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*Article*

# A Study of a Flyover-Bridge - Improved Intersection

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**Abstract.** To reduce traffic congestion at an at-grade intersection near a big city, one method is construction a flyover bridge at the old junction in two directions on one of the main highways. The flyover facilitates the traffic flow in the directions of the bridge, but the infrastructure cannot fully solve all of the problems especially on the secondary road. Under the bridge, although it relieves the traffic congestion at the intersection; the traffic signal still uses the same control as the "before" situation, that is the fixed time control plan. With the flyover bridge in place, it was found that about 30-35% of all traffic volumes diverted to the bridges, and time delay reduced by 30% over the same period. This paper which is one part of the first author's thesis, presents the issues that still exist at the flyover-improved junction and makes suggestions to increase the benefits of the flyover such as creating a new cycle and phase times and improving the physical area under the bridge. The SIDRA software is used to determine the appropriate fixed time plans, and using the process of Road Safety Inspection (RSI) to audit the safety of the site and presents the improvements to the remaining problems.

**Keywords:** Flyover-bridge intersection, SIDRA, RSI, signalized intersection, time delay.

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## 1. Introduction

The flyover-bridge intersection is an intersection that has a special bridge constructed over an at-grade intersection to allow for the free flow in two directions on one of the main road – to increase capacity of traffic flow and reduce the traffic congestion in both of these directions, but underneath of the bridge, the existing traffic signalization is still used to control traffic as the situation before (Fig. 1). This model is used for increasing traffic capacity at a bigger intersection in suburb area, there are 29 flyover intersections in Thailand (excluding Bangkok and its vicinity) [24]. In this study 5 existing flyovers were selected covering all regions of Thailand.

According to the guidelines for controlling traffic at an intersection, [10] it used traffic volume as criteria to choose a type of junction, for traffic volume about 25,000 to 45,000 vehicles/day, two levels of control should be used. The flyover only facilitates traffic flows in the directions of the bridge, but the infrastructure cannot fully solve all of the problems especially on the secondary road. This research presents issues that still exist at the flyover intersection and recommend improvements to the problems

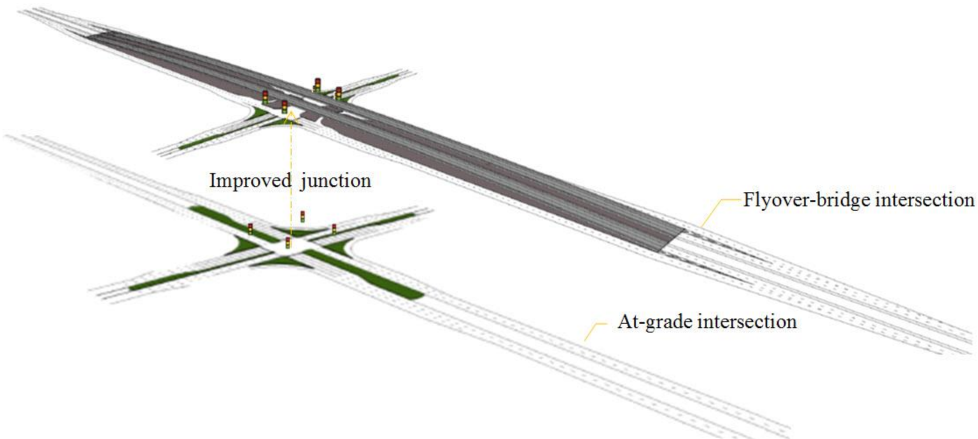


Fig. 1. The layout of an at-grade intersection converted to a flyover-bridge intersection.

## 2. Objectives

- To study the remaining traffic and road safety issues at the flyover-improved intersections
- To make suggestions to further improved the performance of existing flyover-bridge improved intersections

## 3. Scope of Study

- This study which is one part of author's thesis, presented the problems that could still be found at the flyover areas such as road safety and its consequence compared with "before" situation
- The Signalized (and unsignalized) Intersection Design and Research Aid (SIDRA) is an advanced micro-analytical tool used for evaluating of alternative intersection designs in terms of capacity, level of service and a wide range of performance measures, including time delay, queue length, as well as fuel consumption, pollutant emissions and operating costs [1]. In 2012, the latest versions of the software were in use by over 1350 organizations in 70 countries such as USA, Australia, South Africa, Canada, New Zealand, Malaysia, Singapore, as well as over 140 organizations in Europe. This study used SIDRA to analyze traffic data and determine an optimum cycle-phase time of three peak times traffic data of case studies,
- The process of Road Safety Inspection (RSI) was used to audit the sites and highlighted critical issues in the hazardous zone.

