Evaluation of the efficiency of a motorcycle-specific pausing area at the traffic signals on the urban road

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**Abstract**—The objective of this research was to evaluate the efficiency of the motorcycle-specific pausing zone under the Bike Box Project (BBP). This zone is designated at the very front of the waiting line for the traffic light. The indicators used to measure the efficiency comprised the lost time when starting up at the beginning of the green light, the change of the proportion of the motorcycle pausing points, the accident statistics, and the worthiness for investment. Two intersections in urban areas were used for the analyses and evaluation, which were carried out to compare between the period
prior to and after the project began. The study indicated that after the project began, the start-up lost time could be reduced by roughly 31-46% during peak hours, with approximately 73-78% of motorcycles pausing in the green zone (Bike Box Zone). The number and severity of the traffic accidents after 1-year of BBP implementation significantly decreased. The results of the study showed the efficiency of traffic management, safety, and worthiness for investment. It is thus appropriate to extend the project to other areas in the country and abroad, especially in urban areas where motorcycles are greatly used.

**Keywords**—bike box, start-up lose time, project evaluation, motorcycles, traffic accidents

### Introduction

The effects of motorcycle accidents in Thailand cannot be neglected as motorcycles are the vehicles with the greatest risk of traffic accidents. The death rate of motorcycle users (riders) from accidents accounts for 81% (Thai RSC, 2021). Motorcycle users predominate in accidents, especially at intersections, which are among the most critical locations in the road transport network where all vehicles share the zone, and frequent accidents have been recorded. The risk of accidents and the severity of injuries here are high (PIARC, 2019). Most roads in Thailand, especially urban roads, are used by a variety of small and big vehicles. When they pause and wait for the green-light signal at the intersection, small vehicles usually move to the front, pausing on the pedestrian crossing, or at the front part of the far-left or far-right lanes, or in between other cars. When the green light is on, the motorcycles, owing to their movement agility, start off faster than other vehicles. Moreover, they are able to easily intervene between bigger cars and move towards their direction. These behaviors risk loss of assets, and the severity can cause injuries, and death.

Additionally, it was found that at signalized intersections, motorcycles interfere with traffic flow efficiency; if a motorcycle is positioned ahead or between vehicles, the start-up lost time is increased at 30% (Torquato R.M.N., et al., 2020). A study showed the behaviors of motorcyclists when crossing a signalized junction. Roughly 46.5% changed the lane for a straight direction, which caused conflicts of traffic directions that possibly led to accidents (Nemmang, M. S., et al., 2022). Another study showed that if the proportion of motorcycles is high at an intersection, the behaviors of the motorcyclists can turn irregular, such as pausing in front of the stop line, or pausing between bigger cars, or in a vacant place, etc. The motorcycle proportion and the pausing behaviors affect the traffic flow efficiency at intersections (Kariyana, I. M., et al., 2021; Rongviriyapanich, T. & Suppattrakul, C., 2005). Many studies, likewise, found that the pausing and starting-up behaviors of motorcyclists bring impact on the traffic flow efficiency and this positively correlated with the lost time during the start-up period (Minh, C. C., & Sano, K., 2003; Rongviriyapanich, T. & Suppattrakul, C., 2005).
A number of research studies in many countries showed the management of these problems. Some study was conducted on a specific-pausing point for motorcycles or bicycles to wait for the traffic lights, using specific coloring (generally green) on the road pavement. This has been done also in Thailand, in order to clearly indicate the specific pausing space for motorcycles or bicycles. Traffic signs are also painted (such as arrows) in this designated zone on the road pavement. As a result, conflict points have been decreased as well as accidents from lane cutting by vehicles that turn or go straight, resulting in more safety (Bureau of Highway Safety, 2018; Dill, J., Monsere, C. M., & McNeil, N., 2012; Hsu, T. P., & Wen, K. L., 2019; Kuenpet P., 2021; Sutandi, A. C., & Siregar, D. D., 2017; Wall, G. T., Davies, D. G., & Crabtree, M., 2003).

Department of Highways, Thailand (Bureau of Highway Safety, 2018) has built a specific pausing point for bicycles and motorcycles at the front of the waiting lines of an intersection using a special green color on the pavement with pictures of bicycles and motorcycles to indicate that it is a specific area for common understanding. Nevertheless, this special zone for pausing is not popular in many areas in Thailand, especially in the areas under the responsibility of the local administrative organizations. Motorcycles are greatly used here, and the problems related to traffic still occur from the starting-up of the motorcycles. Studies conducted on constructing the specific-pausing space for motorcycles in Thailand are only few, while the results of such studies in foreign countries have not much been publicized, or not direct to the condition confronted by Thailand’s local administrative organizations, most of which have problems related to road safety budget and management.

