THE ANALYSIS OF BANGKOK METROPOLITAN ROAD TRAFFIC SAFETY

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Abstract

According to the Depart of Highway, the number of victims in the road traffic accidents is as high as 21,622 people in 2012. It is a nationwide problem since those injuries and lives lost affect the lost in social and economic. In addition, the road accident issue is more crucial in Bangkok metropolitan. According to Traffic Accident on National Highway Annual Report (2012), Bangkok metropolitan was ranked as having the highest priority factor, which calculated from accident statistic (2012) by Royal Thai Police, compared with other regions. Especially for only Bangkok capital, its priority factor is the highest among all other provinces. Therefore, the road traffic safety analysis of Bangkok metropolitan is established. This paper includes a study of road traffic accident factors and the appropriate road traffic safety standard and technique. Moreover, a primary road traffic measurement method, which accessing road infrastructure, is also provided in this paper. The objective of this project is to enhance the road traffic safety by providing knowledge and tool to support those road safety issues in the hopes that it will help making roads in Bangkok safer for everyone.

Keywords: Road Traffic Safety, Index, Bangkok Metropolitan

1. INTRODUCTION

According to the Journal of Society for Transportation and Traffic Studies (JSTS) Vol.1 No.3, World Health Organization (WHO, 2004) pointed out the need of concerning the road traffic safety problems said, “without increased efforts and new initiatives, the total number of road traffic deaths worldwide and injuries is forecast to rise by some 65% between 2000 and 2020, and in low-income and middle-income countries deaths are expected by as much as 80%.” This implies that the road accident is a huge problem that should be counteracted by improving the road traffic safety.

In addition, according to International Transport Forum (2008), Road Traffic Safety refers to “methods and measures for reducing the risk of a person using the road network being killed or seriously injured. The road traffic safety method aimed to prevent the vehicle occupants and other road users include pedestrians, cyclists, motorists, their passengers, and passengers of on-road public transport, mainly buses and trams.”

Furthermore, most road traffic accidents in Thailand often occurs in Bangkok metropolitan area according to the traffic accident statistics on Royal Thai Police (2012), the number of accidents in Bangkok was as high as 36,988 times (apart from the total number in Thailand of 61,114 times), higher than the rest of Thailand combined. Therefore, Bangkok is the area that should be mostly emphasized on.

The study of main influencing elements that contributed to road traffic accidents is provided with a selection of focusing on only one element, environment factor, in the analysis since the environmental factor is the factor that is primarily able to control and alter. Of this environment includes among others intrinsic safety of roads and environment with the view on the design of road infrastructure which can create huge impacts on traffic accidents and fatalities of road users. Moreover, the survey of which factor most people in Bangkok conceive as the most significant factor has been conducted to study the road accident factors. In order to measure the road traffic safety, the method of identifying road infrastructure deficiencies in Bangkok has been developed and is primarily discussed in this paper.

The Analysis of Bangkok Metropolitan Road Traffic Safety is aimed at analyzing each feature of the road infrastructure in order to detect the deficiencies and to identify which elements or topics of the road infrastructure should be improved. Therefore, the analysis would allow solving road safety problems before they become traffic accidents.

2. LITERATURE REVIEW

The majority of Analysis of Bangkok Metropolitan Road Traffic Safety intends to highlight the traffic accident situation and road safety measurements in Thailand and study on the past and current development of road safety issues in the country as well as to adapt the road safety measurement tools to be practical in Thailand.

2.1 Study of Severity of Road Traffic Accidents

In everyday, there are always a number of injuries and casualties due to the road accidents. From the study, there are several evidences to support the severity of road accidents issue in Thailand. First of all, according to World Health Organization (WHO), Thailand is the third rank of the world that has high rate of road accidents. Also, the records of the Bureau of Highway Safety Department of Highways indicates that the number road crashes are fluctuate during the past twelve year with a peak number of 18,548 cases in 2004 and continually down to 11,013 cases in 2012. However, the accidental rate in this period has never down below 10,000 per year which still be the large number (see in Figure 1).

