Contributing Factors of Road Crashes in Thailand: Evidences from the Accident In-Depth Study

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Abstract: The urgent need to improve the road accident problem in Thailand is to build up accident knowledge and research base which has led to the establishment of Thailand Accident Research Center. The goals of this establishment are to conduct the accident in-depth study to investigate, analyze, and evaluate the mechanisms behind crashes and the incidence of injuries on a continuous basis. The objectives of this paper are to present the findings on the contributing factors of road crashes through accident in-depth study in Thailand. The study involves scene investigation to inspect the accident site and gather all related evidences. Then, all of evidences are reconstructed in order to determine the crash significant factors. The findings of this study summarize different characteristics of crashes encapsulating most of the accident cases in Thailand, which related to motorcycle accidents, behavior of young drivers, road side hazard crashes, and rollover crashes.

Key Words: *Accident Investigation, Accident Reconstruction, Research Center*

1. INTRODUCTION

Road crash epidemic has ruined Thailand economic for several decades as a major cause of death. Every year, more than ten thousand people lost their lives on the roads, or uncountable ending at the hospital instead of their trip destination. It has been estimated that the economic losses due to road accidents are about 115,932 Million Baht per year or approximately 2.13%

of GDP (Tanaboriboon, 2004a). Alarmed by the findings of the economic loss study due to road crash, under the World Bank loan assistance, Ministry of Transport and Communication of Thailand has developed a comprehensive road safety master plan in 1998. The master plan clearly indicates that the lack of knowledge of road crashes is one of major constraints for road safety improvement in Thailand. The accident knowledge, particularly on how, when, where, and contributory factors to why they happen is essential for effective road safety improvement. In addition, existing road safety research in Thailand seems to be very limited and fragmented. Accordingly, recognizing the urgent needs of accident knowledge and research, the Thailand Road Safety Master Plan, among others, identified the need for establishing a Thailand Accident Research Center (TARC) as a priority in its long term action plan.

The Thailand Road Safety Master Plan recommends that due to the complex nature of road accidents and the many different sectors involved in the operation of road safety, local research is required to provide a scientific and objective approach to reduce the suffering and losses caused by road accidents. To be able to better understood, the problems have to be put and interpreted in the Thai context and solutions adapted to the conditions in Thailand and accepted by the Thai society have to be found. In addition, the know-how about mechanisms behind the accidents and the incidence of personal injuries is needed to develop suitable solutions and to achieve better road safety.

2. OBJECTIVES

The objectives of this research study are as follows:

- To determine the contributing factors of road crashes in Thailand by conducting in-depth study on road accidents emphasizing on accident investigation and reconstruction.
- To develop a scientific approach for road accident data collection leading to objective analysis to achieve more effective road safety measures.

3. ACCIDENT IN-DEPTH STUDY

This research is an initial study attempting to conduct accident investigation to analyze accidents through a systematic and comprehensive approach to find out the causes and prevent future accidents. Generally, accident analysis is divided into two parts, accident investigation and accident reconstruction.

3.1 Accident Investigation

Accident investigation is the through examination of all elements contributing to the accident, resulting in a well-founded explanation of the series of events which occurred based upon the factual data. Its objectives are to determine: what happened?, where the accident occurred?, when the accident occurred?, why the accident occurred?, and who was involved?. The obtained data will provide the foundation of such in-dept accident analysis.

3.2 Accident Reconstruction

Accident reconstruction is an in-dept accident analysis for the purpose of determining how the collision occurs, and utilizing physics principles including impulse and momentum in attempts to figure out the root causes of such accident. Accident reconstruction requires

comprehensive and complete information as much as possible and the findings are mostly objective, and supported by the facts revealed or determined by the investigation. A computerized system which is PC Crash software is used for the analysis. The program can be used for the analysis of all types of automobile collisions including multiple vehicle impacts, intersection collisions, and low-speed impacts from all directions.