With the above reasons, the Khon Kaen Accident Prevention Team proposed a Bike Box Project (BBP) to increase the efficiency of traffic engineering, with the intention of reducing the amount of traffic collisions at intersections. This project received financial support from the Safer Roads Foundation, England (Safer Roads Foundation (SRF), 2021). The project initially started its full operation on January, 2021. The objective of this research was thus to assess the efficiency in different aspects of the Bike Box Project (BBP) at two traffic-signal intersections, which included the starting-up time at the beginning of the green light, the proportion of motorcycles waiting, the severity of accidents, and the worthiness of investment. The assessment was conducted one year after the BBP commencement to demonstrate the efficiency of the project and possibility in application of the study results in their respective areas.

**Materials and Methods**

**Study Areas**

The assessment of efficiency in implementing the Bike Box Project (BBP) was carried out at two intersections in Khon Kaen city, Thailand, namely, 1) Khon Kaen Hospital Intersection, and 2) Khon Kaen University Junction, as shown in Figure 1. At both intersections, the traffic is dense, especially with motorcycles, which account for 53-56% of all vehicles. Based on the road hierarchy, both intersections are arterial roads. For Khon Kaen Hospital Intersection, the main road comprises 5 traffic lanes including the left-turning and right-turning lanes.
The intersection is the crossing with two 2-laned collector roads. The second junction, Khon Kaen University Junction, is in front of Khon Kaen University. It connects the large-sized university community with the main road in Khon Kaen (Highway Number 2). The road connects to a collector road that also has 2 traffic lanes. The collector road is in the campus of Khon Kaen University, where users of motorcycles account for a great number, especially the students. This collector road in turn connects to communities around the University, and is used by various groups of public besides the university's students and personnel.

Figure 1. Both areas under the Bike Box Project (BBP)

**Bike Box Project (BBP)**

The Bike Box Project (BBP) consists of the 5 meter long specific pausing zone for motorcycles or bicycles. The pavement zone was painted with cold plastic green color. This kind of color gives higher surface friction than the normal road pavement, based on the Department of Highway's standard (Bureau of Highway Safety, 2018). Additionally, this green zone was painted with pictures of a motorcycle and a bicycle, segregating dotted lines for the lanes, and arrows indicating the moving direction (Hsu, T. P., & Wen, K. L., 2019; Wall, G. T., Davies, D. G., & Crabtree, M., 2003). These were painted with cold plastic white color. The forms of the segregating dotted lines and the direction arrows had been recommended by senior engineers of the Department of Highway to match the real behaviors of road users. Moreover, at the side of the BBP zone, a traffic sign was installed that indicates the waiting traffic-light for car drivers and a sign indicating a specific-pausing zone for motorcycles and bicycles, as shown in Figure 2.
Traffic data Survey

In order to evaluate the traffic engineering outcomes, based on the start-up lost time and the proportion of the pausing position of motorcycles as the indicators of the efficiency, the survey was thus conducted in two periods: 1) Prior to the project implementation – This survey was manually conducted on the amount of traffic and the traffic light signals during 07:30-09:30 a.m. (peak time), 11:00 a.m.-13:00 p.m. (off-peak time), and 16:30-18:30 p.m. (peak time); and on the start-up lost time in the system at the beginning of the green light. This was done by drone in addition to man for one hour during the periods similar to the amount of traffic survey. The physical characteristics of the road and the intersections were also surveyed. 2) Twelve months after the project began – Duplication of the first-period survey was carried out for twelve months after the project began.

Road traffic accidents and related data collection

For the evaluation of the efficiency in the management against accidents that happened at the intersections, the traffic accidents data in the research sites were collected. This research received assistance in terms of the data from the accident databases of Khon Kaen Hospital and Khon Kaen University (Emergency Medical System, EMS., 2022; Security division Khon Kaen University, 2022). The data obtained were prior to the project implementation (in 2021), and 1 year when the BBP was ongoing (in 2022). The data comprised the number of accidents, the number of slightly injured people, the number of severely injured people, and the number of deaths. The worthiness for investment of the project was then assessed from compilation of the economic cost of losses from traffic accidents in Thailand (Thailand Development Research Institute, TDRI., 2021), as shown in Table 1. The loss values were then analyzed to determine the project worthiness.

Table 1
The economic cost of road traffic accidents in Thailand

<table>
<thead>
<tr>
<th>The degree of severity of road accidents</th>
<th>Cost (Dollars)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slightly injury</td>
<td>1,649</td>
</tr>
<tr>
<td>Seriously injury</td>
<td>13,746</td>
</tr>
<tr>
<td>Fatality</td>
<td>102,445</td>
</tr>
</tbody>
</table>

Remark: * 1 dollar is worth 35.32 Thai Baht.
Data analysis

This research only considered the critical direction or the direction with the greatest number of motorcycles in the system. The analyses were divided into 5 parts as follows:

- Analysis of the total start-up lost time from the headway time spent of each vehicle in each traffic lane. The data was collected until the period of traffic flow saturation, as shown in Figure 3. The results were taken to compare between the two periods: prior to the project and when the project was ongoing in order to evaluate the efficiency of traffic during peak and off-peak hours.

