IS IT A TIMELY APPROACH FOR BUS ACCIDENT INVESTIGATION IN THAILAND?

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Abstract

Worldwide it is estimated that 1.2 million people lose their lives and as many as 50 million injuries and disabilities from road accidents every year. It is more infliction burden for developing countries like Thailand when Thai statistics indicate over 12,000 people became fatal with accident costs comprising about 3.4 percent of GNP. Among all types of vehicles involved, bus accident is considered a major public concern as transportation of many innocent people is involved. The gravity of the situation is getting more public concern as annually 4,000 bus accidents occurred in Thailand. Single vehicle-bus accident with running off road accounts a major portion of bus accidents. This research attempts to investigate such single vehicle bus accidents to collect detailed information of crash scene, vehicle and occupants. The findings of this research indicate the possible factors leading to collision with a particular demonstration of the case studies.

Key Words: accident investigation, bus accidents, roadside hazard

1. INTRODUCTION

The death tolls with injuries from road crashes in Thailand significantly affect Thai economic and social structure. The actual crash victims are much higher than the official statistics of 12,858 fatalities reported by the Royal Thai Police (GRSP, 2006). This situation creates a serious long term economic crisis when the earning members of the family become the victims of road crashes. In addition, the monetary losses due to road crashes account about US$300,000 per hour resulting in 3.4 percent of GNP annually (Tanaboriboon, 2004). This figure is not only a burden for developing countries but also points out the lack of the seriousness of the concerned road safety authorities. It is the opportune time to think and initiate some innovative road safety research to understand the crash scenarios and events prior to crash, in crash and post crash phase. In-depth study of road crashes focusing on investigation of the contributory factors leading to crashes provides such scope to have a
better understanding and a scientific way of analyzing the factors behind the consequences of the crash dynamic situations.

2. BACKGROUND

A study by Tanaboriboon (2004) in the final report for ADB-ASEAN Road Safety Program presented about the crash situation in Thailand with the records of two decades for better understanding of the seriousness of the situation as shown in Figure 1 (updated with statistics of 2003 and 2004). Crash cases increased to 124,530 in 2004 followed by 102,610 in 1994 from 18,445 in 1984 indicating quite high figure in terms of percentage (about 575% increase). However, after 1994 the number decreased to 67,800 cases but again followed the rising trend from 2001.

![Figure 1 Road traffic accidents in Thailand, 1983 – 2004](Source: Tanaboriboon (2004))

Figure 1 shows the injuries per 100,000 populations sharply increases starting from 88.6 in 2001 to 148.6 in 2004 (about 68% increases). However, the deaths per 100,000 populations have not increased maintaining little fluctuations in its own trend.

A study by Suriyawongpaisal and Kanchanasut (2002) also mentioned about the situations of crashes in Thailand by setting accident in the 2nd rank among other causes of death as presented in Table 1.
Table 1 Main causes of death in Thailand, 1998

<table>
<thead>
<tr>
<th>Causes</th>
<th>No. of Deaths</th>
<th>Deaths/100,000 Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diseases related to blood circulation (I00-I99)</td>
<td>59,601</td>
<td>98.6</td>
</tr>
<tr>
<td>External causes: accidents etc. (V01 – Y89)</td>
<td>37,662</td>
<td>62.3</td>
</tr>
<tr>
<td>Cancer (C00 – D48)</td>
<td>26,478</td>
<td>43.8</td>
</tr>
<tr>
<td>Respiratory diseases (J00 – J98)</td>
<td>20,415</td>
<td>33.8</td>
</tr>
<tr>
<td>Infectious &amp; some parasitic diseases (D50 – D89)</td>
<td>16,894</td>
<td>27.9</td>
</tr>
<tr>
<td>Diseases of blood and blood production organs, etc. (D50 – N98)</td>
<td>8,806</td>
<td>14.6</td>
</tr>
<tr>
<td>Digestive system (K00 – K92)</td>
<td>8,400</td>
<td>14.3</td>
</tr>
<tr>
<td>Diseases of nervous system (G00 – G98)</td>
<td>8,400</td>
<td>13.9</td>
</tr>
<tr>
<td>Diseases of reproductive and urinary system (N00 – N98)</td>
<td>5,242</td>
<td>8.7</td>
</tr>
<tr>
<td>Diseases of endocrine glands, etc. (E00 – E88)</td>
<td>4,941</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Source: Medical Institute for Accidents and Disasters, Division of Health Statistics, Bureau of Health Policy and Planning. Bangkok: Ministry of Public Health; 1999

