In-depth Study on Road Accidents: Thailand Perspective

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ABSTRACT

Road accident is one of the major causes of premature deaths of the economically active segments of population in the developing countries. Among ASEAN countries, Thailand's road safety situation is deteriorating while level of motorization and socio-economic development are in the rising trend. On an average, two people become fatal and the costs of these road accidents amount to 12 million Baht (about US$300,000) per hour resulting in losses of about 3.4 percent of GNP annually. Crash investigation and reconstruction is a new approach yet in practice for Thailand to conduct in-depth analysis of road accidents. Thailand Accident Research Center (TARC) is the pioneer to undertake such kind of in-depth study in this region. This paper highlights the contributory factors of an investigated case by TARC team. Conventional hand calculation based on trajectory concept and physical evidence was carried out to estimate the speed, time and other important injury parameters to describe the crash scenario.

NOMENCLATURE: ABS = Anti-lock Braking System; ASEAN = Association of South East Asian Nations; cm = Centimeter; Kg = Kilogram, KJ = Kilo joule; KN = Kilo newton; E = East; GNP = Gross Domestic Product; km/hr = Kilometer per hour; m = Meter; mm = Millimeter; ms = Millisecond; N = North; N = Newton; POR = Point of Rest; psi = Pound per square inch; PIEV = Perception-Intellection-Emotion-Volition.

1. INTRODUCTION

The real number of deaths in road accidents is usually higher than the official police statistics of 12,858 people in 2005 if the health records are counted [1]. In addition, the estimated economic losses due to road accidents are over 100,000 million Baht (approximately US$2500 million) per year [2]. Considering the existing road safety situation in Thai context, it is timely to initiate an innovative research in road safety. In-depth study of road accidents is a new direction to such innovative safety research in Thailand. TARC is envisioned to carry out such in-depth study of the road crashes. Initiated, funded and technically supported by Department of Highways of Thailand (DOH), Volvo Car Corporation, Sweden and Thailand Global Road Safety Partnership (TGRSP), TARC took a quite timely endeavor to establish its innovative research work-plan in the context of Thai road safety improvement strategy.

TARC team is always on alert of crash cases occurred within the area specified. With proper safety equipments and other investigating materials, TARC team motivates to collect all necessary information required for in-depth analysis. However, all concerns of investigation are focused on three major components (i.e. human, vehicle and road-environment) of the system.

Among all type of crashes, single vehicle crash is considered as one of the interesting crash types to be investigated and to conduct in-depth analysis. Over the last three years single vehicle accidents account 43.34 percent of total accidents in 2003 and increased to 45.45 percent in 2005. However, about 4,755 fatal single vehicle accidents occurred during the last three years [3].

2. METHODOLOGY

On April 7, 2006 TARC obtained a report of pick-up run-off crash through "Jor-Sor 100" Radio news (FM 100) at 9:30 a.m. located on Highway No. 1 in front of Thammasat University hospital. TARC team immediately went out to investigate the case at 9:45 a.m. The direct investigation process is highly influenced by the distance of crash location from the TARC office.

The driver and eye witnesses of the crash were interviewed. Vehicle damage profiles were also inspected (e.g. tire blown out, other exterior contacts). Road-environment information was collected with a proper care having a view to understand the crash process that could be useful for analysis through accident reconstruction. The driving strategy and the evasive action taken by the driver to avoid the crash was gathered and analyzed. TARC maintains the confidentiality of the personal information of the interviewees. Exclusively particular information for analysis were extracted from the investigation in order to understand the consequences of the crash. On the other

hand, photographs of the crash scene, vehicle and other related subjects were undertaken.

An investigation and reconstruction process of the single vehicle run-off case was conducted considering the availability of time, resources of the team and the scope of the analysis. A systematic investigation and reconstruction procedures are described in the following subsections.

3. CRASH INFORMATION

The crash involved vehicle, Isuzu D-max, was reported to have front left tire blown out and running into the ditch on the left side of the road at the position of N 14^0 $4'$ $26.5"$; E 100^0 $36'$ $56.2"$ on Highway No. 1, Paholyothin. The driver, only one occupant, received no injury.

4. PRE-CRASH INFORMATION

4.1 DRIVER INFORMATION

A 23 years old male driver started his trip from Hi Tech Industrial Estate, Ayutthaya at about 7 o'clock in the morning. He was traveling towards Bang Na. The driver had the driving experience of two years. However, he had (driver's statement) only one week of driving experience with his own vehicle (i.e. Isuzu D-max), that had been found crash involved.