4. RESEARCH METHODOLOGY

To understand the road accident situation and to determine mechanisms behind accidents and incidence of the personal injuries, an accident investigation and reconstruction are conducted to achieve better understanding of road safety. The investigation team investigates the accident cases by reaching to the crash scenes as soon as the crashes occurred. Then each team member collects all important information about road crash. This includes general information, crash scene, vehicles, and victims. In order to avoid biases, the conclusion will not be drawn until the investigation and analysis processes are completed. All information will be used in the analysis to describe the events of crash, injury mechanism, and finally the contributing factors of such accident. For the cases where the damage profile of vehicles can be measured, and evasive actions taken by the drivers in the form of skid marks or yaw marks can be found as evidence, a complete accident reconstruction was performed by computer simulation to simulate the events before and after accident. Finally, an accident report will be produced describing all necessary information to provide a complete picture of the crash. In this study, the accident investigation was conducted on the accidents occurred during 2005 to 2007 Statistic shows that most of the crashes (76.2%) involving motorcycle (Tanaboriboon, 2004a). Also, single vehicle crashes shared a highest proportion among other crash types. The main focus of this study, therefore, has to be taken in account to reflect the accident situation in Thailand. The accident investigation form was designed to keep the records of all necessary information of the accidents to be investigated. This form was carefully designed in collaboration with Volvo research experts from Sweden and Thailand Accident Research Center (TARC) team to cover all important accident information as well as to be appropriate with respect to Thai context. Even though the information collected through this accident form may contain lots of data fields to be filled up, it serves the advantage of further in-depth analysis from this information. The accident investigation form is mainly divided into three main parts: crash scene, vehicle, and human, which are the system components of road safety. After all evidences from the scene have been gathered, the analysis process was done through accident reconstruction. Vehicle speed and position over the time frame, post-crash, crash, and pre-crash, to answer why accident occurred, is the main outcome on this process.

In addition, level of injury, seriously injury was defined as an injured person who admitted to hospital as in-patient, while slightly injury was not admitted. The victim's injury information, gathered from hospital, is meaningful to understand mechanism of injuries. It could describe what's source of injury on the crash. Investigator has a duty to determine the relationship between injuries and source on injuries, most of the time showing as evidences on vehicle interior or on the crash scene.

5. ACCIDENT IN-DEPTH ANALYSIS FINDINGS

A total of 64 accident cases were collected during two years period of accident investigation and reconstruction research. These cases include 11-fatal, 21-serious injury, 20-slight injury,

and 12-no injury based on the investigation records. It covers the area of four main regions in Thailand, including Bangkok (central region), Khon Kaen (northeastern region), Chiang Mai (north region), and Surat Thani (south region). A total of 457 people involving in the crashes are 34-fatal, 124-serious injury, 180-slight injury, and 119-no injury. Considering from a total of 114 vehicles involved, pickup shares the highest proportion of 40 vehicles (35%), followed by 31 motorcycles (27%) and 19 passenger cars (17%). In addition, it was found that seven bus crashes caused the highest number of people involved in term of casualties and severities.

5.1 Accident Types

Accident types were grouped to classify the accident characteristics corresponding to vehicle movement before and during crash events. It was considered by vehicle traveling direction, driving maneuver, and another vehicle or object involved. NHTSA (2000) defined accident types in six categories. Each category consists of different configurations showing the difference among vehicle movement maneuver. In total, it was separated into 13 subcategories of accident type.

Table 1 illustrates investigated cases classified by accident types. The categories are classified according to NHTSA crash report (NHTSA, 1996). Single vehicle accident shares the highest proportion of crash types (35%). Approximately 17% of total crashes are the vehicles left roadside on the left (Left-hand side driving in Thailand). For multiple vehicles crash, rear-end collision shares 23% of total crashes, which most of them occur in the same traffic direction. However, the changing traffic way due to vehicle turning shares 22% of total crashes. This crash type occurred in many parts of the road, including merging and diverging area near access section. The rest of 5 cases or 8% of total crashes are the accident on the intersecting paths.

Table 1 Accident types with classified configurations under TARC investigation

Category	Configuration	Number	
Single Vehicle	Right Roadside Departure	6	(9%)
	Left Roadside Departure	11	(17%)
	Forward Impact	6	(9%)
Same Traffic way Same Direction	Rear-End	15	(23%)
	Forward Impact	1	(2%)
	Sideswipe Angle	4	(6%)
Same Traffic way Opposite Direction	Head-On	2	(3%)
	Forward Impact	-	-
	Sideswipe Angle	-	-
Change Traffic way Vehicle Turning	Turn Across Path	7	(11%)
	Turn Into Path	7	(11%)
Intersecting Paths	Straight Paths	5	(8%)
Miscellaneous	Backing	-	-

5.2 Impact Regions of Vehicles

The area of impact represents the area of motor vehicles that received the initial impact and had the most damage in a crash (NCSA, 2003). It is very important for evaluating injury severity in relation to motor vehicle impact and crash severity. Three categories of vehicle were grouped, including bus and truck as heavy size vehicle, passenger car, pickup, and van as medium size vehicle, and motorcycle as light size vehicle.