## 4. Research Framework

A research framework consists of six steps (Fig. 2), the first is selecting 5 case studies covering all regions, the second is data collection consists of physical data, traffic data and accident statistics, the third is data assessment, fourth is data analysis and comparison data consists of the control at intersection, road safety, accident cost and used the SIDRA software to find the results in terms of traffic control such as phase times, time delay, vehicle queue length and level of service, then conclusion step and the last step is recommended to improve the case studies to better control.

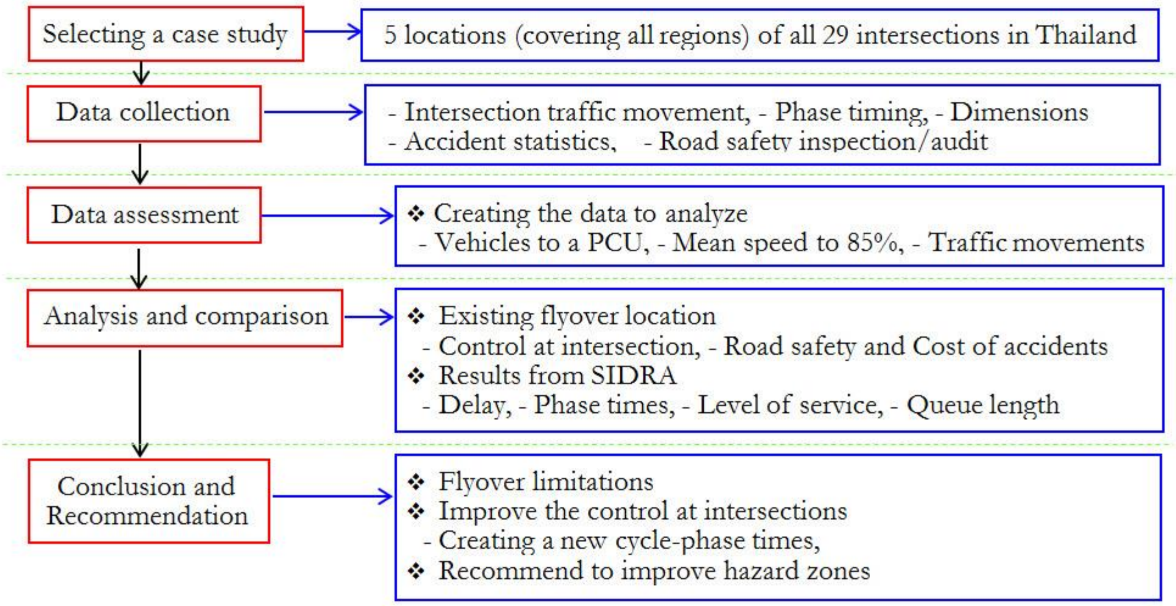


Fig. 2. Research framework.

## 5. Data Collection

Not only on-fields collected data, but also the important information such as the construction costs, number of casualties and flyover designs, in Table 1 shows these items of 5 example cases. Each location is different in the design and management because it is designed by depending on its physical locations, some locations must have an auditor for recording and inspection of these information more than six people such as at Udon Thani case study location – the dimension of the intersection is very big (it's located on the bypass highway), consequently, we need help with video record for checking traffic movement of each direction on the ground level, furthermore, author can also check and calibrate to the SIDRA software such as road user behavior and cycle phase time.

## 6. Data assessment

### 6.1. Traffic Data Collection

Under the bridge; the traffic movement is counted at each leg/direction that vehicles entering to the intersection, at locations marked as 1, 2, 3 and 4, on the bridge; the traffic movement counted at locations marked as A, B, C and D (Fig. 3). The vehicles were categorized into five groups; 2-wheelers (MC), 3 and 4-wheelers (PC), 6-wheelers (MT), Bus (B) and Heavy-duty (L) [19]. The traffic volume is converted to equivalent passenger car unit (PCU) by the unit factor 0.33, 1.0, 1.75, 2.25 and 2.25 respectively [22].

The timing of vehicle delay and queue length are counted in a cycle phase time of traffic signal on three peak times (as shown in Fig. 3).

The traffic signal programs used the same control as the situation of the at-grade intersection, 4 in 5 case studies are controlled by fixed-time control plan throughout the day (as shown in Fig. 4).