He was belted and driving in the outer lane of 2-way 6-lane divided highway heading to the south. He claimed to be attentive under normal driving condition. No alcohol use by the driver before or during the trip was found during investigation process.

According to his statement, he uses this route with this vehicle once a month making the same origin-destination. The duration of the journey is estimated to be two and half hour. From the crash scene it was about two hours of driving remained to reach his destination, Bang Na.

4.2 VEHICLE INFORMATION

Isuzu D-max (SLX 3.0 Di Turbo) was pick-up having the curb weight of 1,530 kg. It was silver in its body color with a cab behind the 2-seat in the passenger compartment without covered loading bed. It was manually transmitted without ABS equipped. There was no cargo in the loading bed at its back.

4.3 ROAD-ENVIRONMENTAL INFORMATION

4.3 (a) CRASH SCENE DESCRIPTION

Highway No. 1 is straight, level section with 4 percent cross slope where the run-off road crash occurred. The road surface was dry with asphalt surface which was very recently resurfaced (co-efficient of friction = 0.84). The surface of the ditch was mixed with mud and gravel (some small stones). During the driving situation, there was day light with no direct sunshine. There was a ditch separating between the highway and the frontage road with no guard rail. The temperature of the day was approximately 34 degree celsius. The speed limit for pick-up truck is 90 km/hr according to the traffic law (i.e. B.E. 2522).

The in-equal skid marks (straight) were found starting from the left shoulder to the roadside embankment. However, the marks also found to be continued inside the ditch (by the left wheels) and on the roadside embankment (by right wheels) until the Point of Rest (POR). The slope of grassy roadside embankment is 13.3~15.0 percent while that of left shoulder was 4 percent. The schematic (plan view) of the crash scene is shown in Figure 1.

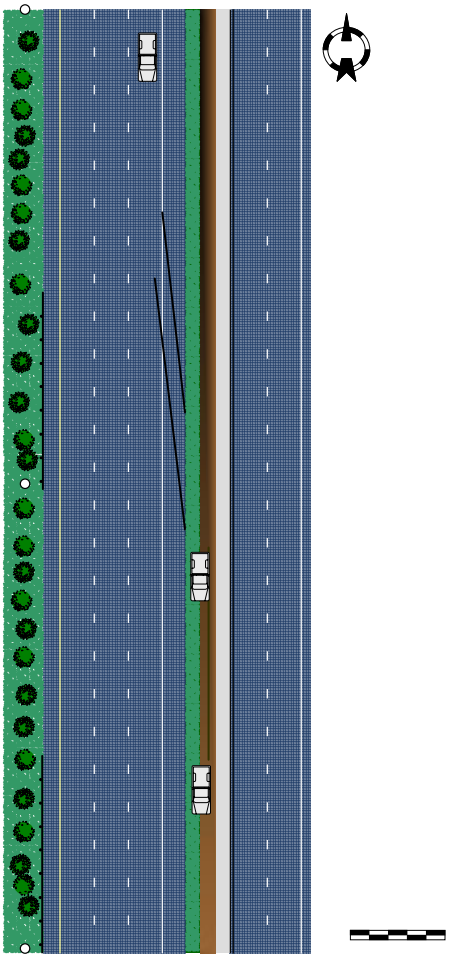

Figure 1: Schematics of Crash Scene

5. CRASH INFORMATION

5.1 STARTING OFF-ROAD

Around 30 minutes after the start of his trip, he found the difficulty of having the front-left tire blown out. He applied the brake to control the movement. But he failed to stop even 23.75 m (on an average: left wheel 20.90 m and right wheel 26.60 m) long skid marks on the left shoulder adjacent to the depressed median. Nevertheless, the vehicle continued to go 33.60 m (on an average) more with the left

wheel on ditch and right wheel on the grassy roadside embankment. Figure 2 shows the skid marks found at the scene while the vehicle was going run-off the road. The total length of tire marks found indicating the distance traveled by the errant vehicle from the shoulder to the POR is about 57.30 m.