According to Figure 1, it can be clearly observed for most of the crashes on heavy vehicle that the impact forces are directly in the frontal part of vehicles as shown in 43% of total impact directions in all heavy vehicle crashes. Besides, 22% of crashes involved rear-end collision. All heavy vehicle crashes involved critical pre-crash events mostly due to decelerating by in-front traffic or traffic making turn. It can be explained due to the fact that the character of heavy vehicle is normally traveling in slower speed comparing with others. Therefore, the risk of rear-end crash could be increased since the following motorists had limitation of sight distance by bus/truck's height. It was blind area for following motorists to observe or perceive the traffic in front.

For light size vehicle, even though most parts of impact regions are in the frontal part of vehicles (45%), 10% of the crashes are found to have the impact direction in the direction of 4 o'clock which entirely involving merging and diverging maneuvers. Lastly, for medium size vehicle, 22% and 23% are observed in the frontal and rear parts of vehicles, respectively, while 25% of crashes are the angle collision and sideswipe.

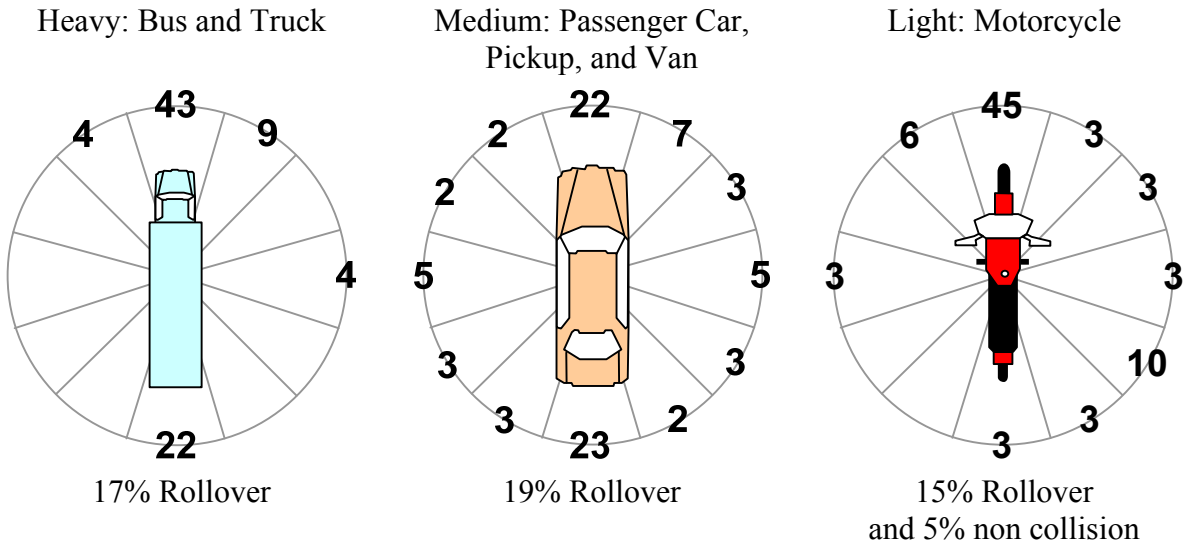

Figure 1 Percentage of impact on body region of vehicle by vehicle type

5.3 Safety Equipment

In the light of passive safety, road users are required to protect themselves by a protection system in order to reduce the amount of impact force by dissipating the energy transferred from the collision. Helmets for motorcyclists and seatbelts for vehicle occupants are widely known as the effective safety equipments to reduce the victim's injuries in "crash" event. The characteristics of safety equipments used, therefore, are needed to be considered through accident investigation process. Figure 2 presents details of safety equipments used by road accident victims from investigated cases.

