COMPREHENSIVE TRANSPORTATION POLICY DEVELOPMENT USING TRAFFIC SIMULATION TECHNIQUE FOR KHON KAEN CITY, THAILAND

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Abstract: This study discussed the possibility to develop the comprehensive transportation policies using traffic simulation technique for Khon Kaen City, Thailand. The development approach mainly consists of the data collection, the traffic simulation model development and the model application. The estimated demand data and surveyed traffic information were applied to develop and validate the traffic simulation model for Khon Kaen City network through PARAMICS. The developed model was applied to evaluate the local transportation policies to address the traffic congestion in the study area. The results of policies evaluation revealed that the construction of overpass or underpass along Friendship Highway at Sam Liam intersection, or construction of new road connecting between Friendship Highway and Darunsamran Rd. at train station roundabout could improve the entire system traffic performance in term of increasing average speed. In conclusion, the proposed approach is very effective and practical to develop the comprehensive local transportation policies for Khon Kaen City.

Key Words: Trip O-D matrix, Traffic Simulation Technique, Local Transportation Policy

1. INTRODUCTION

So far transportation policies used to evaluate with the future transport demand estimated using the four steps estimation technique with person trip data. However, this technique tends to look at overall results and sometime is not flexible enough for the detail analysis. At middle sized city like Khon Kaen City, Thailand, many of transportation policies concern not only with huge scale road development projects but also with local improvements of road facilities and/or traffic control systems so that it is difficult to evaluate those policies with the four steps estimation technique only. Traffic simulation technique had to be used instead to evaluate effectively the local transportation policies, even it has ability only limited area. Recently, many developed traffic simulation models have a capability for applying to the urban scale network. Nonetheless, the processing traffic simulation models require the detailed input data, which need the long time expense and a large amount of money for collecting such that input data. As the example problem of lack of data, the transportation planners at many provincial areas in Thailand, such as Khon Kaen City have a limited ability to make the local transportation planning due to a lack of budget to collect the traffic information. Therefore, the final selected solution sometimes may not be the optimal solution and could not solve the existing transportation problems. One interesting solution is provided the input data from the estimated trip O-D matrix resulted from Four Steps Estimation Technique, which usually is available in the transportation master plan studies of many provincial areas. Therefore, this study attempted to conduct the feasibility study of development of comprehensive transportation policies from estimated trip O-D matrix by using traffic simulation technique at Khon Kaen City.

According to progress of computer technological development, there have been many attempts to apply the traffic simulation to large scale urban network and developed the transportation policies for them (Roland Trapp (2002), Vovsha et al. (2002), Yun et al. (2003) and Regidor et al. (2003)). On those studies, the preparation of input data in consistency with the person trip data and other information to set up the parameters and justify the model has been one of important issues. Since almost of them developed the transportation policies from the available or collected traffic volume from entire network, which usually is not provided for such the provinces in developing country due to budget constraint, this issue should be discussed in this study.

2. STUDY OBJECTIVES

The objectives of this paper are as listed as follows.

- To propose the approach to develop the comprehensive transportation policies by using the traffic simulation technique.
- To conduct the feasibility study of proposed approach to develop the local transportation policies of Khon Kaen City, Thailand.
- To evaluate the local transportation polices to address the traffic congestion in the Khon Kaen City network.

3. TRANSPORTATION PLANNING IN KHON KAEN CITY

3.1 Existing Situation of Transportation Problems

Khon Kaen City locates in the Northeast part of Thailand with about 400 kilometers far from Bangkok. The Khon Kaen City network could be separated into two areas; 1) the grid network in CBD, 2) the network in sub-urban area. The entire network of Khon Kaen City is illustrated in Figure 1. Currently, Khon Kaen City encounters the critical traffic congestion. The traffic flows at many locations within CBD are saturated or oversaturated conditions as shown in Figure 2 (OTP and KKU, 2003). The most critical intersection is the Sam Liam intersection, the largest and major key intersection in the network. Its location is shown in Figure 3(A). The traffic delay at this location illustrates F level of service in all approaches during the rush hour. It can be noticed how critical congestion at this location from the Figure 3(B).



