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RESEARCH PAPER

Dropped in Capacity and Traffic Speed of Urban Arterial: A Case Study at U-Turn Section in Aceh Province, Indonesia

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Abstract - Dropped in traffic capacity and travel speed during congestion were studied at a u-turn section on an arterial road in Indonesia. Traffic characteristics during congestion were analyzed using oblique cumulative plots and breakdown method. Both approaches are time series treatment between cumulative vehicles arrival versus time contracted from data recorded by video tape. Studies were conducted in both morning and evening peak hours on three regular weekdays. This study found traffic breakdown condition during the peak periods; the breakdown lasted on average 40 minutes. It was found that capacity during traffic breakdown drops in the range 8-9 percent from the before-breakdown capacity. Similarly, during the breakdown, speed drops on average 10 percent from the before condition. Several alternatives were selected and tested for improving existing conditions. It was found that adding a 50m pocket lane would help improving the existing situation by reducing the delay to 69 percent, increasing speed to 39 percent, and improving capacity to 11 percent compared to the result of simulation an existing condition.
Keywords: Decreasing capacity, speed reduction, oblique cumulative plots, breakdown event function, u-turn section, congested arterial, microscopic simulation.

Introduction

Indonesia, in current condition is challenging by experiencing of traffic congestion problems on road networks certainty in urban arterial corridors. High traffic demand and limited supply of roadways are always the main factors produced stop and go traffic. Nevertheless, there are other sources of local and temporal congestion, such as uncontrolled access point, median opening or so-called u-turn, which cause reduction of roadway capacity during peak periods. Such locations create interruption of smooth traffic flow along arterial streets, which in turns stimulate related problems, such as, excessive air pollution, additional energy consumption and driver's frustration due to the stop and traffic jammed. Understanding the quantitative effect of these activities on the roadway capacity would lead us to an appropriate policy and guideline for planning and designing urban street corridors. So far, most developing countries still lack of experiences and research to understand capacity drop on the arterial and collector road in these locations.

The conventional method as known as Indonesian Highway Capacity Manual (IHCM, 1997) is provided statics method for assessing the capacity of the roadway and directly adopted from US Highway Capacity Manual (HCM, 1985). It provides a methodology for analyzing the capacity of roadway, but this methodology does not take into consideration of bottleneck activities on arterial roads, such as, uncontrolled access point, u-turn and unrestricted on- street parking. This condition could happen simultaneously; mostly repetitive and predictable in same peak period on weekdays and weekend. Previous works employed dynamic capacity approaches for detecting and assessing traffic stream on active bottlenecks. Cassidy and Windover (1995) proposed dynamic capacity method for estimating roadway capacity on active bottleneck using maxima method and product limit method, which were followed by other researchers, for example Brilon *et al.* (2005; 2007) and Geistefeldt (2008). Oblique cumulative plots is another approach which is widely uses for analyzing bottlenecks on uninterrupted flow such as Cassidy and Bertini (1999), Cassidy and Rudjanakanoknad (2005), Ahn and Cassidy (2007), and Chung *et al.* (2007), Persaud *et al.* (1998), Elefteriadou *et al.* (2001), Zhang (2001) and Lertworawanich and Elefteriadou (2003) were also studied breakdown mechanism in freeway segment using breakdown probability function method. The works were pointed the current definition and understanding of the roadway capacity that the facilities become congested and breakdown.

Breakdown is defined as a traffic stream condition in which transition from non-congested (stable) state to a congested state (unstable) when demand exceeds the capacity. The findings from previous studies concluded that under breakdown situation a capacity of the road more reasonably analyzed using dynamic approaches. Nevertheless, most of the previous dynamic studies are commonly done for uninterrupted flow facilities. A recent study of Rudjanakanoknad (2009) was perhaps the first study who applied oblique cumulative plots method for assessing traffic mechanism at a u-turn section on the local street in Bangkok. The study found that increase of u-turn volumes might not significantly reduce the bottleneck capacity but the u-turn restriction at this study would likely increase the bottleneck capacity with the average ratio of u-turns to through cars about 1:5. Furthermore, Rudjanakanoknad's work was focused only in identifying general factors that are effecting of traffic in bottleneck section but less detail about how to quantify the breakdown parameters

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such as road capacity, vehicle speed and the time of the occurrence. Thus, this study was emphasized on assessing and quantifying the detail parameters in median opening (u-turn section).