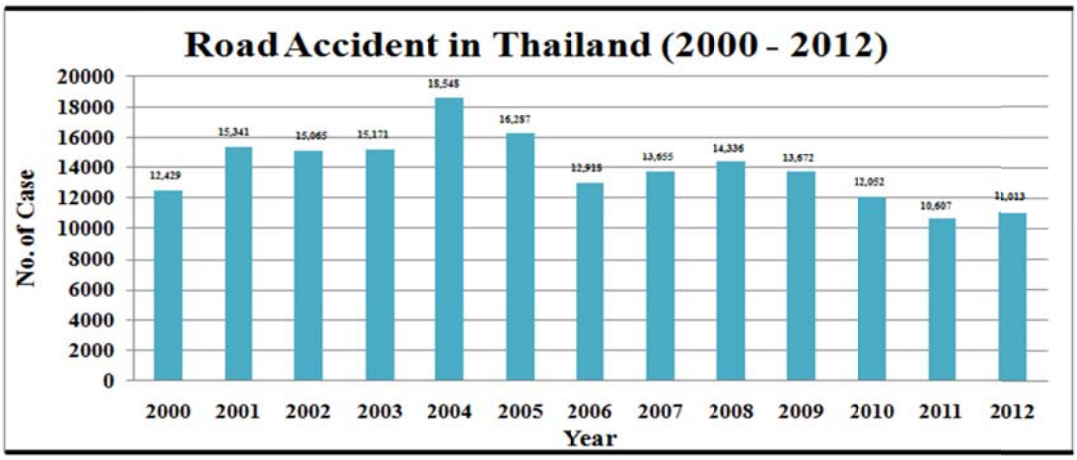

Figure 1: Number of road accidents in Thailand from year 2000 to 2012.
(Source: Bureau of Highway Safety, Department of Highways)

Moreover, compared with other countries, Thailand has the highest number of casualties per 100,000 populations per year (the data observed by WHO in 2010 and published in 2013). As in Figure 2, Thailand has higher casualties rate than both countries with high level of income and countries with low level of income.

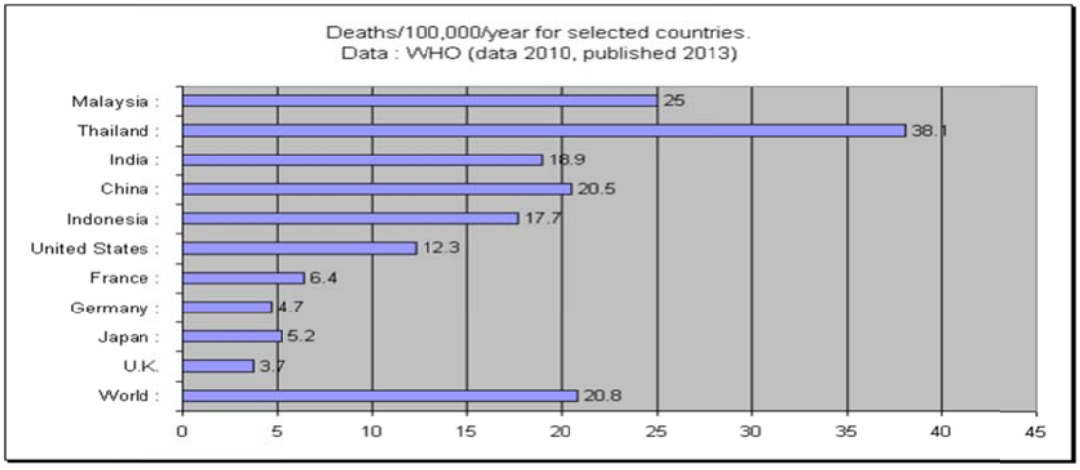

Figure 2: Rate of casualties per 100,000 populations per year from road accidents in Thailand compared with other countries in year 2000-2012 periods.
(Source: Traffic Accident Statistics for Thailand,
http://www.thaiwebsites.com/caraccidents.asp)

Furthermore, the number of traffic accident in Bangkok metropolis is crucial according to the statistic shown in Table 1. Bangkok Metropolis also has highest priority factor among other regions in Thailand.