Figure 1. Entire Network of Khon Kaen City



Figure 2. Degree of Saturation along Road Network of Khon Kaen city



Figure 3. Sam Liam Intersection Location and Its Critical Traffic Congestion

For the road sections in CBD, the traffic flows along several main roads such as are oversaturated condition during morning peak hour. One of most congested road sections is the Prachasamosorn road, especially the section in front of the provincial bus station, at where the Song Thaews always stop to load/unload passengers at in front of the bus station. The queues of Song Thaews sometimes occupy more than one lane; it results to interrupt the flow of other traffics as shown in Figure 4.



Figure 4. Song Thaew Queue in front of Khon Kaen Bus Station

3.2 Considered Local Transportation Policies

As the previous mentioned critical congestions at several locations along the network, the Khon Kaen provincial government has therefore attempted to address these problems. To improve the traffic congestion along the network within the short-term periods, the various local transportation policies have been proposed by several provincial governmental authorities and private companies. For example; 1) the constructions overpass or underpass proposed by Khon Kaen University, KKU, 2) the construction new road planned by OTP and KKU (2003), 3) the establishment of no parking zone planned by OTP and KKU (2003). The overviews of those policies are described briefly as followings;

- P1: Construction of overpass along Friendship Highway; the overpass has been decided to be constructed along Friendship Highway (i.e. from North to South) to cross the Sam Liam intersection. Its geometric layout is two-way and two lanes per direction as shown in Figure 5(A). In addition, the phase signalization at Sam Liam intersection also has been decided to change to the appropriate traffic signal control stage. The objective of this proposed project was to decrease delay at most severe congested intersection. Especially, north-south traffics could pass through this intersection without delay.
- P2: Construction of overpass along Prachasamosorn Rd.; the overpass has been proposed to be constructed along Prachasamosorn Rd. (i.e. from East to West) to cross Sam Liam intersection. Its geometric layout is two-way and one lane per direction. Moreover, the phase signalization has been decided to give the proper signal phases. This policy was proposed to alleviate delay at the most severe congested intersection, especially, delay of traffics approach from East and West.
- **P3: Construction of underpass;** the underpass has decided to be constructed along Friendship Highway (i.e. from North to South) under the Sam Liam intersection, its geometric layout is two-way and two lanes per direction as shown in Figure 5(B). In

addition, the phase signalization at Sam Liam intersection also has been decided to change to the appropriate traffic signal control stage. The objectives of this policy were to decrease delay at this intersection as same with P1. in addition to reduce the impact of new road to residential along roadside.

- **P4: Construction of new road;** the new road has planned to be constructed at the train station roundabout in order to connect between Friendship Highway and Darunsamran Rd as shown in Figure 5(C). Its geometric layout is two-way and three lanes per direction.
- **P5: Establishment of no parking zone;** the no roadside parking zone during peak hours along both roadsides has been planned to be established along several main streets in CBD, including Prachasamosorn Rd., Na Muang Rd., Krang Muang Rd. and Lang Muang Rd. This policy was proposed to increase the capacity of main streets in CBD. It supposed to alleviate the traffic congestion in CBD.

Recently, the provincial government has requested to the KKU to evaluate the benefit of those policies with respect to traffic performance. The KKU has been evaluating those policies through considering the improvement of traffic condition. However, it is unfortunate that the evaluation would be conducted only local network level (i.e. at particular location and its neighboring network), since there is a lack of traffic information due to budget constraint. Consequently, it seems to be difficult to determine the most appropriate solution. Therefore, it becomes the good opportunity to apply the concept of this study to evaluate the current considered policies as the entire network performance.