The aim of present study was assigned the flow intteruption of through traffic on an urban arterial road due to u-turn. The specific objectives include assess the decrease in traffic capacity and speed of a u-turn segment on arterial roads during peak hour, and propose an alternative that should improve the traffic operation for the u-turn segment and the on-street segment. This study analyzed traffic dynamic behaviors on an urban arterial using the oblique cumulative plot technique and breakdown event to visually analyze the changes in flows, capacity, and activities on the u-turn section (median opening). Understanding the quantitative effect of these activities on the roadway capacity and speed will lead an appropriate policy and guideline for traffic analyst particularly for planning of design operational capacity in urban arterial corridors, especially for helping DOT and DOH in Aceh Province of Indonesia in planning and operation of traffic in arterials system.

Materials and Methods

Study area and data collection

The study site is a major urban arterial road which is connecting suburban area to central of Banda Aceh city. The average hourly traffic volume is approximately on average 3,200 pc/h. Abutting land use is primarily mixed land use, including business area, private and public offices. The composition of traffic includes 55% motor cycles, 40% private cars, and 5% large vehicles, such as, buses and trucks. There only few people use public transport, mainly because service and performance of existing public transport (bus, minibus) is very poor. Thus, people prefer to travel for daily activities using their own car or motorcycle. The section is the busy road in Banda Aceh which is connected the capital city of Aceh with rural and suburban area in central and eastern districts of Aceh. The road segment of study areas is shown in Figure 1, and the existing condition of study area in Figure 2.

Currently, traffic flow from u-turn line interrupt through traffic behind and produces mainly blocking of traffic. Traffic stream were recorded by using videotape recorder installed on pedestrian bridges and vantage point. Video tapes were recorded for three days during weekday at morning and evening peak hours as shown in Table 1.

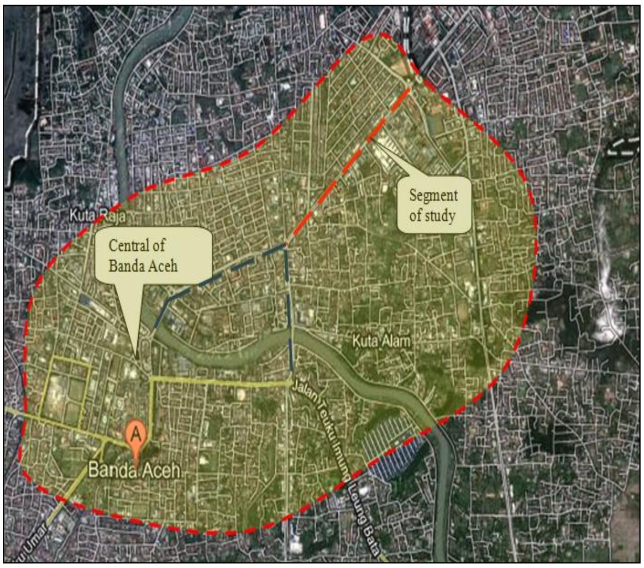

Figure 1. Map of Study Area (Google Earth, 2011)