Table 1: Traffic accident statistic (2012) by Royal Thai Police
(Source: Traffic Accident on National Highway, Annual Report 2012)

จังหวัด Province		อุบัติเหตุปี 2555 Accident in 2012			อัตราต่อประชากร 100,000 คน Rate per 100,000 population			อัตราต่อยานพาหนะจดทะเบียน 10,000 คัน Rate per 10,000 registered vehicle			ค่าคำนวณลำดับความสำคัญ Priority factor
		อุบัติเหตุ Accident	คนตาย Death	คนบาดเจ็บ Injury	อุบัติเหตุ Accident	คนตาย Death	คนบาดเจ็บ Injury	อุบัติเหตุ Accident	คนตาย Death	คนบาดเจ็บ Injury	
กรุงเทพ	(BANGKOK)	32,675	306	7,225	575.92	5.39	127.35	43.43	0.41	9.60	167.85
สมุทรปราการ	(SAMUT PRAKAN)	2,622	106	1,227	214.34	8.67	100.30	193.20	7.81	90.41	146.96
ปทุมธานี	(PATHUM THANI)	856	136	289	82.80	13.15	27.95	68.02	10.81	22.96	57.42
นครปฐม	(NAKHON PATHOM)	309	121	318	35.33	13.83	36.36	7.63	2.99	7.86	30.27
นนทบุรี	(NONTHABURI)	414	47	89	36.26	4.12	7.80	25.25	2.87	5.43	19.76
สมุทรสาคร	(SAMUT SAKHON)	112	33	90	22.01	6.49	17.69	5.64	1.66	4.53	16.27
รวมกรุงเทพปริมณฑล (BANGKOK METROPOLIS)		36,988	749	9,238	353.76	7.16	88.35	43.25	0.88	10.80	113.17

Nevertheless, the Journal of the Eastern Asia Society for Transportation Studies stated that *the cost of accident-related damage for 1994, as estimated by the Minister of Transport and Communications, MOTC, was 106,367 million baht or 3.41% of the country's GNP.* Furthermore, the journal also mentioned about the key action areas for initiate a nationwide master plan for road safety that is to develop a road safety audit process for Thailand. They further stated that the application of crash reduction countermeasures at hazardous road location and the accident prevention can lead to a safer road environment.

2.2 Study of Road Infrastructure Measurements and Its Importance

To begin with, according to Journal of Society for Transportation and Traffic Studies (JSTS) Vol.1 No.3, a study originally published by Treat (1977) revealed that there are three main influencing elements that contributed to the accidents including human, vehicle and environment. JSTS revealed a model called Triple-E model to address with those road safety problems. This model comprises of "Education" such as training course for road users, "Enforcement" such as controls of the road user to follow the regulations of road traffic and "Engineering" such as measurement of the design of road infrastructure beside other sub-areas of engineering which significantly influence on road traffic safety. The analysis in this project emphasized on "Engineering" which involves environment factor which has significant effect to road traffic safety according to the statement *"It is acknowledged that the design of road infrastructure has a strong influence on road traffic safety. According to Treat (1977) more than 40% of accidents are influenced by the element 'Environment' which comprises road infrastructure"*. Moreover, the statement *"Various road traffic safety measures and methods were successfully implemented related to the influencing-element, environment, and the action-area "Engineering" in Germany in the last decades"* has been proved in the journal by showing a percent reduction in road accidents (reduced by 30%), injuries (reduced by 87%) and deaths (reduced by 88%) which reduced significantly after

introduced the compact one-lane roundabout as a new intersection type in Germany. Therefore, improving road engineering leads to improving road traffic safety. JSTS also pointed out the need for adapting the measurement standards and strategies from other countries to apply in national and indicated the limit of road engineering in Thailand according to the statement, *"Thai road engineers often have no such guidelines to follow because only a few national guidelines exist and relate to only few topic areas."*

Rankers, ranking for European road safety (2008) also categorized the six elements of road infrastructure that used to inspect including road alignment such as lanes and shoulder width, roadside such as threes and obstacles, junctions such as road access and intersection, pavement such as road surface, overtaking such as coherence between road marking, and road layout consistency such as relationship between curvature of consecutive curves. These elements are used as the guideline in the Analysis of Bangkok Metropolitan Road Traffic Safety to identify the range of road infrastructure issues.