Figure 5. Model Pictures and Location of Policies

4. TRANSPORTATION POLICY DEVELOPMENT

The Framework of transportation policy development is shown in Figure 6. It consists of two main parts. The former part proposes the framework of traffic simulation model development. The later part concerns to the application of developed model.



Figure 6. Framework of Transportation Policy Development

Firstly, the study area, problems, and constraints had to be identified clearly in order to develop the traffic simulation model. The primary data would be surveyed at the study area for developing and validating the model. The secondary data obtained from trip O-D matrix development would be modified, before it would be inputted into the micro traffic simulation

program. Afterward, the model development including network and zone modeling has been processed to develop the traffic simulation model. The traffic parameters have been set inside the model. Once the model has been developed, the model validation would be conducted by comparison of the traffic volume obtained from model running and surveyed traffic volume at same locations. In this study, the developed model was satisfied when at least 80 percent of two data sets should be correlative each another (i.e. satisfied R square value equal to or more than 0.80). In case of unsatisfied (i.e. R square value less than 0.80), the model should be modified through resetting of traffic parameters until the R square value is equal to or more than 0.8.

For application of the developed model, firstly, the local transportation policies would be established in order to solve the transportation problems at study area. To evaluate the proposed policies, each policy would be implemented in the developed model; the outputs from running model were the measures of performance, such as the average delay and travel time. After that, the decision making based on traffic performances would be conducted among policies. Finally, the optimal solution could be determined.

4.1 DATA COLLECTION

To develop the traffic simulation model for Khon Kaen City network, there were two main required data types. The first was the primary data (i.e. the data obtained from surveying traffic information at sites), which consists of the traffic volume, travel speed and etc. The second was the secondary data (i.e. the data obtained from trip O-D matrix development), which consists of trip O-D matrix, zone separation and etc. The data acquisition methods and data utilizations are discussed in the following sub-sections.

• **Traffic Volume Survey:** This study surveyed the traffic volume at specific sites. The seven key locations were selected as the representatives of entire network as shown in Figure 7. The traffic volume was classified into three different modes; 1) Regular vehicle (including a mini bus, a Song Thaew, a Tuk Tuk and a small truck), 2) Large vehicle (including a large bus and a large truck) and 3) motorcycle. The turning movements were counted every 5 minutes during morning peak hours (7AM to 9AM), off peak hours (11AM to 1PM) and evening peak hours (4 PM to 6PM). The collected traffic volume would be applied to validate the developed traffic simulation model.



Figure 7. Locations of Traffic Volume Survey

- **Travel Speed Survey:** The travel speed survey would be applied to collect the average travel speed and average travel time of traffic flow inside the central city and around suburban areas. The travel speed survey would be conducted along the three representative routes in the central city as shown in Figure 8(A). For suburban areas, the three representative routes also would be surveyed as shown in Figure 8(B). To collect the data, the Global Positioning System, GPS would be installed inside the probe vehicle. Once the travel speed data was collected, it would be transferred into Geographical Information System, GIS software. The travel routes would be traced and the travel speed and travel time of probe vehicles would be analyzed. The data obtained from travel speed survey would be utilized to develop the traffic simulation model.
- **Geometric Survey:** The geometric survey would be conducted in order to examine the geometric layout, a junction description, a lane marking, traffic control information and other associated information. To conduct survey, the video camera would be installed inside the vehicle, after that, the vehicle would travel around the surveyed network. The surveyed geometric data would be used to develop the link characteristic and junction description.



Figure 8. Travel Speed Survey Routes in Central City and Suburban Areas

4.2 MODEL DEVELOPMENT

In this study, the PARAMICS (QUADSTONE, 2003) was selected as the representative of micro simulation program to develop the traffic simulation model for Khon Kaen City entire network. The PARAMICS has been selected since it has a sufficient efficiency to develop the road network of large size city, a high performance and flexible function.