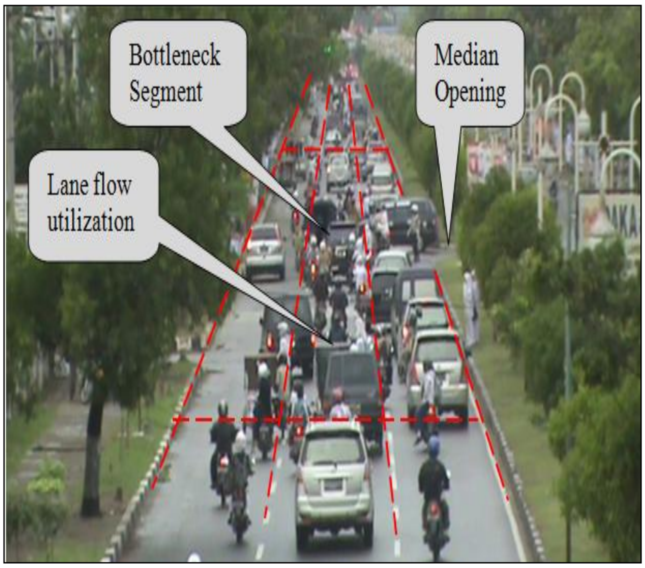

Figure 2. Blocking and lane flow utilization of existing condition.

Table 1 Schedule for Data Collection

No.	Road Name	Day/date of Observation	Time	Analysis
1.	T. Nyak Arief	Monday, April 25th, 2011	07.15-08.15 am	U-Turn Section
2.	T. Nyak Arief	Monday, April 25th, 2011	04.30-05.30 pm	U-Turn Section
3.	T. Nyak Arief	Wednesday, April 27th, 2011	07.15-08.15 am	U-Turn Section
4.	T. Nyak Arief.	Wednesday, April 27th, 2011	04.30-05.30 pm	U-Turn Section
5.	T. Nyak Arief.	Friday, April 29th, 2011	07.15-08.15 am	U-Turn Section
6.	T. Nyak Arief	Friday, April 29th, 2011	04.30-05.30 pm	U-Turn Section

Methodology

The oblique cumulative plots and breakdown event methods were used in this study to analyze the decrease of capacity. The cumulative arrival curve is a visual presentation of traffic observations collected directly from the roadway. The oblique cumulative plot is time-series data treatment between the cumulative vehicle arrival and time. The measurement of arrivals are conducted in a short time period such as one minute or even less, and the time interval selected can be influence the magnitude of the flow. Oblique cumulative plots is a special time-series data treatment of O(t) versus t, in which O(t) denotes cumulative vehicle after re-scaled, and can be drawn as $O(t) = N(t)\text{-}q_o x(t\text{-}t_o)$. N(t) is cumulative vehicles count during time t, q_o is selected background flow, and t_o is starting time. Background flow is determined from trial and error from the curve of vehicles arrival versus time arrival. Rescaling curve of vehicle arrival by subtracting selected background flow created the oblique coordinate system amplifies changes in slopes, making possible the visual identification of flow changes at each measurement location. From the oblique cumulative plots, researchers estimate the slop of each increasing or decreasing flow rate by time interval. The slopes are representation the dynamic capacity of the road section during observation period. Breakdown probability function is also time-series data treatment which is powerful for detecting capacity and speed drop. The main purposes of using this method are listed by Lertworawanich P, et al (2003), Elefteriadou *et al.* (2001) which is breakdown probability function better for quantifying three capacities on the active bottleneck based on time series plots of flow and speed as following:

1. Identify and quantify each transition interval from non-congested to congested flow, breakdown event, and document the corresponding breakdown flow.
2. Identify and document the maximum pre-breakdown flow. This flow is the maximum observed at the site prior to the occurrence of congestion.
3. Identify and document the maximum discharge flow. This flow is the maximum observed at the site after the occurrence of breakdown, and prior to recovery to non-congested conditions.

Developing breakdown curves requires information of speed, flow rate and time. Then time-series data was plotted as time on the X axis and flow rate and speed in the Y axis. After developing breakdown curve, moving average line treatment was used in order to easily identifying and understanding the breakdown mechanism. In order to detect the breakdown process, speed is typically used as indicator of breakdown occurrence. In other words, when speed drop in certain threshold breakdown identify as flow rate immediately before breakdown as recommended by Elefteriadou *et al.* (2001). Critical speed was defined as the average speed during observation periods. When speed plotted below the critical speed is identified as speed during capacity drop. Whereas, when speed plotted above critical speed are identified as speed during before or after capacity drop.