3. METHODOLOGY

3.1 The Road Accident Factors

A questionnaire survey about road traffic safety is conducted to determine which factor is the most significant from the view of people in Bangkok. The objective of this survey is to study the road traffic accident factors and to ensure that environment, in the aspect of road infrastructure, is also a major influencing factor to be concerned. Base on three factors that have been already informed (Human, Environment and Vehicle); the environment factor is further divided into two segments which are intrinsic environment (e.g. road infrastructure) and extrinsic environment (e.g. climate). Therefore, the survey falls into four main categories including human, vehicle, road infrastructure (intrinsic environment) and climate (extrinsic environment). A result of the survey is summarized in Figure 3.

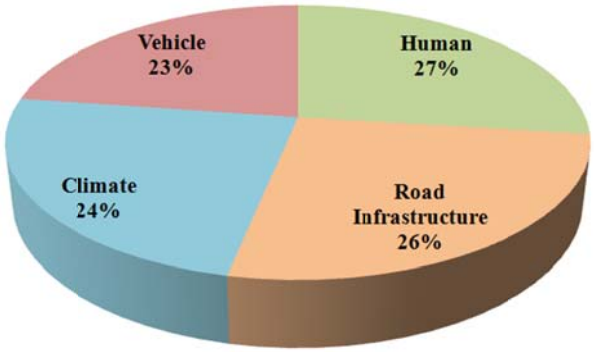

Figure 3: The significant percentage of each factor that contributed to the road traffic

As shown in the chart above, the result is that human is the most significant factor and the second significant factor is road infrastructure. In addition, the questions about whether each detailed elements of each factor significantly influencing the occurrence of accidents are developed in the survey. In the questionnaire, each element will be scored, ranking from '5' (Most important) to '1' (least important). The summation of scores on each element is show in the pie chart in Figure 4.

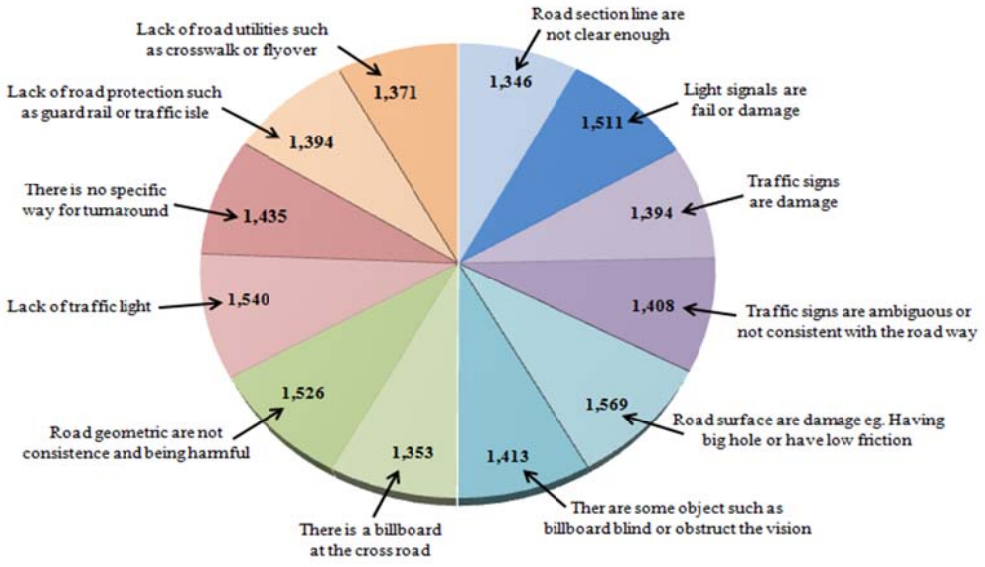

Figure 4: The pie chart showing summation of the scores of each element with the total score of 2,000 point.

In Figure 4, Damage of road surface is the element that has highest score which means that most people agree that it has significant impact on the accidents. Furthermore, the total scores of each element seemed to stick together as all numbers are not much different, which can conclude that most of all elements play the role on the road traffic safety and the analysis should cover these elements.

3.2 Road Safety Assessment

The road infrastructure measurement method attempts to reduce the risk of accidents. It has been categorized in five main topics and each topic consists of its relevant elements. The five topics with their symbols and scopes are shown and listed in the figure below.