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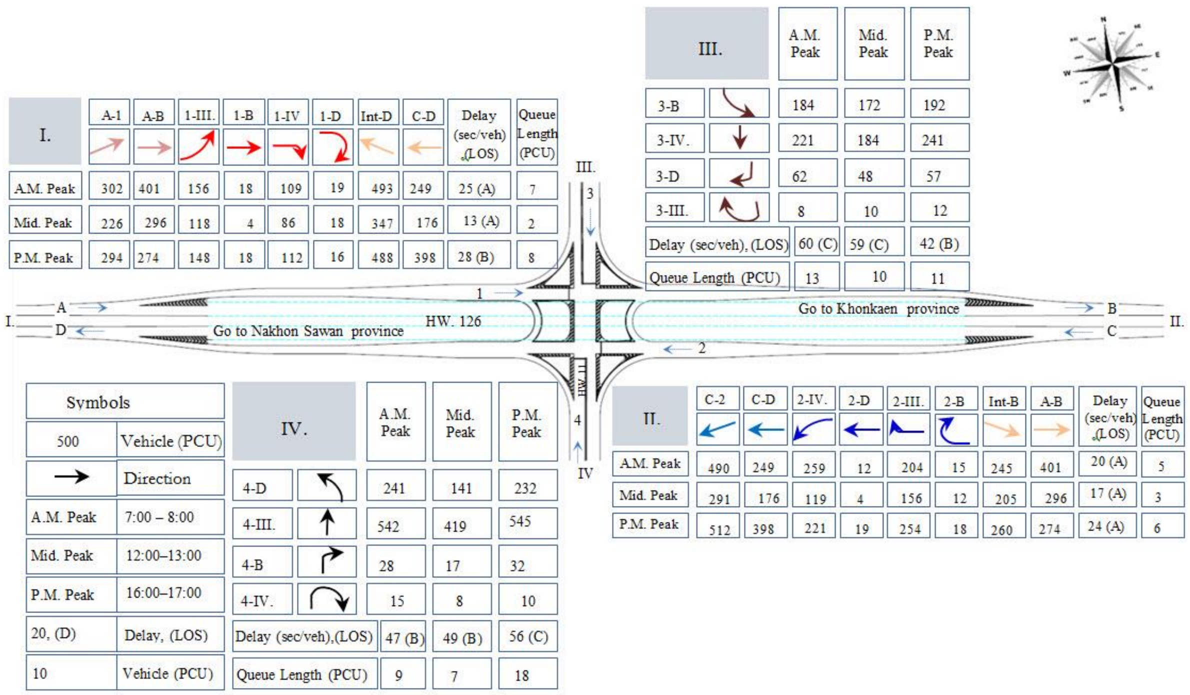
Table 1. Collected data of 5 existing flyover-bridge intersections.

| Items \ Location | 5 existing flyovers (province in Thailand) | | | | |
|---|---|---|---|---|---|
| | Songkhla | Udon Thani | Rayong | Phatthalung | Phitsanulok |
| 1. Flyover locations | HW# (4 + 43) | HW# (22+216) | HW# (36+3139) | HW# (4 + 41) | HW# (11+126) |
| 2. Traffic survey<br>- vehicle movement<br>- delay and queue length | Collected data at three peaks-time a day (07:00 - 08:00 am., 12:00 am. – 01:00 pm., and 04:00 – 05:00 pm.) in a working day. | | | | |
| 3. Cycle times (fixed-time), (second/cycle) | 176, 176, 176 | 178, 178, 178 | 160, 160, 160 | 184, 144, 184 | 159, 159, 159 |
| 4. Average speed (km/hr) | 65 | 62 | 68 | 58 | 64 |
| 5. Dimension (Bridge length (meter)) | 390 | 750 | 340 | 410 | 670 |
| 6. Road Safety Inspection<br>- Conflict points<br>- No. of accidents (3 years) | 64<br>27 | 64<br>40 | 40<br>30 | 64<br>17 | 66<br>37 |
| 7. Construction cost (Million Baht) and Opening date | 117.00<br>Aug, 1996 | 242.20<br>2008 | 203.80<br>Aug, 2001 | 198.97<br>Sep, 2008 | 116.20<br>2002 |




*Source: Applied from Traffic and Highway Engineering* [11],

Fig.3. Traffic movement, Delay and Queue length information at 3 peak times (Phitsanulok case study)