Results and Discussion

Capacity and travel speed dropped

Oblique cumulative plots in Monday morning and evening are shown in Figure 3. As shown, traffic behaviors mostly fluctuated in the morning peak period from 07:15 to 8:15. The capacity began to drop from 3,242pc/h to 3,017pc/h at 07:25. Then, the capacity was increased slightly to 3,187pc/h at 7:40, and the capacity began to recover at 3,420pc/h before a drop of demand at 08:15 approximately to 3,070pc/h. In the evening observation from 16:30 to 17:30, the traffic demand continuously increased from 16:00am (2,850pc/h) to 16:48am (3,045pc/h). Then, the capacity drops between 16:50 to 17:22 to approximately 2,777pc/h, and then began to recover around 17:25 (2,871pc/h). Pertaining from the whole traffic behaviors shown in figure 3, it concluded that u-turn opening actually affected to the traffic stream in the major street during peak hour observation. Field observations showed vehicles directly change lane when reaching on u-turn, some time vehicle in queue to reach on u-turn used two lanes of roadway. It created blocking for through traffic, and unstable flow occurs repeated during high demand of traffic. The same pattern was analyzed for the other two survey days and the results are summarized in Tables 2 and Table 3.

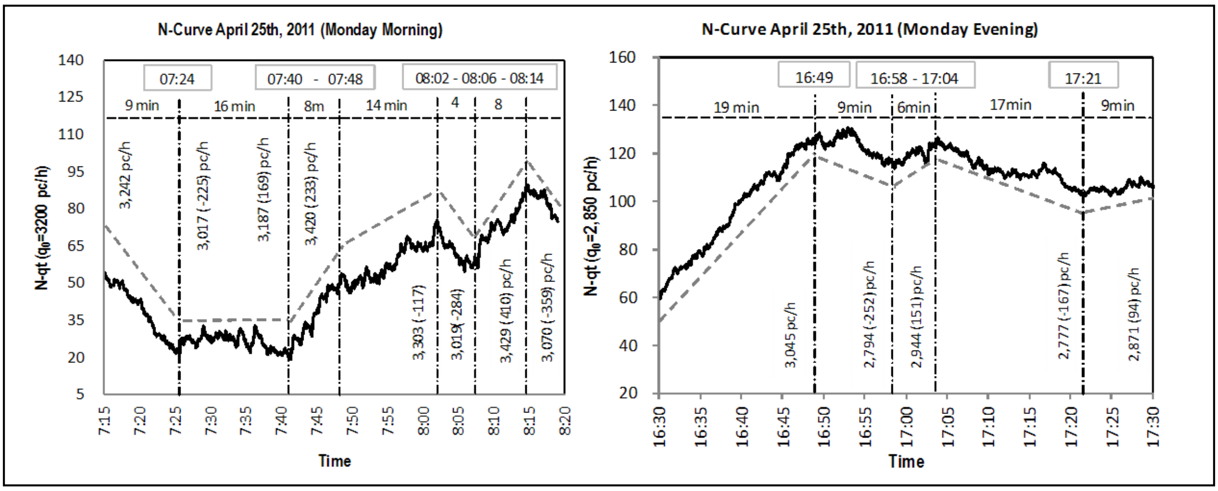

Figure 3. Oblique cumulative curve of Monday morning (left) and evening Peak 25th April 2011 (right)

As shown in Table 2, the capacity of the roadway section based on the oblique cumulative plot was found to be 3,130 pc/h. This is lower than the static capacity of a Class III arterial, derived from USHCM 2000 was 4,174 pc/h. The static method give higher of result of analyzing in case of congestion condition. The result shown was about 25 percent higher than compared to dynamic approach. The duration of breakdown derived by using oblique cumulative plots on average is about 32 minutes within an hour peak hour observation. During the traffic breakdown in the morning peak periods, the capacity dropped 8 to 12% of normal capacity immediately before at breakdown occurs, or it is equivalent to a decrease of traffic deficiency of 247-388 pc/h from normal operational capacity of 3,200 pc/h. From table 3, it can be seen time duration of breakdown during evening peak hour observation approaching 34 minutes. Capacity in the evening peak periods was drop around 163-314 pc/h from normal capacity before and after breakdown, or equivalent to 6 to 10% drop. In overall, combining morning and evening observations, the decrease of capacity approximately 8 to 10% or equally dropped of capacity 2,816 pc/h from normal capacity before breakdown 3,097 pc/h and after breakdown of 3,092pc/h.