However, this study also mentioned, “…Nearly two decades after the enactment of the comprehensive laws related to road safety in 1979, advocacy groups had not entered the policy arena of road safety. This might reflect the fact that the public views road crashes as acts of God or as accidents as such, so nothing could be done to avoid them.”

3. BUS ACCIDENTS – URGENT RESEARCH NECESSITY

Bus accidents are leading to serious impact on national road safety issue involving public transit carrying large number of passengers to be either fatal or seriously injured. One serious bus accident could cause undesirable consequences where many lives are involved and threatened to injuries where literally no protection system is usually installed in the bus. A study by Taneerananon and Satapan (2006) shows that on an average 4,000 bus accidents occur annually in Thailand accounting 3% of total vehicles involved in accidents. Surprisingly, bus accidents in Bangkok alone constitute 2,600 cases which are 65% of total national bus accidents annually. Referring to the statistics of Royal Thai Police, this study also shows the number of bus accidents in different regions in 2005 as presented in Table 2.

Table 2 Number of bus accidents in different regions (2005)

<table>
<thead>
<tr>
<th>Regions</th>
<th>No. of Bus Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central (except Bangkok)</td>
<td>537</td>
</tr>
<tr>
<td>Northern</td>
<td>290</td>
</tr>
<tr>
<td>North-Eastern</td>
<td>289</td>
</tr>
<tr>
<td>Southern</td>
<td>285</td>
</tr>
<tr>
<td>Western</td>
<td>168</td>
</tr>
<tr>
<td>Eastern</td>
<td>127</td>
</tr>
</tbody>
</table>

Source: Royal Thai Police

Table 3 shows the number of buses and total vehicles involved in accidents in different years in whole Thailand. The number of buses involved in accidents decreased from 1998 to 1999 but the trend increased from 3343 in 1999 to 4509 in 2003 whereas the total vehicles involved in the accidents kept increasing from 1999 to 2004.
### Table 3: Bus accidents statistics

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Accidents</th>
<th>No. of Buses Involved</th>
<th>All Types of Vehicles Involved in Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>73,725</td>
<td>3,717</td>
<td>120,077</td>
</tr>
<tr>
<td>1999</td>
<td>67,800</td>
<td>3,343</td>
<td>107,409</td>
</tr>
<tr>
<td>2000</td>
<td>73,737</td>
<td>3,533</td>
<td>114,488</td>
</tr>
<tr>
<td>2001</td>
<td>77,616</td>
<td>3,618</td>
<td>121,297</td>
</tr>
<tr>
<td>2002</td>
<td>91,623</td>
<td>3,823</td>
<td>146,008</td>
</tr>
<tr>
<td>2003</td>
<td>107,565</td>
<td>4,509</td>
<td>172,254</td>
</tr>
<tr>
<td>2004</td>
<td>124,530</td>
<td>4,433</td>
<td>191,208</td>
</tr>
</tbody>
</table>

Source: The Royal Thai Police

Fatalities and injuries from bus accidents involving buses of Transport Company, a semi government enterprise which holds all the long distance route licenses, and it affiliates buses decreased from 1997 to 2000, but all these statistics increased from 2000 to 2001 (Taneerananon and Somchainuek, 2005).

One study by Taneeranonon and Cheewapattanmuwong (2001) indicated that the estimated number of bus accidents constitute some 5% of road crashes in Thailand. However, considering the fatalities from bus accidents, a study by Somchainuek (2002) found that an estimated 1,500 people are killed annually with some 5,400 injuries. The high number of fatalities and injuries are leading to create more concerns and a growing need to conduct pragmatic research studies to determine the possible causes of bus accidents and to prevent or reduce the crash and injury severity due to bus accidents.