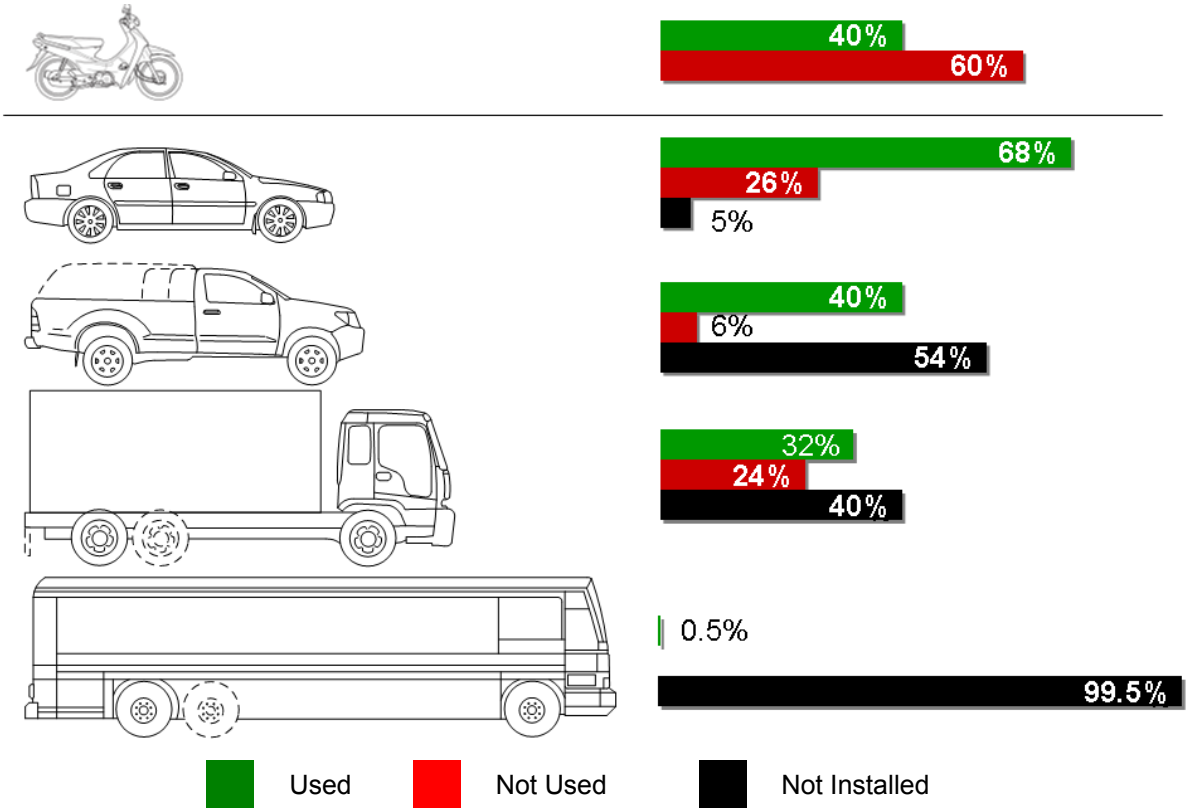

Figure 2 Safety equipments used by occupants in each vehicle type

According to a total of 43 motorcyclist riders and pillions in the data set, 40% used helmet. Among this group, 82% of them were observed using a half-cut helmet which is widely used in Thailand. However, it is still questionable about the effectiveness of the half-cut helmet to prevent the head injury of motorcycle accident victims. For seatbelt use, the traditional data collection in Thailand has included only two options of seatbelt is "used" or "not used" which low percentage of seatbelt use has always been observed. The data collection from accident investigation, however, has shown that most of the "not used" occupants were compulsory sited on the seating position with no seatbelt installed. In the data set, more than 50% of pickup victims sited on the cab or in pickup bed with no installation of any restrained system. Therefore, Figure 2 includes "Not installed" as one of the three classified groups of safety equipment use. It was shown that the vehicle in which seatbelts were not installed and involved a large number of victims is the bus. Only 0.5% of occupants used seatbelt in the bus while 99.5% of bus occupants' seat had no seatbelt installed.

5.4 Mechanism of Motorcyclist Injuries

The injury characteristics of motorcyclist show that 20% suffer from head injury, and followed by lower leg (17%), forearm (16%), and wrist and hand (16%). Comparing with the injuries on crash victims from other vehicle types, head injuries of motorcyclists (20%) show significantly lower number than those victims from other vehicles (31%), while forearm, wrist and hand, and lower leg injuries show higher, as shown in Figure 3.