- **Zone Modeling:** The zones from the Four Steps Estimation Technique could not be applied directly to traffic simulation model since the zones from purpose of macro planning are quite too large areas to be applied in purpose of micro planning. Therefore, those zones have to be modified before applying to develop the traffic simulation model. The strategies of zone development for traffic simulation model are listed as follows.
 - Firstly, the zones from Four Steps Estimation Technique were imported into the traffic simulation program through transferring the coordination of zone.
 - Next, the centroid of each zone should be established. The centroid should be located at the center of zone.

- For the connection between zone and the neighboring road network, the link should be applied to connect between the zone and the road.
- For large zones, especially zones in suburban areas, the sufficient links connected between zone and road network should be created to each zone in order to accommodate sufficiently traffic volume, which generated from that zone.
- The zone should not be connected directly to the major roads, but it should be connected to the minor road, that connects to that major road.
- **O-D Matrix Development:** To develop the vehicle O-D matrix in the micro simulation program, PARAMICS, the trip O-D matrix resulted from the Four Steps Estimation Technique had to be convert into vehicle O-D matrix, consisting of passenger vehicle, motorbike and Song Thaew O-D matrix through using the vehicle occupancy rate of Khon Kaen City (OTP and KKU, 2003).

The complete entire network of Khon Kaen City developed by PARAMICS is illustrated in Figure 9 and the example of simulation scene of PARAMICS is shown in Figure 10. Once the model development was finished, the model has to be validated its practicality before applying the model to the local transportation policies.



Figure 9. Modeling Khon Kaen City Entire Network on PARAMICS



Figure 10. The Simulation Scene of PARAMICS

4.3 MODEL VALIDATION

The developed traffic simulation model for entire system was validated against the traffic volumes at sites. The observed traffic volumes at sites were compared to the simulated traffic volume at the same locations in simulation model. As the result of model validation, the correlations of the two data sets are as shown in Figure 11. The correlation of two data sets reveals as 0.87. This could be explained that approximate 87 percent of the total variance in the traffic volume from running simulation is close to traffic volume at sites. It implied that the developed model was highly accurate as it could provide the performance similar to the real network performance. Therefore, the proposed approach could develop the high accurate traffic simulation model.



Figure 11. Correlation between Observed Traffic Volume and Simulated Traffic Volume

5. MODEL APPLICATION

Once the traffic simulation model for entire network has been developed, the developed model would be verified its practicality by application on the Khon Kaen City network. As previous mention, the several local transportation policies have been proposed to address traffic congestion along the network. The developed model would be applied to implement the proposed policies in order to evaluate their performance.

5.1 Decision Making Criteria

To make the decision, all proposed policies would be compared with the existing condition. In this study, many measures of effectiveness, especially average speed would be selected to measure the traffic performance of entire system.

5.2 Statistical Analysis of Results

The developed model would be run as many times with different seed values through PARAMICS, since PARAMICS is a microscopic stochastic simulation model, at least 100 simulation runs with different seed values would be conducted as follow a recommendation of QUADSTONE (2003). The statistical analysis was utilized to compare the average speed of proposed policies with the existing condition. The distribution of average speed outputted from running simulations would be plotted. The Kolmogorov-Smirnov Test with 95% level of confidence would be used to test the distribution of average speed through SPSS program. In case that distribution of average speed is not follow the normal distribution, the simulations with different seed values still were continued in order to obtain more samples. After obtained enough samples with normal distribution, the comparison between average speed of proposed policies and existing condition was conducted by Independent-Sample T-Test with 95% level of confidence.