The results of accidents statistics of Bureau of Traffic Safety under Department of Highways from 1997-2000 revealed that 3,000 buses were involved in accidents resulting in 1,500 fatalities. However, more than 50% of the crashes were caused by single bus ended up in overturning as a common pattern. Most of these single bus accidents were influenced by the driver’s error with speeding (71.9%) ranking the top. A study by Somchainuek (2002) revealed that 52.5% bus drivers drove 4-6 hours without taking a rest from the interview of accident involved bus drivers.

A study by Taneerananon and Somchainuek (2005) also demonstrates that single bus accidents comprise 60% of total major bus accidents in 2004 in Thailand as shown in Table 4. This study also indicated that the roll-over strength of inter-city buses in case of run-off the road and roll-over or run into a roadside object, becomes a critical factor where in many cases the body of the buses was crushed by the force of impact.

#### Table 4: Major bus crashes in 2004

<table>
<thead>
<tr>
<th>Types of Service</th>
<th>Number of Causalities</th>
<th>Types of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fatalities</td>
<td>Injuries</td>
</tr>
<tr>
<td>Category 2 Bus</td>
<td>31</td>
<td>140</td>
</tr>
<tr>
<td>Category 3 Bus</td>
<td>16</td>
<td>285</td>
</tr>
<tr>
<td>Tourist Bus</td>
<td>20</td>
<td>159</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>584</td>
</tr>
</tbody>
</table>

Note: Category 2 Bus runs between Bangkok and the Provinces; Category 3 Bus runs between the provinces
4. RESEARCH OBJECTIVES

This paper attempts to focus on the investigation of public bus accidents on the highway. The objectives of this study were set as follows:

1. to conduct detailed investigation of the serious bus accidents
2. to investigate the factors contributing to bus accidents

5. BUS ACCIDENT INVESTIGATION: CASE STUDIES

Bus accident investigation is one of the focal investigation areas of Thailand Accident Research Center (TARC) research team. TARC investigation team works closely with road accident information supported by the Radio News Service (Jor Sor 100). After receiving the news, TARC team investigates the cases with their specific objectives and detailed at-scene investigation facilities. Covering Crash General Information, Crash Scene, Vehicle and Occupant aspect of the case, TARC team motivates to collect necessary information regarding all contributing factors in each case.

5.1 Crash Narrative
Two bus accidents occurred at Bang Khan Interchange on main arterial Highway No. 1, Paholyothin, the 8-lanes divided highway at Bang Khan, Klong Luang, Pathumthani Province. The locations of these crashes were in an opposite direction. It was about 40 kilometers north of Bangkok. The location of crash scene is shown in Figure 2.

![Figure 2 Locations of two crashes in Pathumthani province](image)

The first crash occurred on February 21, 2006, around 6:20 a.m., a factory bus, bound with factory workers to Navanakorn, was traveling straight northbound in the outmost left lane in the frontage road. The bus suddenly went into the gore area diverging between Highway No. 1 and Highway No. 3214. According to the information received from the police officer in charge and witnesses, it was found that one vehicle cutting in front of the bus. After losing the control, the bus hit the “Directional Sign” post. The bus was seriously damaged at the front-center of its body and intruded by the sign post. Consequently, the directional post was
collapsed from its original position after the hit. Thirty-two causalities were reported including one serious injury and 31 slight injuries due to this collision. All injured persons were admitted to Thammasat Hospital. The rest position of the bus was shown in Figure 3. The travel direction of the bus was shown in Figure 4.

Another crash, Crash No. 2, was on April 13, 2006 around 6 p.m. an inter-city bus, 40 passengers on board, was traveling straight southbound in the outer lane of the main road. The bus suddenly went into the left side roadside ditch. The passenger did not perceive the driver to be braking. After going some distance in the ditch, the bus hit the “Directional Sign” post.
The front of the bus was intruded by the post. Forty causalities were reported including two fatalities, 16 severe injuries, and 22 slight injuries due to this collision. They were admitted to Pattara Thonburi Hospital and Thammasat Hospital. The rest position of the bus was shown in Figure 5. The travel direction of the bus was shown in Figure 6.