Table 2. Capacity drops on u-turn section at morning peak's observation

No.	Day of Observation	Time of Traffic Break down	Duration of Break down (min)	Capacity Observation in Bottleneck			Capacity Drops		Percent of Capacity Drops	
				Before Break down (pc/h)	Break down (pc/h)	After Break down (pc/h)	Break down to Before (pc/h)	Break down to After (pc/h)	Break down to Before (%)	Break down to After (%)
1.	Mon, 25th April 2011	07:24 to 08:06	42	3,242	3,017	3,429	-225	-412	-7	-12
2.	Wed, 27th April 2011	07:25 to 07:55	25	3,117	2,794	3,140	-323	-346	-10	-11
3.	Fri, 29th April 2011	07:26 to 07:55	29	3,031	2,826	3,244	-205	-418	-7	-13
Average in morning Peak			32	3,130	2,879	3,271	-251	-392	-8	-12

Table 3. Capacity drops on u-turn section at evening peak's observation

No.	Day of Observation	Time of Traffic Break down	Duration of Break down (min)	Capacity Observation in Bottleneck			Capacity Drops		Percent of Capacity Drops	
				Before Break down (pc/h)	Break down (pc/h)	After Breakdown (pc/h)	Break down to Before (pc/h)	Break down to After (pc/h)	Break down to Before (%)	Break down to After (%)
1.	Mon, 25th April 2011	16:49 to 17:21	32	3,045	2,777	2,827	-268	-50	-9	-2
2.	Wed, 27th April 2011	16:40 to 17:13	33	3,075	2,730	2,934	-345	-204	-11	-7
3.	Fri, 29th April 2011	16:44 to 17:22	38	3,068	2,728	2,975	-340	-247	-11	-8
Average in evening peak			34.33	3,063	2,745	2,912	-318	-167	-10	-6

Marking of breakdown method, we analyzed the traffic data for individual 60 minutes during the observation periods. The flow and speed was plotted against time on the X axis. Then, employing a moving average line treatment for better plots and visualize of breakdown events during the observation periods. The Breakdown Curves in Monday morning and evening are shown in Figures 4 and Figure 5, while the results of analysis for other days are summarized inTables 4 and Table 5. In general, breakdown was identified during morning and evening observation. There are shown white areas is before breakdown interval, grey marked areas is breakdown time, and again white marked showed recovery processes.

Figure 4 showed the traffic fluctuation during an hour of observation (07:15 to 08:15) in the Monday morning peak. As shown, traffic speed continuously increased until 07:20 then dropped from 07:25 to 08:05 before immediately recovered at 08:15. Breakdown period was identified by using speed indicators. It is showed in Figure 4 curve of speed immediately dropped at 07:20 then slightly constant till 08:25 just immediately before recovered of speed. The interval of the time during speed identified dropped was called breakdown period. Moreover, determined speeds before, breakdown and after breakdown were used as critical speeds. In this work critical speed is average speed during an observation. Speeds which are distributed above critical speed line 26kph (Figure 4) were identified as speed before and after breakdown. Otherwise, it is speed during breakdown period. The capacity was estimated as average distributed flow rate each areas follows the areas of speed in before, breakdown and after breakdown. For instance, capacity before breakdown was determined as average flow rate points which are distributed same area with speed areas before breakdown. In this case, the area is white color within time 07:15 to 07:24.

Finally, the dropped of capacity and speed were determined by comparing capacity and speed in breakdown period to capacity and speed in before and after breakdown. Evening peak hour observation showed shorter time of breakdown in speed and capacity, as shown in Figure 5. In general, it showed capacity and speed approximately maintaining constant during 23 minutes from 16:30 to 16:52, then breakdown occurred. Accordingly, both speed and capacity dropped for almost 30 minutes before immediately recovered in speed and capacity at 17:23. Identifying the exact time of the breakdown and recovery events occurred requires critical line in speed time-series.