5.3 Results of Performance and Decision Making

As results of comparative analysis in Table 1, the constructions of an overpass (P1) and the construction of an underpass (P3) along Friendship Highway at Sam Liam intersection, and the construction of new road connecting between Friendship Highway and Darunsamran Rd. at train station roundabout (P4) could increase significantly the average speed of entire system with 1.6%, 3.3% and 1.6% increasing from the existing condition, respectively. It was noticed that the construction of an underpass along Friendship Highway at Sam Liam intersection could produce the highest improvement because it could reduce the severe of traffic congestion at key intersection of network. Conversely, the construction of overpass along Prachasamosorn Rd. at Sam Liam intersection (P2) and the establishment of no parking zone along main streets (P5) could increase insignificantly the average speed of entire system from the exiting condition. Consequently, those policies (P1, P3 and P4) could improve the entire system traffic performance in term of increasing average speed. In addition, when considering to implement the multiple policies, implementing the construction of overpass along Friendship Highway at Sam Liam intersection (P1) together with the construction of new road connecting between Friendship Highway and Darunsamran Rd. at train station roundabout (P4) could improve more significantly with 4% increasing of average speed from the existing condition.

Tuble 1. Results of Comparison between Troposed Toneles and Existing Condition						
Policy	Total No.	Total Travel	Total Travel	Aver. Speed	Difference	Result of
	of	Distance	Time	(kph)	in Aver.	T-Test
	Vehicles	(veh-km)	(veh-hr)		Speed (%)	
P0	31,333	191,481	5,226	36.6	-	-
P1	31,355	193,297	5,200	37.2	1.6%	Sig.
P2	30,644	190,505	5,177	36.8	0.5%	Not Sig.
P3	30,777	193,426	5,115	37.8	3.3%	Sig.
P4	31,323	192,508	5,170	37.2	1.6%	Sig.
P5	31,328	191,751	5,213	36.8	0.5%	Not Sig.
P6	31,335	193,465	5,073	38.1	4.0%	Sig.
Note: P0: Do Nothing, P1: Overpass Construction (along Friendship Highway), P2: Overpass						
Construction (clong Prochagomagom Rd) R2: Undermaga Construction R4: Now Road						

Note: P0: Do Nothing, P1: Overpass Construction (along Friendship Highway), P2: Overpass Construction (along Prachasamosorn Rd.), P3: Underpass Construction, P4: New Road Construction, P5: No Parking Zone and P6: Multiple Policies (Implementing P1 together with P4)

6. CONCLUSIONS AND RECOMMENDATIONS

This study discussed the possibility to develop the comprehensive transportation policies using traffic simulation technique for Khon Kaen City, Thailand. The approach to develop the model consists of 1) the data collection (the primary data and the secondary data), 2) the traffic simulation model development including the zone modeling and the O-D matrix modeling and 3) the model application. The estimated demand data and surveyed traffic information were applied to develop and validate the traffic simulation model for Khon Kaen City network through PARAMICS. The results of validation showed that the developed model could produce the traffic performance, which is obviously close to existing traffic condition. After achieved the accurate model, the developed model was applied to evaluate the several local transportation policies to address the traffic congestion along Khon Kaen City network. The results of evaluation reveal that the construction of overpass or underpass along Friendship Highway at Sam Liam intersection, or the construction of new road connecting Friendship Highway and Darunsamran Rd. at train station roundabout could improve significantly the entire system traffic performance in term of increasing average speed. However, the construction of an underpass along Friendship Highway at Sam Liam intersection could produce the highest improvement. In addition, implementing integration of the construction of overpass along Friendship Highway at Sam Liam intersection and the construction of new road connecting between Friendship Highway and Darunsamran Rd. at train station roundabout could increase significantly average speed more than those isolated policy implementations. In conclusion, the proposed approach in this study is very effective and practical to develop the comprehensive local transportation policies for Khon Kaen City.

For recommendations, as evaluation of proposed transportation policies, this study evaluated the policies only in term of average speed of entire system; therefore to make final decision, the other traffic parameter should be included into the evaluation process. In addition, as considering for further study, the process of validation of developed model should compare the simulated traffic parameters with surveyed parameters with not only traffic volume but also other traffic parameters at many network widely locations during various time intervals. To develop more specific zone of trip generation, the GIS technology should be provided to analyze the personal trip information, which obtained from the questionnaire.

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