![Bus striking the directional Post](image1.png) ![Bus fell inside ditch](image2.png)

Figure 5 Rest position at direction post inside roadside ditch

![Figure 6 Schematics of crash scene](image3.png)

Figure 6 Schematics of crash scene

5.2 Injuries of the Occupants
Most of the injured regions of accident victims were found on the upper part of the body ranging from head to lower part of the body. Serious injuries were found in the head whereas slight injuries were found in the shoulder and arm regions. It was observed that passengers in
both buses were not protected by any safety device (i.e. seat belt). Table 5 represents the injuries of the occupants from two bus accidents.

Table 5 Injury summary of crash victims

<table>
<thead>
<tr>
<th>Cases</th>
<th>Fatality</th>
<th>Serious Injury</th>
<th>Slight Injury</th>
<th>No Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\textsuperscript{st} case</td>
<td>-</td>
<td>1</td>
<td>31</td>
<td>-</td>
</tr>
<tr>
<td>2\textsuperscript{nd} case</td>
<td>2</td>
<td>16</td>
<td>22</td>
<td>-</td>
</tr>
</tbody>
</table>

5.3 Vehicle Information
The first bus was 56 seated and 6-wheeled. It is 2.40 m wide, 3.12 m in height and 11.67 m in length. It is a factory bus, white-red-blue-green color, running between Navanakorn and major arterials covering the pickup zone of the workers.

The wheelbase was measured after the crash 6.20 m at the right and 6.00 m at the left. The height of front bumper’s upper and lower end was 77 and 38 cm whereas the rear bumper’s 82 and 50 cm from the ground.

Another bus was 46 seated and 6-wheeled. It is 2.40 m wide and 3.29 m in height. It is an intercity bus, running between Bangkok and Ayutthaya.

The wheelbase was measured after the crash 6.60 m at the right and 6.15 m at the left and rear over-hang 3.16 m at the right and 3.20 m at the left. The height of rear bumper’s lower and upper end was 65 cm and 112 cm from the ground. The front-left tire was found blowout during the inspection.

5.3.1 Exterior Damage
The exterior damage of the first bus shows mostly at front. The damage includes the total breaking of windshield, deformed and breaking of front bumper. The middle part in-between A-pillars were deformed inwardly. Due to front thrust, the side doors-both left and right were found non-functional. In addition, the roof-top at the front pushed outward. Figure 7 shows the extent of damage of the bus.

![Right-front of bus](image1)
![Front of bus](image2)

Figure 7 Front exterior damages

The exterior damage of the second bus also shows mostly on the front. The damage includes the total breaking of windshield, deformed and detached front bumper. The left side of the bus was damaged and windows broken due to dragging with the concrete linings of the ditch. The
A-pillar was completely collapsed. The windows at the right side were broken. Figure 8 shows extent of damage of the bus.

5.3.2 Interior Damage
The seating positions of both vehicles were not found haphazardly oriented. During the investigation, the photographs were taken to keep the record of the relative position of the seats. The first bus, there were 56 seats inside the bus with 14 rows. The bus was hit at the front and center of its body. However, the windshield, front bumper, driver’s door-panel, instrument panel was severely damaged and displaced. Figure 9 shows the orientations of the seats inside the bus with ‘B’ representing blood stains found during the investigation.

Figure 10 shows the schematic drawing of the seating positions inside the second bus. There were 41 seats inside the bus with 10 rows. The windows at the left side were found broken where the bus rolled over inside the ditch.
Figure 9 Seating positions of the first bus after the crash

Figure 10 Seating positions of the second bus after the crash
5.4 Highway Information
The crash occurred on Highway No. 1 of Paholyothin road running from Bangkok to Chiang Rai. The highway is straight section with 8-lane, 2-way, depressed median separated having 3-lane main road and 2-lane frontage road in both directions. Main road is 3-lane each 3.6 meter wide with 2.4 meter shoulder with 1.5 meter wide ditch separating main and frontage road. It is asphalt surface with coefficient of friction of 0.88 on the main traffic lane and 0.80 on the shoulder with crown slope of 4 percent. The approaching frontage road is 3-lane each 3.0 meter wide. It is concrete surface with coefficient of friction 0.52 with crown slope of 2.67 percent.