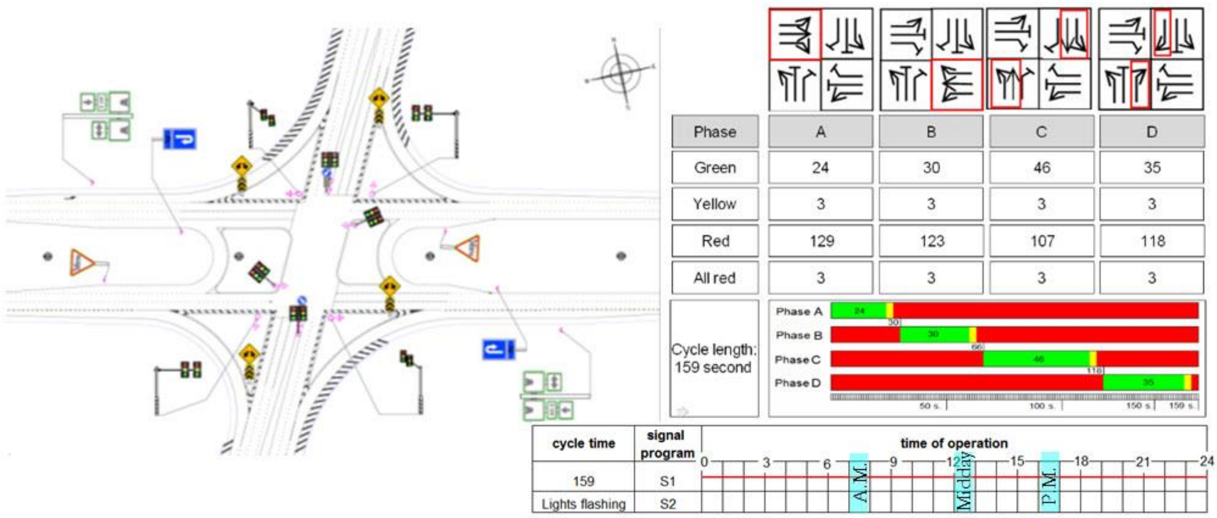



Fig.4. Traffic signal programs (Phitsanulok case).

Table 2 shows the passenger car units (PCU) data of both levels and cycle length of all case studies.

Table2. Passenger car units data per peak times and Cycle times.

| Items \ Location | | 5 existing flyovers (province in Thailand) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Songkhla | | | Udon Thani | | | Rayong | | | Phatthalung | | | Phitsanulok | | |
| Time period considers | | A.M. (7:00-8:00) | Mid (11:00-12:00) | P.M. (16:00-17:00) | A.M. (7:00-8:00) | Mid (11:00-12:00) | P.M. (16:00-17:00) | A.M. (7:00-8:00) | Mid (11:00-12:00) | P.M. (16:00-17:00) | A.M. (7:00-8:00) | Mid (11:00-12:00) | P.M. (16:00-17:00) | A.M. (7:00-8:00) | Mid (11:00-12:00) | P.M. (16:00-17:00) |
| Cycle time (second) | | 176 | 176 | 176 | 190 | 190 | 190 | 160 | 160 | 160 | 184 | 144 | 184 | 159 | 159 | 159 |
| PCU | on bridge | 1802 | 1038 | 1538 | 2470 | 2102 | 2969 | 3242 | 3146 | 3535 | 1965 | 1710 | 2182 | 650 | 472 | 672 |
| | at-grade level | 5643 | 5566 | 6521 | 5213 | 4701 | 5225 | 2383 | 1970 | 3070 | 4492 | 3516 | 4120 | 2036 | 1464 | 2071 |

## 6.2. Accident Statistics

Accident statistics of each location were collected for 3 years (2010-2012) from 3 agencies in Thailand consisting of Department of Highways (DOH), Police records and Emergency Medical Services (EMS). The statistics were used for computing costs of accident that occurred at these existing locations. Table 3 shows the number of casualties in 3 years of accidents. Eq. (1) was used to find an annual average accident cost, to describe the combined effects of the number and severity of the accidents in these case studies.

Table 3. Number of casualties and time of accidents, 3 years (2010 – 2012).

| Case studies (province) | Time of accident | | | Number of Casualties | | | DOH Damage | PDO |
|---|---|---|---|---|---|---|---|---|
| | Day | Night | Rain | Slight Injuries | Serious Injuries | Deaths | | |
| Songkhla | 12 | 15 | 0 | 24 | 1 | 2 | - | 27 |
| Udon Thani | 27 | 13 | 0 | 21 | 14 | 2 | - | 40 |
| Rayong | 15 | 15 | 0 | 20 | 10 | 3 | - | 30 |
| Phatthalung | 6 | 7 | 4 | 12 | 4 | 5 | - | 17 |
| Phitsanulok | 12 | 25 | 0 | 42 | 6 | 5 | - | 37 |
| Sum | 70 | 75 | 4 | 119 | 35 | 17 | None | 151 |

*Source: Accident statistics at the flyover areas: DOH. (2010 - 2012)* [3], *EMS. (2010 - 2012)* [4], [5], [6], [7], [8] *and Police records* [9], [12], [13], [14], [15]

$$\text{ACa} = \frac{A(F)*MCA(F) + A(Dis)*MCA(Dis) + A(SI)*MCA(SI) + A(LI)*MCA(LI) + A(PDO)*MCA(PDO)}{t} \quad (1)$$

*Source: RIPCORD-ISEREST (2005)*, [17]

where ACa: annual average accident cost ($/year);
A: number of accidents (acci);
MCA: mean cost per accident ($/acci) as shown in Table 4; and
t: the period of time under review (year).