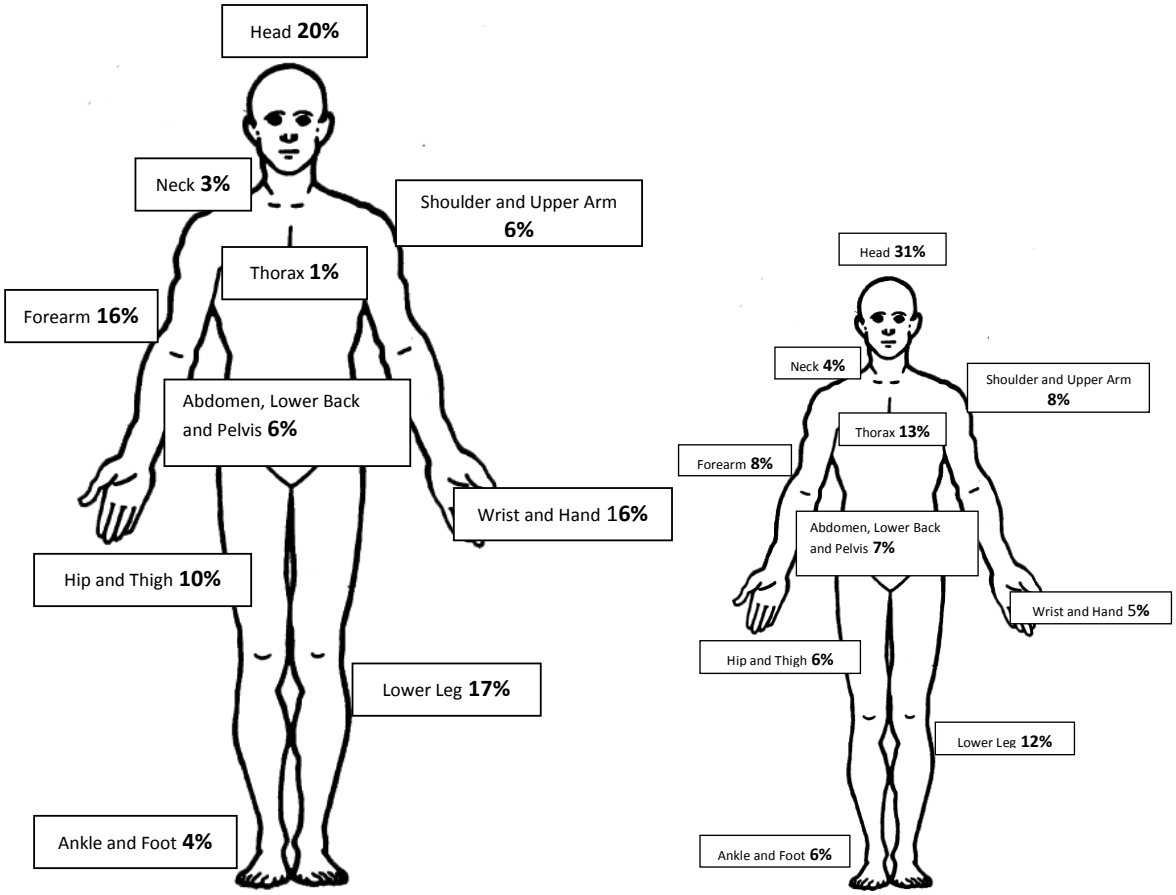

Figure 3 Overall injuries on motorcyclists (left) and car occupants (right)

The comparison of injury severity in each body region is conducted to understand the injury mechanism of the motorcyclists and other car occupants. The comparison shows that even though the number of head, forearm, wrist and hand, hip and thigh, and lower leg injuries of car occupants are considerably high, low severity was observed in those injuries. Most of the injuries are only superficial or open wound injuries. It is clear that even though the motorcyclist has less chance to suffer from head injury than the car occupants, the injury is found to be more severe. In this study, 45% of head injuries on non-motorcyclists are superficial injury, while 65% of head injuries on motorcyclists are open wound of head and intracranial injury. Besides, the fracture of shoulder and upper arm of motorcyclists are highly observed (50%).