5.5 Physical Evidence
5.5.1 Vehicle Rest Position
The rest position of the first bus was found stuck to the directional post fixed inside concrete foundation at the gore area diverging between two roads as shown in Figure 11.

![Directional sign post at the gore area](image1)

Figure 11 Directional sign post at the gore area

The rest position of the second bus was found stuck to the directional post fixed inside the concrete foundation inside a road side ditch. The width of ditch was measured to be 2.66 m from the concrete linings to the edge of the shoulder of the road. The left side (as shown in Figure 12) was a concrete slope 1.15:1 and right side was grassy with mud having 2:1 Slope. The depth of the ditch was measured about 55 cm. Figure 13 shows three different perspectives of the ditch (left: from long distance, middle: inside of ditch and right: close to the direction post).

![Cross-section of the roadway (southbound)](image2)
5.5.2 Directional Post
The dimension of the Directional post for the first crash is shown in Figure 14. The 40 cm diameter and 8.85 m length post had a steel base of 74x74 cm², was embedded in 77x80 cm² cross-section concrete foundation with 53 cm height from the ground. There was a significant scratch marks on the post 379 cm from the ground.

Figure 14 Direction post where bus crashed

Figure 15 shows the post of second crash. The 32.5 cm diameter post was embedded in 84x84 cm² cross-section concrete foundation with 107 cm height from the ground. There were two significant scratch marks on the post 154 cm and 357 cm from the ground.
6. FINDINGS OF INVESTIGATED CASES

The investigation of the bus accidents on highway particularly running off the road and hitting the roadside fixed object was a particular interest as presented in this paper. However, the major findings from this investigation are shown in Table 6 as follows:

<table>
<thead>
<tr>
<th>Factors</th>
<th>Crash No.1</th>
<th>Crash No.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>Loss of control by the driver as supported by police and witness information having a vehicle cutting in front of the bus</td>
<td>No evasive maneuver to correct the driving path of the bus while it was running off the road supporting the drowsy driving by the driver</td>
</tr>
<tr>
<td>Vehicle</td>
<td>there were no occupants protection system particularly seatbelts for passengers installed inside bus where the passengers were reported to be injured significantly due to adjacent seats</td>
<td>there were no occupants protection system particularly seatbelts for passengers installed inside bus where the passengers were reported to be injured significantly due to adjacent seats</td>
</tr>
<tr>
<td>Road and Environment</td>
<td>• The bus was severely impacted and deformed by the unprotected fixed object- the directional post which is located at the gore area between two diverging roads • Roadside design particularly sloping concrete guard rail at the gore area leading to the directional</td>
<td>• The bus was severely impacted and deformed by the unprotected fixed object- the directional post which is located about 2.6 m away from the outer shoulder edge • Roadside design particularly the side slope of the ditch was not warranted by safe design</td>
</tr>
</tbody>
</table>
7. POSSIBLE ALTERNATIVES TOWARDS ‘FORGIVING ROADSIDE’

7.1 Treatment of Gore Area
The end of concrete guard rail and culvert railing was not completely treated at the end – the gore area. Crash cushion is recommended to be placed at the gore area. As mentioned by Ogden (1996) that such devices are effective at the ends of longitudinal safety barriers in medians, and freeway/motorway gore areas, bridge pier in narrow medians, the end of concrete barrier walls, toll plazas, etc. All crash cushions are based on the principle of absorbing some of the kinetic energy of an errant vehicle before it impacts the object. The installation and withstanding capability against heavy vehicles need to be carefully considered so that the cushion can be placed at the appropriate location. Gore area is one of the potential areas to be prioritized.