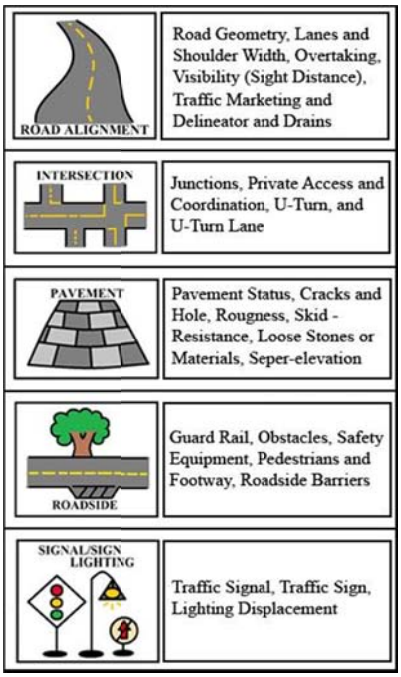

Figure 5: Five main road infrastructure topics.

Moreover, there are two important issues to be considered in inspection of road infrastructure;

3.2.1 Road Section Length

The length of road section has to be specified for inspection. Based on Rankers, Ranking for European Road Safety, "*the length of application of the road must be long enough to be cost-effective but it must also be short enough so any compensation effect within too long sections can be avoided.*" Therefore, the selected length used in this analysis to apply in inspection is 2 kilometers.

3.2.2 Criteria for Road Assessment

A common evaluation scale has been developed for marking each topic based on the urgency of actuation that each deficiency appeared for each road section. The scale must allow the comparison between each topic and show the urgency of each road infrastructure defection need to be immediately improved. Therefore, the marking scale has four levels including 0,1,2,3. Then, the sum and average marking for all questions of each topic will be calculated and expressed as a percentage. A symbol for each road infrastructure topic is presented and will be colored in one of four colors (Red, Orange, Yellow and Green). Four marking options were defined in following table. (0 being the worst and 3 the best)

Table 2: The meanings of each marking for each road section

Marking	Meaning
0	**Very poor**; needs urgent remedial measurement and improvement.
1	**Poor**; the deficiencies exist and needs improvement.
2	**Good**; needs some maintenance (minor improvement is required).
3	**Excellent**; only needs routine and periodic maintenance.

An example of one of the questions in Road Alignment topic is shown below:

Example1.) **What is the shoulder width of the road? (Shoulder Width = SW)**

0 if SW < 1.50 m.

1 if 1.50 m. < SW ≤ 2.00 m.

2 if 2.00 m. < SW ≤ 2.50 m.

3 if SW > 2.50 m.

If the road section that is inspected has the shoulder width about 1.75 meters, the marking score to be recorded in this question would be '1' meaning that it is poor and needs an improvement.

Moreover, four colors represent four range of the percentage of all question scores in each topic summarized in the Table 3. And an example illustrates when each color is applied to a symbol is shown in Figure 6.

Table 3: Each color with its marking percentage and meaning

Color	Percentage	Meaning
RED	0% - 25%	**Very poor**; needs urgent remedial measurement and improvement.
ORANGE	26%- %51%	**Poor**; the deficiencies exist and needs improvement
YELLOW	51% - 75%	**Good**; needs some maintenance (minor improvement is required)
GREEN	76% - 100%	**Excellent**; only needs routine and periodic maintenance

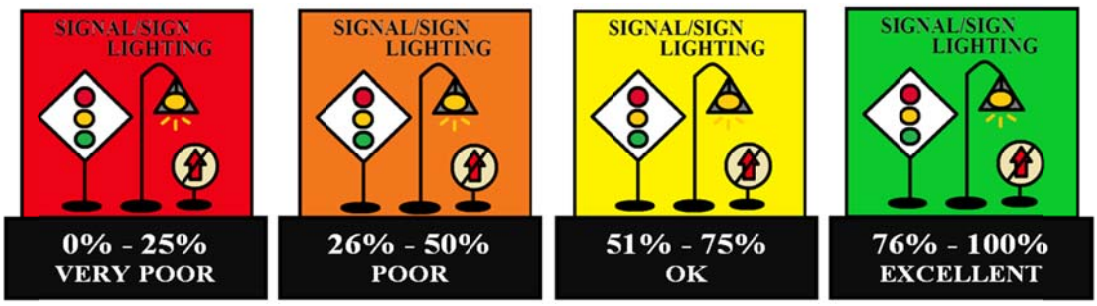

Figure 6: The example of a colored symbol.