Since motorcyclists are considered as “unprotected road user”, any force typically from the crash would be transferred directly to the motorcyclists. For this reason, the motorcyclist injury mechanism is defined as two categories according to crash events, which are direct impact and consequent after first impact. Direct impact represents the first contact between motorcycle/motorcyclist and collision partners while motorcyclist is in seating position. It could be regarded as primary impact whereas the contact of occupants after the primary contact could be termed as secondary impact. The impact is directly goes to both motorcycle and motorcyclist. Besides, consequences after first impact are the series of events in terms of occupants’ injury right after motorcycle and motorcyclist hit to the collision partners either cars or fixed objects. The review of motorcycle accidents vs. the other vehicular accidents by Van Kirk (2001) shows that the motorcyclist must expend his/her energy by impacting another fixed object such as car, tree, or pole, or must impact or slide along the ground until all his/her kinetic energy has been dissipated. In summary, the chance to have more severe on

open wound injury is high during the first impact. There is no injury of cranial nerves found for consequences after first impact. In addition, injuries on hip and thigh, and lower leg, shows higher chance to suffer from the direct impact, especially motorcycle hitting passenger car or pickup. Shoulder and upper arm injuries, on the other hand, are more likely to occur and have more severe on this consequence after impact event.

5.6 Young Riders

The young riders are mostly found in the motorcycle accidents. In Thailand, the regulation allows motorcycle rider to have motorcycle driving (riding) license if he/she is over 18 years old and also allows young age of 15-18 years old riding motorcycle under 50 cc. However, this type of motorcycle is rarely found in the current market. According to the analysis of Thailand road accident situation, the trend of motorcycle victims was observed to decrease significantly in the older age group. It clearly indicates that more than 25% of these victims were under 20 years old (Tanaboriboon, 2004b). This result has the same trend as the study in the US, which shows that younger and older drivers were two age groups with higher risk to face serious crashes as observed from the number of severe crashes per billion kilometer traveled (Evans, 2004). Young riders in Australia are found to have a record of 47.0 fatalities per 100 million motorcycle kilometers traveled. The fatality number is about 9 times higher than the fatality of age group of 50-54 years (ATSB, 2002). Hurt et al. indicates that based on 3,600 in-depth motorcycle accident investigations, the motorcycle riders between the age of 16 and 24 are significantly overrepresented in accidents, and motorcycle riders between the age of 30 and 50 are significantly underrepresented (Hurt et al., 1981).

In this study, among motorcycle crashes involving young riders, it was found that the age of riders is in the range of 12 to 21 years old. The average age of young motorcyclist riders is about 16 years old. It should be noted that most of motorcycle crashes involving young riders is the lack of rider's attention to be aware of u-turning passenger cars downstream. The possible contributing factors could be a U-turn maneuver that eventually created a conflict with the normal traffic stream at the u-turn location, and an unsafe merging maneuver when the riders merged to the main traffic at the intersection causing side swipe collision.

5.7 Roadside Hazards

In Thailand and some other developing countries, roadside furniture, e.g. traffic sign post, electric pole, kilometer stone, or tree, has not certainly been taken into account as the contributing factors of the accidents as reported by responsible organizations (Tanaboriboon, 2004b). In contrast, the drivers have been always blamed due to the lack of skill to control vehicles properly on their traveled way, even though the furniture is installed beside the carriageway posing as serious threat for errant vehicles, and causing death tolls and serious injuries. The terminology 'Forgiving Highways' has been introduced recently prioritizing the responsibility to the safer roadside design. The design of safe roadside for making recovery in case of errant maneuvering should be therefore incorporated. In addition, the installation of shield or impact attenuators for fixed objects to minimize the collision severity from errant vehicles must be pragmatically implemented.

Several serious crashes on roadside furniture were also investigated in this study. Based on a total of 79 people involved in fixed object crashes, 72 of them are the bus passengers with no seatbelt use. However, all of them were compulsory unbelted because no seatbelt is installed in the buses. Three serious crashes were investigated to be caused by roadside sign posts which surprisingly occurred in the same area of interchange (Bang Khan Interchange). Table 2 summarizes crash information due to the roadside sign posts.