Figures 4 and Figure 5 both show the situation of flow rate in terms of capacity and speed distribution during an hour observation. Every event under the critical lines (dashed line) was speed drops during an observation, and it is a

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function parameter indicator for defining the drop capacity. For instance, there were 26kph and 31kph respectively critical speed which is chosen for identifying the capacity drops during an observation. Overall, the capacity and speed parameters as represented breakdown mechanism on a u-turn section by deeply studied and analyzed from breakdown curves are shown in Table 4 and Table 5 for the morning peak hour and Table 7 and Table 8 for the evening peak was in summary.

The breakdown method indicated that the average breakdown duration in the morning of weekdays was around 46 minutes. The capacity during traffic breakdown on average dropped between 9 to 12 percent of the capacity during normal condition. In this case the normal capacity was in between 3,174 pc/h to 3,264 pc/h, and the breakdown capacity dropped to 2,886pc/h. In terms of speed reduction, the blockings of vehicles at the u-turn section cause speed decrease by 10 to 13 percent of the normal speed (approximately 30kph).In the evening peaks as shown in Tables 6 and 7, similar pattern of traffic behaviors on the main stream was founded.

In general both of the table shows that evening peak has a lower capacity and speed drop compared to morning observation. It clearly shows that the drop of capacity in the evening peak in the range 8-11 per cent by controlling normal capacities 3,177pc/h, 2,826pc/h and 3,084pc/h for each capacity before, breakdown, and after the breakdown. Speed drops also show lower percent of drop around 10 percent. Nevertheless, considering controlling speed, speeds evening peak mostly higher than morning peak. It can be seen in the evening peak speed 31kph, 28kph and 31kph, for before, breakdown and after respectively. Reflection to speed in morning peak hour was around 30kph, 27kph and 31kph for before, breakdown and after respectively. In concluding that speed in the evening peak approximately 1kph higher than morning peak observation, but at the same time per cent of drop morning observation 3 per cent higher than evening peaks. It was concluded that percent of the speed drop mostly depends on control of speed.

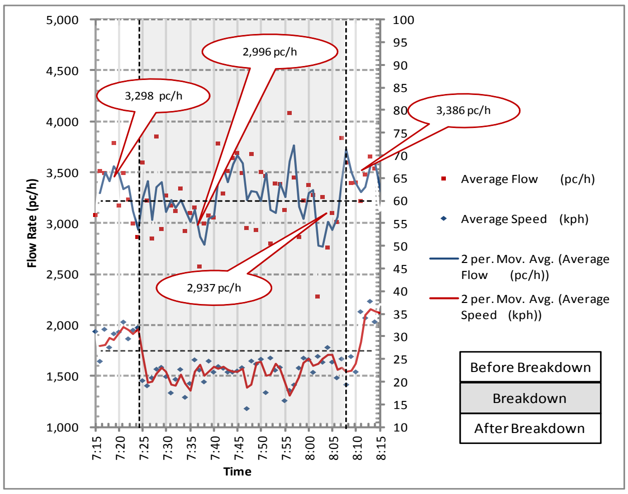

Figure 4. Moving average of breakdown curve for Monday Morning Peak 25th April 2011

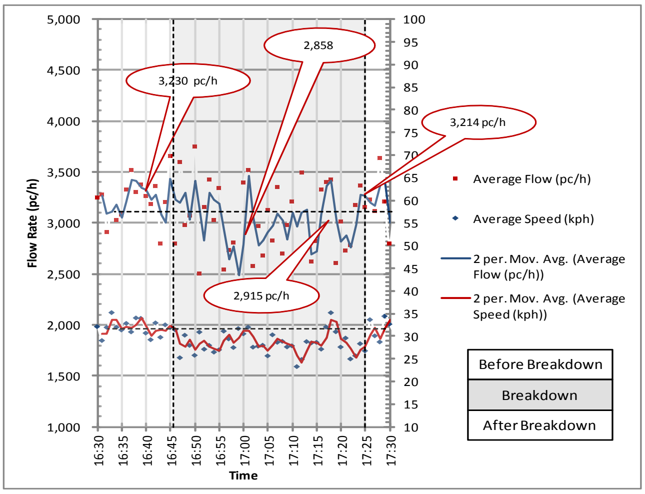

Figure 5. Moving average of breakdown curve for Monday evening peak 25th April 2011

