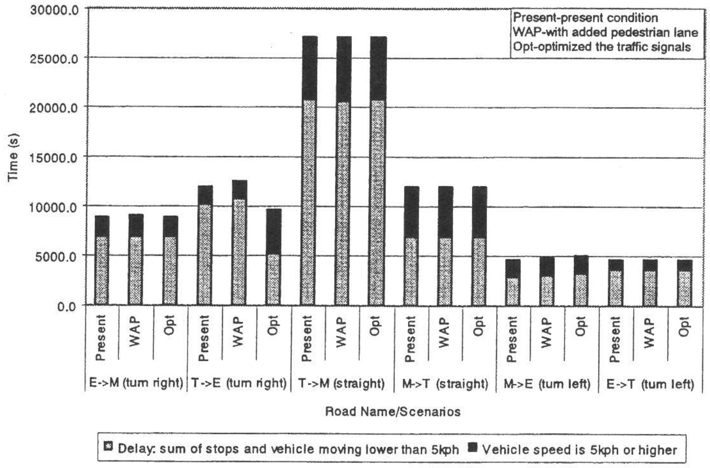

Figure 9. Total travel time of all vehicles per

V. SUMMARY

The research was able to shed light on the issue of weather providing non elevated pedestrian lane as alternative to the existing elevated pedestrian system would be possible without disrupting the traffic flow. Different scenarios and cases were evaluated as part of efforts to come up better understanding and precise suggestions to the issue. Taking into account the present volume of vehicles and or the 10 percent increase, the results shows encouraging factors for provision of the non elevated pedestrian lane provided modifications to the traffic signals will be made. The average travel time and delay of vehicles from different directions have great chance to remain prior to the provision of the said pedestrian lane. However, if the volume of vehicles will increase as much as 20 percent or higher, keeping the present design of pedestrian infrastructure as support for the intersection is perceived to be more appropriate since such increase will cause longer travel time to some road directions particularly the direction of T to E.

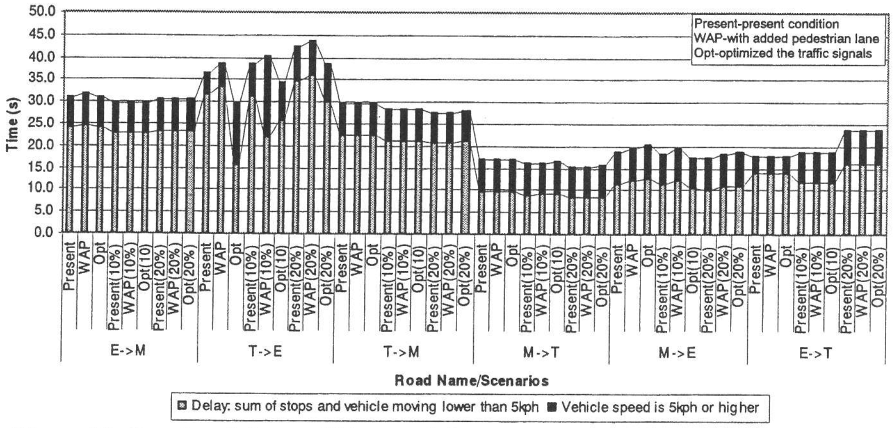

Figure 10. Speed variations within travel time

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