The mean cost per accident in Thailand is used to estimate the accident cost, the number of casualties per unit is transformed to be the cost value (money), in this case used the mean value of the other provinces (in Table 4) to estimate.

Table 4. Mean cost per accident for various severities (2012).

| Severity | Thailand (Million Baht) | Bangkok (Million Baht) | Other Provinces (Million Baht) |
|---|---|---|---|
| Fatality *(F)* | 5.062 – 5.956 | 10.561 - 12.413 | 4.757 - 5.599 |
| Disability *(Dis)* | 5.114 - 6.910 | 11.611 - 13.934 | 5.608 - 6.729 |
| Serious Injury *(SI)* | 0.158 - 0.164 | 0.328 - 0.337 | 0.148 - 0.155 |
| Slight Injury *(LI)* | 0.0386 - 0.0389 | 0.1731 - 0.1733 | 0.0297 - 0.0298 |
| Property Damage Only *(PDO)* | 0.052 | 0.164 | 0.039 |

*Source: Mean cost of severities per road accident in Thailand: DOH. (2012)*, [2]

## 7. Data analysis

### 7.1. Description of Intersection Control

Although the control of intersection is improved by the installation of a flyover bridge, it still has many limits and can't fully solve the traffic problems that exist in similar situation of the at-grade intersection model such as vehicle delay, traffic congestion and road accidents. The bridge is just increasing the convenience for the road users in two directions on one of the two main roads while under the bridge, the same traffic control plans as the "before the flyover" were still in use. Even though it was found that about 30-35% of the total traffic volume diverted to the bridge and the vehicle delays reduced by 30% over the same period [18], the traffic flow situation on the secondary road is almost the same as that of the previous at-grade intersection.

The fixed-time cycle plan of the traffic signalization was used to control traffic volumes at ground level (4 in 5 case studies used only one plan of control throughout the day), it leads to an unnecessary loss of vehicle time. Table 5 further describes the issues relating to the flyover model that were found in this study, in terms of its advantages and disadvantages

Table5. Advantages and disadvantages of the flyover intersection.

| Items | Disadvantages | Advantages |
|---|---|---|
| The bridge over an at-grade level | - The visual landscape is obscured, especially the commercial building that located near this area. | - Convenient for road users using the bridge, free flow on the bridge |
| Traffic capacity | - Small increase in traffic capacity for the secondary road | - Empowered to handle large traffic volume, especially on the main road |
| Delay & Queue length | - The delay and queue on secondary road are quite the same as the situation of the at-grade intersection | - Reducing a number of delays and vehicle queues in the direction of the bridge constructed (main road)<br>- Saving travel time, increasing vehicle speed, especially, on the main road from 29.8 km/hr. to 52.5 km/hr. (at 85% vehicle speed) |

| Items | Disadvantages | Advantages |
|---|---|---|
| Traffic control | - Traffic signalization still uses the fixed-time control plans as the previous situation of at-grade intersection, which does not fully utilize the benefits of having a flyover | - Reducing time for waiting at the intersection (by adjusting a new cycle time for flyover situation) |
| Road Safety | - In the flyover area, the hazard zone is spread to more zones, especially at the approaching and exiting zones of the bridge | - Reduce traffic conflict points at the junction<br>- Reducing rear-end collisions |
| Cost and benefit | - During construction, road accidents and vehicle time delay incurred extra costs<br>- Higher maintenance costs | - The flyover is an essential part of the highest type of highway, the expressway or freeway. It has cheaper construction cost than other types of grade separations.<br>- No land needs to be expropriated. |

### 7.2. Road Safety Inspection [16], [20], [21]

According to the physical data, the area of intersection has increased compared to the old one and under the bridge, the existing traffic signalization still uses the same previous fixed time control plans; hence, similar problems as those of the previous at-grade intersection still exist. Furthermore the hazardous zone has spread out to other zones in the flyover area (as shown in Fig. 10) as follows:

*At the approaching and exiting zone of the bridge (bottleneck)*; road users behavior at an approaching zone may lead road crashes from weaving conflicts because the vehicles cutting in sharply from the right lane to the left lane before entering the auxiliary lanes or heading for the bridge. At the exiting zone, conflicts of vehicles merging can lead to road crash because some vehicles from the left auxiliary lane cutting across the chevron markings to the right lane of the main road abruptly (Fig. 5).