7.2 Treatment of Side Slope
The roadside slope was 2:1 (H:V) at the ditch adjacent to the main road. The ditch was a potentially hazard for any errant vehicles as clearly demonstrated with one of the investigated cases, Crash No. 2. Considering the cross section particularly the roadside design, Ogden mentioned (1996) that flatter roadside slopes have been found to have a significant effect on accidents, especially single-vehicle accidents (Zegeer and Council, 1992, 1993). Accidents rates fall steadily as side slopes are flattened from 3:1 to 7:1 or flatter. However, little accident reduction is expected from flattening a 2:1 to 3:1 side slope. Therefore, side slopes of 5:1 or flatter are needed (Zegeer and Council, 1992).

Slopes steeper than 4:1 are too steep to allow recovery of control, and vehicles encroaching on such slopes can be expected to travel all the way to the bottom if they do not roll over.

7.3 Treatment of the Pole
The potential measures to reduce the risk of roadside object crash, especially the traffic pole, were recommended by Ogden (1996), are as follows:

• relocation of the pole further away from the roadway or to an alternative, safer, location
• removal of some poles by increasing the pole spacing, inter-poling to replace a pole in a particularly hazardous location
• shielding of poles with a safety barrier (guard fence or impact attenuator)
• use of impact absorbing poles, which fail by yielding progressively, entrapping the impacting vehicle, these are particularly suited to areas where there is high pedestrian use
• as a last and least satisfactory resort, attaching reflective delineators to the pole
• larger signs such as advance direction signs should be of frangible design so that if it is struck, the supporting post shears and the vehicle passes beneath it

In these two investigated cases, roadside facilities need to be carefully designed by concerned authorities (e.g. Department of Highways) to reduce the extent of severity of injury of occupants. This hazardous roadside treatment project should address the application of more energy absorbing materials as shielding role upto certain height of the hazardous fixed roadside objects along the highway under risk-prone locations.
8. CONCLUSIONS

Both of the crashes occurred on the same highway – named Paholyothin (Highway no. 1) only about two months difference on opposing traffic lane. Both of the accident had the similar characteristics of running off the road prior to hitting the roadside fixed object. As this paper considers mainly on investigation of bus accidents, precipating factors leading to collision were highlighted.

Human factors:
- Loss of control and drowsy driving were identified in the first and second accidents respectively. The first accident occurred in the early morning peak hour (between 6-7 am) whereas the second one occurred in the evening peak hour (between 6-7 pm).
  - Driving condition was one of the precipitating factors to be focused and required further investigation. Driver’s error could be broadly identified in these two investigated cases where workload of the public bus drivers is of prime importance. Legal daily driving schedule for public bus should be carefully maintained by the transit operators and owners. More importantly, the bus drivers are required to be respectful to the system.
  - Driving behavior such as affective, cognitive and sensorimotor are a timely need to address through proper investigation in minimizing the crash and injury severity of bus accidents.
  - Considering the driving training and education, this aspect of driving skill should be properly administered by the concerned authorities. It is clearly pointed out by Taneerananon and Somchainuek (2005) that driving competency and behavioral controls should be ensured through proper driving test and free medical check-up of public transit drivers addressing the physical fitness particularly the eyesight of elderly public bus drivers.

Vehicular factor:
- Since there was no seat belt installation inside both of the accident involved buses, the ejection of the passengers from the seats was reported while being injured.
  - Passive safety features (e.g. seatbelts, strength of seat installation, etc) need to be strictly enforced and regulated by the concerned authorities. It is therefore recommended based on this study that the regulation of seat belt installation should be enforced by Thai government. In this regard, conventional safety regulations (e.g. European standards) concerning installation of seat belt should be ensured.

Road and environmental factors:
- Based on TARC investigation, it is very clear that roadside objects such as directional post at the gore area and inside the ditch can be hazardous material to the errant bus-driver.
  - The highway needs to be carefully designed towards “forgiving highway” for the errant vehicles. In this regard, proper roadside hazard management should be ensured considering local deign needs to address the concept of “forgiving highway”.

Since an accident is considered as a chain-of-events, proper counter measures to make road and environment safer for any errant vehicle driver in terms of reducing crash and injury severity need to be addressed. Therefore, it is a timely need for the developing countries like Thailand to conduct such accident investigation to identify the factors and propose possible alternative countermeasures to reduce the extent of unwanted injuries and damages.
ACKNOWLEDGEMENTS

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