Figure 2: Crash Scene showing the Tire Marks of Running-off Road

6. POST-CRASH INFORMATION

6.1 OCCUPANT'S INJURY INFORMATION

There was no report of injury to the driver. However, considering the speed transition from the start of run-off the road (102 km/hr) to the left wheel in the ditch (68 km/hr), the force dissipated to the vehicle was determined about 12.81 KN. The duration of time was calculated to be 1.24 sec over such distance. Since no object was hit by the vehicle on its way entering the ditch, this force generated during such short time did not result in any severe injury to the occupant. The calculation shows 2.81 sec was spent more from the start in the ditch to stop at the POR. The force dissipated to the vehicle was 10.47 KN during this time. No evidence of contacts between the occupant and interior of the vehicle was found. Figure 3 shows the driver's seating position.

Figure 3: Interior of the Vehicle (Driver side)

6.2 VEHICLE INFORMATION

6.2 (a) BODY STRUCTURE

The left side of the vehicle came in contact with the concrete side linings of the ditch. The cover of left side mirror was pushed inward and the cover of the left rear light (at the upper corner) was broken There were several scratch marks on the left side of body varying from 70 cm to 110 cm from the ground. Figure 4 shows the major scratch marks on the body-structure. Finally, the crashed vehicle required to tow from the crash scene by the towing vehicle.

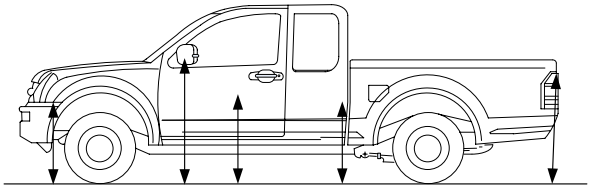

Figure 4: Different Levels of Scratch Marks from Ground

6.2 (b) VEHICLE TIRE CONDITION

The left tire was found completely air blown out without any visible rapture as shown in Figure 5. The mud on the alloy-wheel assembly shows clearly that the air is completely out as found at its POR. The pressure readings from other three tires were found quite fluctuating. The right-front tire was 24 psi, left-rear 28 psi and right-rear 35 psi. The tread depth of the tire was not found very satisfactory for pickup. All the tires were having 5 to 6 mm deep tread. Since the vehicle went down to the ditch left side of the left-most lane, the front and rear wheels were marked with mud and worn-out grasses.

Figure 5: Blown out Left-Front Tire without Rapture

6.2 (c) RESTING AT POR

The vehicle was found at the rest position (i.e. POR) on the roadside embankment. Considering the roll-over, the vehicle made one-eight counter clock-wise of full turn from the initial condition to the POR. Figure 6 shows the POR of the vehicle partially inside of ditch.

Figure 6: Point of Rest of the Vehicle partly in the Ditch

7. RESULTS OF CRASH RECONSTRUCTION

After applying the concept of reconstruction, the speed and time required from the run-off the road to the POR were calculated. The salient figures of these results are presented in Table 1.

Table 1: Major Findings of Reconstruction

	Location	Material	Co-efficient of Friction	Speed (km/hr)	Time (sec)
1	Shoulder	Asphalt	0.84	102 ~ 105*	1.17 ~ 1.24
2	Grassy roadside	Grass & mud	0.64	77	
3	Ditch	Grass, mud & stone	0.62 ~ 0.64	64 ~ 68	2.75 ~ 2.92

** initial traveling speed*

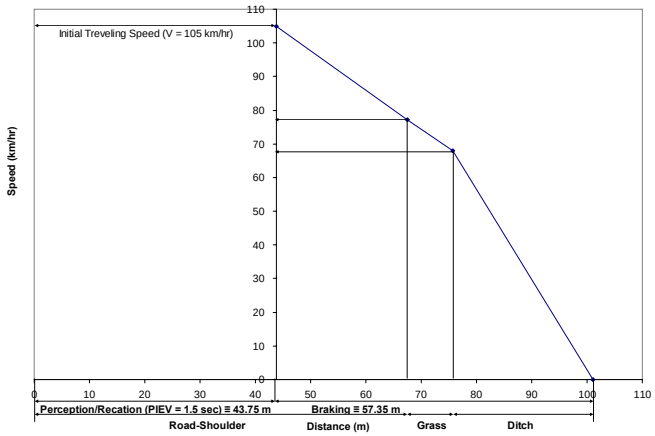

Figure 7: Speed vs. Distance Relationship

Figure 7 shows the relationship between traveling speed and distance traveled by the pickup. Assuming average perception-reaction time for complex situation to be 1.5 sec [4], PIEV distance found to be 43.75 m; while the braking distance was estimated to be 57.35 m. Considering the different friction surface (value given in Table 1), speed was calculated based on the trajectory equations (Newton's equations of motion). Interpreting in reverse direction, it is shown in Figure 7 that the pickup was at POR with zero speed decelerated from 68 km/hr in the ditch. While in the transition zone, it decelerated to 68 km/hr from 77 km/hr at the road-side area. Considering further backward, it decelerated to 77 km/hr from the initial traveling speed of 105 km/hr when it traveled on the shoulder. The total distance traveled from the perception to the POR was estimated to be 101.1 m.