Fig. 5. Traffic conflicts at the approaching and exiting zones.

*The drainage ditches on the median of the road,* at the beginning of the bridge there are illegal paths that were used by motorists for crossing to opposite direction, when a high speed vehicle on the main road passes this area, a crash may occur as a result of the vehicles on the main road hitting the motorcycle emerging from the drainage median (Fig. 6).

Fig. 6. An illegal movement at the drainage ditches on the median of the road.

*The U-turn under the bridge*, it is located near the stop line markings on the bridge direction about 17 meters or 3-vehicle length. For Udon Thani case study, this type of U-turn which allows movements in two directions and becomes an illegal channel for motorcycles, could cause the right or left angle collisions and head-on collisions (Fig. 7).

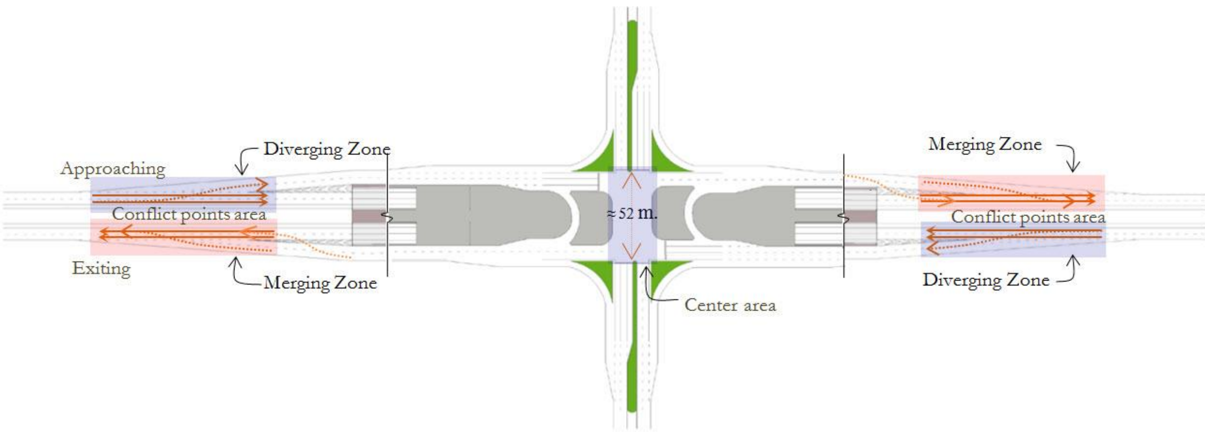
Fig.7. Illegal movements at U-turn under the bridge.

*On the shoulder of the road*, there are many heavy trucks that stop and wait for repair and recess. Some incidents may occur when motorcycles using the shoulder at night time and cannot see a truck in time, a rear-end collision could result (Fig. 8).

Fig. 8. A fixed object - heavy trucks stopped for repair and recess at the shoulder of the road near flyover intersection area.

*Other problems near the flyover area*, because the flyover model doesn't have a standard design, the Phitsanulok case study has a different traffic control for example the U-turn is opened on secondary road (Fig. 9(A)), for the Udon Thani case study, a supermarket is located near the flyover location (Fig. 9(B)) and for the Phatthalung case study, the U-turn has no auxiliary lane (Fig. 9(C)).


Fig. 9. Other problems near the flyover areas.




*Source: Applied the conflict points from Traffic and Highway Engineering (page number 283)* [11],

Fig. 10. Hazardous zones in the flyover intersection area.

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### 7.3. Cost of Accidents

To assess the accident cost at the existing flyover intersections (5 case studies), Eq. (1) is used to estimate the annual average accident cost.

Because the accident statistics from the 3 agencies did not record the number of people who were disabled by the accidents; the authors used estimate as given by Dr. Nima Asgari [23] who stated that "every crash of road accidents in one year will be one person's death, injured 20 people and 1 of 20 people become to a disabled person", so, if there are 100 injured people, 5 people may become disabled. For this reason this paper uses 5% of the slightly injured number as the number of disabled people.

Equation (1) is used to calculate an annual average accident cost (ACa) as shown in Table 6.