Table 4. Capacity drops on u-turn section in morning peak's observation

No.	Day of Observation	Time of Traffic Break down	Duration of Break down (min)	Capacity Observation in Bottleneck			Capacity Drops		Percent of Capacity Drops	
				Before Break down (pc/h)	Break down (pc/h)	After Break down (pc/h)	Break down to Before (pc/h)	Break down to After (pc/h)	Break down to Before (%)	Break down to After (%)
1.	Mon, 25th April 2011	07:23 to 08:07	44	3,298	2,937	3,386	-361	-449	-11	-13
2.	Wed, 27th April 2011	07:21 to 08:06	46	3,112	2,890	3,270	-222	-380	-7	-12
3.	Frid, 29th April 2011	07:21 to 08:09	48	3,113	2,830	3,135	-283	-305	-9	-10
	Average in morning peak		46.00	3,174	2,886	3,264	-289	-378	-9	-12

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Table 5. Speed drops on u-turn section in morning peak's observation

No.	Day of Observation	Time of Break down	Duration of Break down (min)	Speed Observation in Bottleneck			Drops of Speed		Percent Drops of Speed	
				Before Break down (kph)	Break down (kph)	After Break down (kph)	Break down to Before (kph)	Break down to After (kph)	Break down to Before (%)	Break down to After (%)
1.	Mon, 25th April 2011	07:23 to 08:07	44	29	23	30	-6	-7	-21	-23
2.	Wed, 27th April 2011	07:21 to 08:06	46	29	28	31	-1	-3	-3	-10
3.	Frid, 29th April 2011	07:21 to 08:09	48	31	29	31	-2	-2	-6	-6
	Average in morning peak		46.00	30	27	31	-3	-4	-10	-13

Table 6. Capacity drops on u-turn section in evening peak's observation

No.	Day of Observation	Time of Traffic Break down	Duration of Break down (min)	Capacity Observation in Bottleneck			Capacity Drops		Percent of Capacity Drops	
				Before Break down (pc/h)	Break down (pc/h)	After Break down (pc/h)	Break down to Before (pc/h)	Break down to After (pc/h)	Break down to Before (%)	Break down to After (%)
1.	Mon, 25th April 2011	16:46 to 17:25	39	3,220	2,858	3,214	-362	-356	-11	-11
2.	Wed, 27th April 2011	16:42 to 17:25	43	3,176	2,803	3,014	-373	-211	-12	-7
3.	Frid, 29th April 2011	16:40 to 17:14	34	3,134	2,816	3,023	-318	-207	-10	-7
Average in evening peak			38.67	3,177	2,826	3,084	-351	-258	-11	-8

Table 7. Speed drops on u-turn section in evening peak's observation

No.	Day of Observation	Time of Break down	Duration of Break down (min)	Speed Observation in Bottleneck			Drops of Speed		Percent Drops of Speed	
				Before Break down (kph)	Break down (kph)	After Break down (kph)	Break down to Before (kph)	Break down to After (kph)	Break down to Before (%)	Break down to After (%)
1.	Mon, 25th April 2011	16:46 to 17:25	39	31	28	30	-3	-2	-10	-7
2.	Wed, 27th April 2011	16:42 to 17:25	43	31	28	31	-3	-3	-10	-10
3.	Frid, 29th April 2011	16:40 to 17:14	34	31	28	32	-3	-4	-10	-13
Average in morning peak			38.67	31	28	31	-3	-3	-10	-10

Simulation of u-turn improvement using Vissim 5.30

Traffic simulation models were employed for testing and analyzing the effectiveness of installing a u-turn pocket lane of various lengths. Four scenarios for u-turn section include do nothing (existing condition), installing a pocket lane of 25 m, 50m and 75m length. For each pocket lane scenario, a 10m on-auxiliary section was added to accommodate vehicles entering to auxiliary lane, thus minimizing the effect of delay result in from lane changing before approaching auxiliary lane. Each of alternative scenarios was tested by simulation software in order to gain each measure of effectiveness (MOEs) by using Vissim 5.30 such as capacity, delay and speed. Ten numbers of seeds was conducted for running simulations in order to minimize the variety of randomness, and the results were averaged for each parameter-scenario.