The injury mechanism could be ascertained from the results of Table 2.

Table 2: Results related to Injury of the Occupant

Parameters for Injury	Shoulder to Roadside	Roadside to Ditch	How obtained
Force applied to vehicle (KN)	12.81	10.47	$F = \frac{m_{veh+occ}}{2d_{post-brake}}\left(V_1^2 - V_2^2\right)$
Force applied to the driver (KN)	0.56	0.46	$F = \frac{m_{occ}}{2d_{post-brake}}\left(V_1^2 - V_2^2\right)$
Acceleration received by vehicle/driver (g)	0.82	0.67	$a = \frac{F}{m}$
Energy received by the driver (KJ)	15.61	12.49	$E = \frac{1}{2} m_{occ}\left(V_1^2 - V_2^2\right)$

Considering the time available for dissipation of both acceleration and force were below the threshold of human tolerance [5] as presented in Table 3. It was found that the driver did not mention about any injury due to run-off the road.

Table 3: Comparison of Stress Limit with Estimated Parameters

Body Part	Stress Limit			Injury Parameters	
	a_x (g)	F_x (N)	t (ms)	Shoulder to Roadside	Roadside to Ditch
Whole body	40 ~ 80	-	160 ~ 220	a_x = 0.82 g	a_x = 0.67 g
Brain	100 ~ 300	-	-		
Skull	80 ~ 300	-	-	F = 560 N	F = 460 N
Forehead	120 ~ 200	4000 ~ 6000	-		
Cervical vertebra	30 ~ 40	1200 ~ 2600*	-	t = 1170 ~ 1240 ms	t = 2750 ~ 2920 ms
Thorax	40 ~ 60	4000 ~ 8000	> 3		
Pelvis	-	6400 ~ 12500^	-		
Shinbone	-	2500 ~ 5000	-		

** shear stress, ^ application into the knee*

Considering the factors involved in the case, the following conclusions can be drawn based on physical evidence, factual information, and in-depth analysis regarding the system components:

- Vehicle factor:
  - zero tire pressure of the front-left wheel initially caused the vehicle to loose the control and run into the ditch, left side of the travel direction
  - tire condition (e.g. tread depth) was not satisfactory, indicating poor maintenance
  - tire pressure was imbalanced (i.e. variable pressure at different tires)

- Human factor:
  - traveling speed was found to be 102~105 km/hr. In the situation for front tire blown out, it was too fast to control even after taking evasive action (i.e. braking)

- Road-environment factor:
  - steep roadside embankment was not so friendly for any errant vehicle driver to recover in case of run-off the road that could have resulted in severe roll-over

8. CONCLUSION

Even the in-depth analysis indicates more responsibility on vehicle factor particularly the front-left tire blown out condition, inappropriate traveling speed for that particular situation and inexperience (i.e. one week familiarity with the vehicle) of the driver are equally responsible for such consequences. Other factors also play very crucial role for the condition. The roadside design is another very important issue to be considered. Errant driver-friendly roadside design is one of the potential lacks in this run-off the road crash. However, speed limit detection surveillance system could be established with smart resource planning and management by highway police unit.

The in-depth analysis reveals that not only vehicle factor but other factors (i.e. human and road) are highly responsible for this particular crash case. It is timely to think about the highway roadside design and vehicle maintenance standard for safe driving.

9. ACKNOWLEDEGMENT

TARC team members sincerely remember the TARC manager, late Prof. Yordphol Tanaboriboon's mission with TARC research activities and his encouragement for TARC team.

10. DISCLAIMER

The information provided in this paper contains a case investigated completely by TARC team. The case was randomly selected and bears no relationship with any other analysis published in other sources. The analysis and other information are solely presented for academic purpose.

11. REFERENCES

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12. SHORT BOIGRAPHIES

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