Table 6. Annual average accident cost of 5 case studies.

| Mean cost per accident / Locations | | Number of casualties (3 years recorded) | | | | |
|---|---|---|---|---|---|---|
| | | Songkhla | Udon Thani | Rayong | Phatthalung | Phitsanulok |
| Fatal | 5,178,000 Baht | 2 | 2 | 3 | 5 | 5 |
| Disabled | 6,168,500 Baht | 1.2 | 1.05 | 1.0 | 0.6 | 2.1 |
| Seriously injured | 151,500 Baht | 1 | 14 | 10 | 4 | 6 |
| Slightly injured | 29,750 Baht | 24 | 21 | 20 | 12 | 42 |
| Property damage only | 39,000 Baht | 27 | 40 | 30 | 20 | 37 |
| ACa [Baht/year] | | 6,558,900 | 7,046,225 | 8,327,500 | 10,444,700 | 14,148,450 |
| | | Avg ACa = **9,305,155** Baht/year | | | | |

### 7.4. Analysis Results from SIDRA

This software is an advanced micro-analytical tool used for evaluating of alternative intersection designs in many terms such as capacity, level of service, time delay, queue length, as well as fuel consumption, pollutant emissions and operating costs [1]. In this study, the software was used to analyse the performance of each flyover improved intersection and point out the average delay, average queue length and level of service (Table 7).

And to further improve the performance of the intersections, the same data were used to calculate the optimum cycle-phase times by using the lowest time delay as the indicator. Table 8 shows the optimum cycle time and its results for 3 time periods of the 5 case studies.

Table 7. Analysis of field data by SIDRA for 3 time periods.

| Locations | Songkhla | | | Udon Thani | | | Rayong | | | Phatthalung | | | Phitsanulok | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items / Time | A.M. | Mid | P.M. | A.M. | Mid | P.M. | A.M. | Mid | P.M. | A.M. | Mid | P.M. | A.M. | Mid | P.M. |
| Cycle time (sec) | 176 | 176 | 176 | 190 | 190 | 190 | 160 | 160 | 160 | 184 | 144 | 184 | 159 | 159 | 159 |
| Average delay (sec/veh) | 159 | 151 | 195 | 204 | 162 | 191 | 46 | 45 | 46 | 207 | 165 | 232 | 37 | 36 | 38 |
| Average queue length (vehicle) and (meter) | 83 & 543 | 80& 516 | 96& 563 | 72& 474 | 56& 375 | 63& 413 | 13& 77 | 11& 66 | 15& 87 | 66& 395 | 35& 216 | 65& 407 | 11& 66 | 9& 53 | 12& 67 |
| Level of service | F | F | F | F | F | F | D | D | D | F | F | F | D | D | D |

Table 8. Optimum cycle-phase time by SIDRA for 3 time periods.

| Locations | Songkhla | | | Udon Thani | | | Rayong | | | Phatthalung | | | Phitsanulok | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items / Time | A.M. | Mid | P.M. | A.M. | Mid | P.M. | A.M. | Mid | P.M. | A.M. | Mid | P.M. | A.M. | Mid | P.M. |
| Cycle phase time (sec) | 130 | 140 | 150 | 185 | 160 | 170 | 115 | 106 | 115 | 178 | 178 | 178 | 80 | 80 | 80 |
| Average delay (sec/veh) | 153 | 143 | 175 | 140 | 98 | 109 | 38 | 37 | 39 | 139 | 76 | 142 | 28 | 27 | 28 |
| Average queue length (vehicle) and (meter) | 65& 432 | 67& 446 | 86& 501 | 64& 422 | 44& 292 | 53& 336 | 10& 61 | 10& 57 | 13& 76 | 58& 347 | 32& 193 | 57& 357 | 10& 60 | 7& 43 | 9& 54 |
| Level of service | F | F | F | F | F | F | D | D | D | F | E | F | C | C | C |

## 8. Conclusion and Recommendations

This study which is one part of the first author's thesis, presented the performance of the 5 case studies flyovers and suggested improvements to 29 flyover intersections in Thailand.

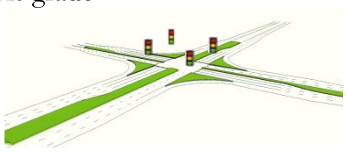
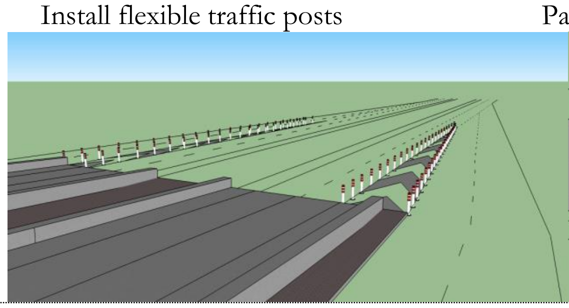
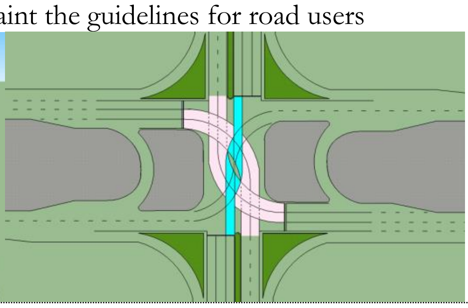
An at-grade intersection was upgraded with an installation of a flyover at a cost of about 175 million THB, to increase capacity of the intersection and reduce vehicle delay and long queue at the at-grade level, the flyover is one of the methods that supported traffic volume about 25,000 – 45,000 vehicle/day [10].