The summary of simulation after 10 random seeds employed by using Vissim 5.30 showed in Table 9 as final finding of parameter of effectiveness. Table 9 shows the installation of an auxiliary lane in u-turn section help improving the traffic conditions. Adding an auxiliary lane of 25, 50, and 75m could reduce delay by 60, 69 and 74 per cent, respectively compared with an existing condition (do nothing). In terms of speed also gained good result as shown a speed increase of 32, 36, and 39 percent compared to doing nothing, respectively Key parameters is the capacity as showed in the table capacity sound adding an auxiliary lane improving traffic capacity by 2,948pc/h, 3,049pc/h, and 3,094pc/h or equivalent increasing traffic capacity by 8, 11 and 13 percent respectively for adding 25, 50 and 75 m auxiliary lane.

Table 9. Evaluation of the improvement alternatives at a u-turn section
Performed by using Vissim 5.30, 10 random seeds, 3600s)

No	Description	Parameters of MOEs			Percent of Effectiveness Compared to do Nothing		
		Flow rate (pc/h)	Speed (kph)	Delay (sec/veh)	Flow rate (%)	Speed (%)	Delay (%)
1	Existing (do nothing)	2,735	18.4	26.94	-	-	-
2	Add. auxiliary Lane 25 m	2,948	24.4	10.80	8	32	-60
3	Add. auxiliary Lane 50 m	3,049	25.0	8.31	11	36	-69
4	Add. auxiliary Lane 75 m	3,094	25.6	6.92	13	39	-74

Conclusions

Finding from this work, employing two dynamic tools namely oblique cumulative plots and the breakdown event function was clearly and effectively manner in analyzing traffic characteristics during congestion at u-turn section on an arterial road. The key finding from this research includes: (1) The duration of breakdown was occurred around 41 minutes on average during morning and evening observation caused by existence of u-turn at major stream of arterial, (2) Capacity drops effected by median opening was approximately in the range 8-9 percent controlled by pre-breakdown condition. This value is based on demand 2,800 to 3,200 pc/h of three lanes urban arterial, and mixed traffic operation with proportion 40% cars, 5% heavy vehicles and 55% motorcycles. Traffic conditions in opposite direction assumed to be are relatively similar, (3) Speed was dropped up to 10 percent, affected by median opening with based on some traffic condition mentioned above, (4) Based on MOEs resulted from simulating before and after improvement by using microscopic simulator so-called Vissim 5.30. Trial run by adding 50m pocket lane founded better operational as improvements for existing u-turn section. Thus, adding 50m auxiliary lane is chosen for improving traffic operation and existing condition based on the effectiveness of MOEs, the feasibility of applying and budget constraint as well.

Accordingly, there are two recommendation addresses based on finding in this study. Firstly, regarding existing condition, it sounds pocket lane working well for better traffic operation. Based on finding this study, it is recommended adding pocket lane as the best alternative for improving an existing condition. Another, regarding the future works, for deeply understanding of breakdown mechanism, it is recommended to quantify of parameter breakdown such as capacity and speed before and after breakdown by using two cameras or even more for better controlling the amount of breakdown in term of speed and capacity. For example, installing video cameras at upstream and downstream section, then, it is most accurately for detecting transition from congestion to un-congestion section. Thus deeply analysis can be performed by controlling mechanism of flow from upstream to downstream segment. But, at the same time it could be time consuming and budget constrains for doing so. Moreover, other geometrics or traffic conditions may better to test dynamic method is either well performing traffic behavior or not such as traffic influence near bus stop, traffic before entering school zone, and merging traffic by grade changing or access point.

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