Table 2 Fixed object crashes at Bang Khan interchange

	Passenger Car	Bus	Bus
Severity	1-Fatality 1-Serious Injury	1-Serious Injury 31-Slight Injury	2-Fatality 16-Serious
Region and Direction of Impact	4 O'clock	12 O'clock	12 O'clock
Object	Mounting Overhead Sign Type I	Two Legs Overhanging Traffic Sign	Over Hang Traffic Sign
Post Diameter	15 cm	40 cm	32 cm
Size of Column Footing	50 x 50 cm	74 x 74 cm	84 x 84 cm

5.8 Vehicle Rollover

The rollover accident is a complex type of crashes. It is considered that this type of crashes is seriously influenced by all three main factors, driver, roadway/roadside design, and vehicle characteristic. Rollover does not occur as frequently as other types of crashes, but in case of occurring; the consequences lead to serious injuries or death. The statistics from the Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System in year 2003 (Linstromberg et al., 2005) has shown that among 10.6 million crashed vehicles, front impact shares highest proportion on crash orientation (46%), followed by side and rear impact. Only 3% of all crashes involve rollover. However, by considering the severity of rollover accident, from 31,904 fatalities, the percentage of people died from rollover crashes is nearly 33%. Even though the cause of rollover accident is quite complex to be explained, some possible contributing factors of rollover can be summarized as follows.

Cargo Load

Many rollover accidents were found to have oversize cargo load that significantly increasing the height of center of gravity, reducing stability of vehicle, and hence causing vehicle roll-over. A Static Stability Factor (SSF) was introduced by the National Highway Traffic Safety Administration (NHTSA) during 2001-2003 to represent rollover resistance rating to public (Boyd, 2004). SSF indicates the probability of vehicle rollover on the single vehicle accident, which is calculated from one-half of track width divided by the height of center of gravity based on the geometry of the vehicles. The lower SSF means the higher chance a vehicle to rollover in a single vehicle crash (Roper, 2001). SSF has been proved to be a potential prediction of rollover since it is based on linear regression of 100 vehicle models of real world crash data of 224,000 single vehicle accidents (Boyd, 2004). According to the statistics from NHTSA, pickup falls into an average between 18-40% chances of rollover which is about two times higher than passenger car. Table 3 summarizes the rollover cases which were influenced by cargo loads. It can be clearly seen from Table 3 that the chance of rollover in all cases is between 18-24% which falls in the range of rollover chance as indicated by NHTSA.

Table 3 Rollover cases involved in cargo load

Vehicle	Load	Estimated Load on Pickup (kg)	SSF	Chance of Rollover
Pickup	Glass	2,160	1.19	24%
Pickup	8 adults and 1 child Passengers	530	1.25	20%
Pickup	10 adults and 2 children Passengers	700	1.30	18%
Pickup (Minibus)	23 adults Passengers	1,380	1.27	19%
Pickup	Raw Food	1,720	1.27	19%

Note: estimated occupant's weights obtain from http://www.anamai.moph.go.th

Panic-Like Steering

A panic-like steering is the action maneuvered by driver in overcorrecting the steering condition made from sudden or panic reaction mostly found in case of emergency. It may cause vehicles losing control, consequently the vehicles move along the sideway, and eventually roll over. Six cases of rollover accidents were found as panic-like steering involved, including four pickups and two trucks. The panic-steering in all of them were caused by different emergency stories, and the steering actions were then made in order to avoid such unexpected events, however, it caused adverse outcomes.

Roadside Slope

When a vehicle runs off the carriageways, it is likely to overturn when it strikes a ditch or embankment or is tripped by soft soil (NHTSA, 2004). Many rollover crashes occur along freeways with grassy or dirt medians when a driver loses control at highway speeds and the vehicle slides sideways off the road and overturns when the tires dig into the dirt. Varied range of roadside slope and ground condition on rollover crashes are shown in Table 4. It can be seen from Table 4 that the use of critical slope was found in all rollover cases, and ground condition of the median was observed as soft types. The effect of roadside slope and soil type could be also combined with high speed of the vehicle and lead to the rollover.

Table 4 Different roadside design condition under run-off road accidents

Vehicle	Roadside Slope (H:V)	Ground Condition	Traveling Speed (km/hr)
Bus	1.1-2.6: 1	Grassy Depressed Median	N/A
Truck	2.7:1	Roadside Grassy Area	N/A
Pickup	2.1:1	Roadside Ditch	65-70
Bus	1.2:1	Grassy Depressed Median	N/A
Truck	N/A	Roadside Wet Paddy Field	N/A
Pickup	2.6-4.0:1	Roadside Wet Soft Clay	N/A
Pickup	7.1-16.0:1	Roadside Wet Soft Clay	95-100
Bus	11.4-2.2:1	Roadside Grassy Ditch adjacent to Bridge	100-110