In terms of benefits (the second part study of the author's thesis: "a case study of an at-grade intersection converted to the flyover intersection") [18], it was found that about 35-40% of the total traffic volume diverted to the flyover, and despite an increase in traffic volume of +29.46%, at the intersection, the vehicle delays were reduced by 30.41% over the same period, and saving in travel time and vehicle operation cost amount to 421.65 Million THB.

The results of study, however, show that traffic signalization for both the existing at-grade situation and flyover upgraded situation has been and is still controlled by fixed time control plans, there is still long queue and delay especially on the secondary highways. Hazardous zones in the flyover area spread out to other zones which are at the approaching and exiting areas, at the drainage ditches on a median of roads, at the U-turn under the bridge and at the crossroad under flyover, furthermore, the conflict points increased from 50 points to 64 points. Accident cost is about 9.3 Million THB/year/flyover intersection, average accident number is about 30 crashes, 30 injured people and 1 person death per year.

To improve the performance of the flyover intersections, the SIDRA software (version 5.1) was used to calculate the optimum cycle-phase times based on the lowest time delay. In terms of road safety improvement, the Road Safety Inspection guideline was used for site inspections and recommendations are suggested as shown in Table 9.

Table 9. Conclusion data and suggestion to improving an existing flyover intersection.

<table>
<tr><th>Items</th><th colspan="4">Intersection</th></tr>
<tr><td>- Figure</td><td>At-grade<br><br>Previous</td><td colspan="2">Flyover-bridge<br><br>Present</td><td>Grade separation<br><br>Future</td></tr>
<tr><td>- Construction cost (approximate)</td><td>40,000 Baht/square^2</td><td colspan="2">75,000 Baht/square^2<br>(Avg = 175.63 million THB)</td><td>80,000 Baht/square^2</td></tr>
<tr><td>- Traffic capacity of each type</td><td>≈1,500 – 25,000 vehicles/day</td><td colspan="2">≈25,000 – 45,000 vehicles/day</td><td>> 45,000 vehicles/day</td></tr>
<tr><td>- Situations</td><td colspan="2">Analysis of field data by SIDRA</td><td colspan="2">Optimum cycle times by SIDRA</td></tr>
<tr><td>· Phase time</td><td colspan="2">Avg cycle phase time = 174 second/cycle</td><td colspan="2">= 136 second/cycle (reducing to 38 second)</td></tr>
<tr><td>· Delay</td><td colspan="2">Avg Delay = 127 second/cycle</td><td colspan="2">= 92 second/cycle (reducing to 27.5%)</td></tr>
<tr><td>· Queue length</td><td colspan="2">Avg Queue = 45 vehicles or 287 meters</td><td colspan="2">= 29 vehicles or 245 meters (reducing to 14.0%)</td></tr>
<tr><td>· LOS</td><td colspan="2">between F to E</td><td colspan="2">between F to D</td></tr>
<tr><td>Accidents</td><td colspan="4">Average number of accidents = 30 crash /location/year</td></tr>
<tr><td>No.of injured</td><td colspan="4">Average number of injured = 30 people /location/year</td></tr>
<tr><td>Death</td><td colspan="4">Average a number of deaths = 1 person /location/year</td></tr>
<tr><td>Accident cost</td><td colspan="4">Average accident cost = 9,305,155 Baht/year/location (285,724.09 USD)</td></tr>
<tr><td>- Recommend to improve the existing flyover intersection</td><td colspan="4">Install flexible traffic posts<br><br>Paint the guidelines for road users<br><br>- At the beginning/ exiting of the bridge flexible traffic posts should be installed along the line of the nose-ghost island, the direction arrows should be painted on the weaving zones, installation of traffic signs: speed limit sign, give way sign and intersection warning sign.<br>- At the drainage ditches on the median of the main road concrete barriers should be installed to close off the illegal paths<br>- At the U-turn under the bridge, one way traffic control should be used.<br>- At the junction underneath the bridge, guideline should be painted for road users in all directions.<br>- For a typical existing flyover intersection, around 60-80% time delay is on the secondary road, traffic engineer should design a new cycle-phase times of traffic signalization especially the yellow phase-time which should be appropriately designed in accordance with the size of the intersection.</td></tr>
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## References


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