![Figure 3. Headway and total start-up lost time (Manual, H. C., 2000)](image)

- Comparison of the positions of motorcycle pausing, by observing their points of waiting for the traffic light obtained from the video file records. The two periods, before the BBP and when the BBP began, were compared. The positions of motorcycle pausing were divided into 5 zones, as shown in Figure 4. The results are then presented in percentage.

![Figure 4. Comparative position of each parking zone](image)
• Comparison of the data related to the number of traffic accidents, the number of slightly injured people, the number of severely injured people, and the number of deaths, before and after the project began. The results are shown in a chart that illustrates the number of occurrences at each period.

• Analysis of the worthiness for investment, conducted from the benefit values derived from reduction of losses from traffic accidents against the cost of construction of the BBP at the two intersections, or analysis of the benefits-cost ratio.

Results and Discussion

To evaluate the efficiency of the BBP implementation, the research was conducted by dividing the analyses and discussion of the results in 5 parts as follows:

General data of the study sites

Proportions of motorcycles at the Khon Kaen Hospital Intersection were 51-55% of the total traffic amount during peak hours and 30-45% during off-peak hours. The proportions of motorcycles at Khon Kaen University Junction were 55-60% during peak hours and 38-48% during off-peak hours. At each intersection, the cycles of signals and the patterns of traffic lights assignment were similar for the period before and after the BBP began.

Table 2
General information of the study areas

<table>
<thead>
<tr>
<th>Intersections</th>
<th>Traffic data Volume in peak time (^a) (Veh./hr.)</th>
<th>Before</th>
<th>BBP</th>
<th>Volume in off-peak time (^a) (Veh./hr.)</th>
<th>Before</th>
<th>BBP</th>
<th>Traffic Signals (^b) (Sec.)</th>
<th>C</th>
<th>G</th>
<th>Y</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khon Kaen Hospital</td>
<td>2,133</td>
<td>2,104</td>
<td></td>
<td>1,279</td>
<td>1,253</td>
<td></td>
<td>16</td>
<td>2</td>
<td>30</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Khon Kaen University</td>
<td>675</td>
<td>664</td>
<td></td>
<td>389</td>
<td>372</td>
<td></td>
<td>75</td>
<td>30</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Remark:

\(^a\) Refer to traffic volume in critical direction

\(^b\) Refer to traffic signal data in critical direction (Equal time in two periods)

C, G, Y, and All refer to cycle rang time, green time, yellow time, and all red time, respectively.

The total start-up lost time analysis

Table 3 illustrates the comparison of the total start-up lost time before the BBP and after the BBP implementation. The analysis showed that the BBP could reduce the total start-up lost time at approximately 30-38% for Khon Kaen Hospital Intersection and at 22-40% for Khon Kaen University Junction. The total start-up lost time could be more reduced during peak hours than during off-peak
hours. The decreasing percentage depended on the proportion of motorcycles in each traffic lane.

### Table 3
Results of total start-up lost time

<table>
<thead>
<tr>
<th>Intersections</th>
<th>Total start-up lost time (Sec.)</th>
<th>Peak time a (Differences %)</th>
<th>Off-peak time a (Differences %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before BBP</td>
<td>Before BBP</td>
<td>Before BBP</td>
</tr>
<tr>
<td>1. Khon Kaen Hospital</td>
<td></td>
<td>3.92 (-31.17%)</td>
<td>3.60 (-18.78%)</td>
</tr>
<tr>
<td>- First lane b</td>
<td>5.70</td>
<td>3.60</td>
<td>2.92 (-18.78%)</td>
</tr>
<tr>
<td>- Second lane b</td>
<td>5.29</td>
<td>3.29</td>
<td>2.49 (-25.27%)</td>
</tr>
<tr>
<td>- Third lane b</td>
<td>3.88</td>
<td>2.48 (-35.63%)</td>
<td>1.27 (-38.79%)</td>
</tr>
<tr>
<td>- Right lane c</td>
<td>5.35</td>
<td>2.85</td>
<td>2.10 (-26.49%)</td>
</tr>
<tr>
<td>- Avg. all lane</td>
<td>5.05</td>
<td>2.90 (-37.36%)</td>
<td>-2.19 (-29.83%)</td>
</tr>
<tr>
<td>2. Khon Kaen University</td>
<td></td>
<td>2.35 (-32.86%)</td>
<td>2.50 (-26.40%)</td>
</tr>
<tr>
<td>- First lane b</td>
<td>3.50</td>
<td>5.50 (-46.18%)</td>
<td>3.45 (-18.25%)</td>
</tr>
<tr>
<td>- Second lane b,c</td>
<td>10.22</td>
<td>4.22</td>
<td>2.65 (-22.32%)</td>
</tr>
<tr>
<td>- Avg. all lane</td>
<td>6.86</td>
<td>3.93 (-39.52%)</td>
<td>3.36 (-22.32%)</td>
</tr>
</tbody>
</table>