Injury Characteristics of Rollover Accidents

Out of 175 casualties involved in rollover accidents, 21 fatalities, 76 serious injuries, 68 slight injuries, and 10 no injuries were found and summarized in Table 5. All fatalities were reported as the victims were ejected during vehicle rollover. The injury of belted and unbelted occupants was compared to understand the characteristics of crash injury due to rollover. It should be noted that un-belted occupants could represent either occupant did not use seatbelt or seatbelts were not installed. In total, 12-belted occupants and 163 un-belted

occupants are found from total 175 occupants. In Table 6, no fatality is found for belted occupants, on the other hand, 21 (13%) and 75 (46%) of unbelted occupants suffered fatalities and serious injuries, respectively. It must be noted that all 21 fatalities in rollover cases were ejected from the vehicles. The findings can indicate the need of seatbelt use which has shown as the effective equipment to reduce the chance of occupants to be ejected from the vehicle and to suffer from serious injury in rollover crashes.

Table 5 Summary of severities on rollover accidents

Case	Vehicle Type	Injury Severity			
		Fatality	Serious Injury	Slight Injury	No Injury
060106-01	Pickup	-	-	-	2
060302-01	Bus	3	31	4	-
060413-01	Truck	-	-	1	1
060811-01	Pickup	-	3	8	1
060815-01	Pickup	-	-	1	-
060816-01	Bus	-	2	35	-
	Truck	-	1	-	-
060829-01	Pickup	-	1	-	1
060907-01	Truck	-	-	1	-
060918-01	Pickup	1	3	18	1
061010-01	Pickup	-	-	-	2
061025-01	Truck	-	-	-	2
070119-01	Bus	17	35	-	-
Total		21	76	68	10

Table 6 Comparisons of injury between belted and unbelted occupants

Severity	Total	Belted		Un-belted	
Fatality	21	-		21	(13%)
Serious	76	1	(8%)	75	(46%)
Slight	68	4	(33%)	64	(39%)
No injury	10	7	(58%)	3	(2%)
Total	175	12		163	

6. SUMMARY OF FINDINGS

The research on accident investigation and reconstruction has been encircled all aspects of road safety. The main purpose of the accident in-depth analysis is to determine the contributing factors of accident and to answer how and why the accident happened. The study involves scene investigation to inspect the accident site and gather all related evidences. Then, all of information and evidences collected from the scene have been reconstructed in order to determine the crash significant factors. After two years during the implementation of accident in-depth study in Thailand, several important issues of accidents in Bangkok and other provinces have been identified and grouped in different categories. Those findings have been summarized as follows:

- Human errors were considered the main contributing factors of the accidents. Among them, the greatest proportion was under the condition of decision errors (54%), i.e.

improper driving practice, evasive, and driving technique, followed by recognition errors (21%), performance (action) errors (9%), and critical non-performance (8%).

- Alcohol has directly affected on driving/riding performance in two categories; critical non-performance and recognition errors. For the critical non-performance, the drivers/riders were unable to maintain a normal and regular driving task since they dozed prior to the crashes and no evasive actions performed. For the recognition errors, the drivers/riders delayed in perception indicating an inconsistency in the downstream traffic flow. None of them successfully performed evasive actions to avoid the accidents.
- Even the proportion of head injury for the motorcyclists (20%) was less than the car occupants (31%), most of the car occupants (45%) are superficial head injuries. On the other hand, there were 36% open wound of head and 29% of intracranial injury suffered for motorcyclists.
- A collision with a fixed object is considered as the most harmful event and the injury outcomes are generally more severe than car-to-car crashes. Because the fixed objects are narrow and solidly fixed on the ground, the vehicle needs to absorb all of impact energy from relatively small area.
- Even most of the rollover cases are considered as single vehicle crash, it is commonly misunderstood to conclude the causation originates from driver's errors. Four main contributing factors on rollover crashes under this study were found including loading, tipping, panic-like steering, and roadside slope. Pickups, buses, and trucks were more likely to involve in rollover cases than passenger cars. Sometime tipped rollover and effect of cargo load influenced the Static Stability Factor (SSF) which in turn caused roller over of those vehicles. In addition, there was a significantly different for the injury outcomes between belted and unbelted occupants for this type of crashes. For belted occupants, there were 8% suffered serious and 33% was slightly injured, with no fatality while unbelted occupants were reported 13% fatality, 46% serious injury and 39% slight injuries.
- Bus occupants are the most vulnerable as there was no seatbelt installed inside the buses mostly observed in Thailand.

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