After inspecting each road section, the result will be marked and translated to colored symbols of five topics. The five symbols representative of each topic are combined together as one symbol shapes like a cross mark (shown in Figure 7).

Figure 7: The combined symbol of five topics' symbols with fixed position.

The combined symbol will be drawn along with each road section line in a road map by having only shape and color remain. The position of each symbol when combined together is fixed due to the consistency to the combined symbol when appears on the road map. In addition, the overall outcome or average score of five topics for each road section is also represented by four colors applying into a road section line showed in the road map.

The road map is convenient to capture each road section with status of each topic through its overall status. It is also convenient to focus each topic with number of road section deficiencies. Moreover, the road section that needs urgent remedial measurement and improvement can be easier detected through the colored line in the map (shown in Figure 8).

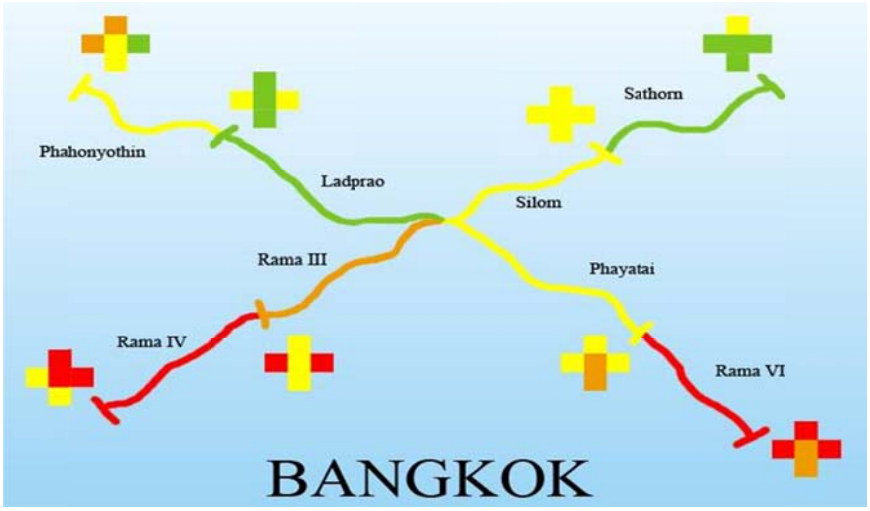

Figure 8: A road map represents road network with the assessment results.

3.3 The Five Topics of Road Infrastructure

The five topics of road infrastructure to be measured are including road alignment, intersection, pavement, signal/sign and lighting, and roadside. Each topic is discussed in detail:

3.3.1 Road Alignment

Road alignment, can also be called as geometric design of road, is a basis of road design consisting of various elements. Basically, road alignment is the primarily topic to go forth in road design analysis. Road alignment can be defined as the geometric design of road deals with the dimensions and layout. Moreover, elements of road alignment that are covered in the analysis include lane width, shoulder width, overtaking, drainage, traffic marketing and delineator, and visibility (or sight distance).

3.3.2 Intersections, Junctions and Private accesses

An intersection is a road junction where two or more roads either meeting or crossing. Intersection layout treatments concern a broad range of measures, including junction type conversions and junction alignment improvements such as 3-way, 4-way, 5-way, 6-way or roundabouts design, etc. depending on the number of road segments that comes together at the intersection.

Intersection is the point that most conflicts occur and subsequent to the high occurrence of road traffic accidents. Therefore, the analysis of accessing the intersection emphasizes on a redesign of road and amount of junctions among main roads and minor roads. The lower number of junctions leads to the lower number of traffic accidents. The elements that are covered in this topic include junction, private access and coordination, and U-Turn lane.

3.3.3 Pavement

Road pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement or road surface should be able to provide a surface of acceptable riding quality, adequate skid resistance and favorable light reflecting characteristics.

Normally, there are two types of pavement, concrete and asphalt pavements. The parameters that are used to evaluate the deficiencies of the pavement in Bangkok are wheel rut, crack length, roughness of road surface, skid resistance, loose stone or material, and super elevation.