Remark:

- Refer to average of total start-up lost time in critical direction,
- Refer to direction straight, c. Refer to turning direction

### Comparison of the waiting zones for the traffic signals

Figure 5 illustrates the proportions of motorcycles pausing and waiting for the traffic lights prior to and after the BBP implementation. It was found that Zone B (The area behind the pedestrian crossing to the front of the first car in the line during the period before the BBP, and the Green Zone or the specific-pausing zone for motorcycles during BBP implementation) could mostly make the motorcyclists change their pausing point. The greatest changes were from 10-15% to 73-78% at both periods. The Bike Box at the intersection with 4 traffic lanes was used more than the intersection with 2 traffic lanes. That is to say, the change was from 13% to 88% and from 5% to 74%, respectively. In other zones, the proportions decreased during the BBP implementation. Nevertheless, in Zones C & E, or at the furthest left and right zones, motorcycles still paused. This was due to certain specific behaviors of individuals who did not want to be at the front of the waiting line and did not want to share the space with other motorcycles.
Road accidents at the study sites

The results of the comparison of total losses from road accidents in the study areas during the time before the BBP and 12 months after the BBP commenced are shown in Figure 6. Most of the accidents found before and during the project implementation were found to involve motorcycles. After the BBP started, the overall number of accidents for all categories reduced at 50%, the number of slight injuries reduced at 44%, the number of severe injuries reduced at 60%, and no case of death was reported during both periods. However, the numbers recorded could be due to the COVID-19 situation.

Benefit-Cost ratio analysis

Table 4 shows that when the BBP was implemented, the cases of slight injuries and severe injuries decreased. Thus, it can be said that the benefit-cost ratio increased from reduction of losses from traffic accidents in the study areas. When compared to the construction costs of the BBP, the benefit-cost values in relation to the present year are higher than the cost of investment. The BBP has proved its worthiness for investment.
Table 4
The project evaluation by Benefit-Cost ratio

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Average cost and worthwhile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the Project (Cost)</td>
<td>82,095 Dollars (2.95 million bahts)</td>
</tr>
<tr>
<td>After the Project began (Cost)</td>
<td>32,669 Dollars (1.26 million bahts)</td>
</tr>
<tr>
<td>Construction budget (2 intersections)</td>
<td>25,195 Dollars (0.89 million bahts)</td>
</tr>
<tr>
<td>Benefit-Cost ratio</td>
<td>1.90 &gt; 1.00 (It is worthwhile.)</td>
</tr>
</tbody>
</table>

Remark: 1 dollar is worth 35.32 Thai Baht.

Conclusions

This article demonstrates the efficiency of the Bike Box Project in terms of traffic engineering, road safety, and the worthiness for investment. The evaluation was conducted on 4 indicators, namely: 1) the total start-up lost time, 2) the proportions of the pausing positions of motorcycles at the intersection, 3) the accident statistics, and 4) the worthiness for investment. The results of the study show that the BBP is advantageous in all categories of evaluation, as follows: 1) It can reduce the total start-up lost time at roughly 31-46% during peak hours and roughly 18-38% during off-peak hours. This agrees with the results of many research studies, especially the studies conducted in Thailand [13]. The factors involved in the reduction depend on the quantity of motorcycles in each traffic lane. 2) After the BBP commenced, approximately 73-78% of motorcyclists parked in the Bike Box, which agreed with overseas research [10, 11, 13], and therefore, pausing in other zones could be decreased. However, there were still motorcycles pausing in the furthest left lane and furthest right lane. 3) The BBP implementation contributed to reduction of traffic accidents, both in relation to the number of cases and severity. 4) The BBP has proved its worthiness for investment.

The results of the study confirmed the benefits from the implementation of the Bike Box Project, in terms of traffic engineering, road safety and worthiness for investment. The Bike Box Project can be expanded to other areas both in the country and abroad, especially in urban areas where motorcycles are predominant and where budget is not high, for it can lead to investment worthiness. In addition, there are aesthetic advantages at the intersection. The BBP can be one important measure to reduce traffic problems and accidents from motorcycles at both the micro- and macro-levels.

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References