3.3.4 Roadside

Generally, the road is the factor that causes the accidents by direct and indirect way. Direct harm factor including unsafe road surface, dangerous curve, dangerous intersection or sign and traffic light defective, etc. However, roadside is an indirect harm factor. The roadside consists of various elements, for instance, pedestrian or foot way, guard rail, crash barrier, clear zone, safety equipment and fixed obstacle (tree, poles, and billboards).

Furthermore, roadside significantly contribute to the car accidents. To illustrate, it can cause potential violence the car overturn, deaths or serious injury. Based on the Department of Highway (DOH), *in 2007, there were 5,837 roadside crashes or 43%, resulting in 586 deaths or 34% of all DOH's highways' deaths (DOH Annual accident statistics, 2008)*. This data proves that the roadside accidents are serious problem. Therefore, by improving the roadside design and inspection, the better road safety can be established.

3.3.5 Signal, Sign and Lighting

General to design the sign, signal and lighting on road is to instruct and inform the road users about road traffic conditions and regulations. To simplify, its role is like an indicator that informs all matters for road users. By definition, *traffic signs are devices placed along, beside, or above a highway, roadway, pathway, or other route to guide, warn, and regulate the flow of traffic, including motor vehicles, bicycles, pedestrians, equestrians, and other travelers.*; *traffic signals are traffic control devices such as stop lights and signs are used to control traffic flow and indicate right-of-way at intersections and pedestrian crossings.* Five fundamental requirements that these three elements must meet are:

- *Fulfill a need*
- *Command attention*
- *Convey a clear, simple meaning*
- *Command respect from travelers*
- *Give adequate time for proper response*

4. APPLICATIONS

After five topics are distinguished, the marking score will be recorded while each road section is inspected. Therefore, the result sheet is developed for recording the results of road inspection on each road section.

An example of result sheet illustrated in figured 9.

	Length					DD/MM/YY												
	Location					Type of road			Single Carriageway			Double carriageway						
						Type of road network			Primary			Secondary			Tertiary			
	1. ROAD ALIGNMENT					2. INTERSECTION (JUNCTION)			3. PAVEMENT			4. ROADSIDE			5. SIGNAL, SIGN AND LIGHTING			
	1.1)		1.5)			2.1)		2.5)		3.1)		3.5)		4.1)		5.1)		5.5)	
	1.2)		1.6)			2.2)				3.2)		3.6)		4.2)		5.2)		5.6)	
	1.3)					2.3)				3.3)				4.3)		5.3)		5.7)	
	1.4)					2.4)				3.4)						5.4)			
AVG.																			
OVERALL SCORE																			
AVERAGE OF OVERALL SCORE																			

Figure 9: Application form for each road section

The result sheet includes all data necessary in inspection to be recorded such as inspection date, actual length of road section, location of inspection, type of road and road network and score of each road infrastructure topic. After inspected and record all marking scores into the result sheet, the average and percentage of each topic will be calculated as well as the total and average score of five topics of a certain road section. Therefore, the result sheet is primarily able to indicate which road deficiencies occur most bases on five topics and those with the need of urgent improvement as well as able to identify the overall level of that road section.

5. CONCLUSION

Road traffic accident is a major social and economic problem of a nationwide which causes a lot of losses in live and injuries each year. Thence, the Analysis of Bangkok Metropolitan Road Traffic Safety project is constructed to address this problem.

Since the road infrastructure has a strong influence on road accident, the road infrastructure measurement is developed by applying several road safety standards from several sources including international and national sources. This proposed method is an effective tool since it combines various appropriate standards and technique, and then

translates into an easy and unique road measurement tool. The method categorizes road infrastructure into five topics and these five topics allow the analyzers to cover all important details of each road infrastructure elements as well as to identify the deficiencies on each road section in detail. Moreover, each different topic is comparable to each other since the common scale is used and percentage of score of each topic is calculated. This measurement method can detect the road section with potential to causes accident and also detect the topic that many road sections has failed to comply with its standard.

Note that this measurement method should be applied to the road network or several road sections, single road section can also be applied but not recommended. Another thing to be aware is that the measurement method developed in this project is used as a complementary tool to evaluate road infrastructure; it is not standalone tool. It attempts to help detect the road infrastructure deficiencies and make the suggestions from the result to relevant road safety departments, like a proactive tool, and remedial measurement is recommended for those road sections with deficiencies. Other complementary tools should be implemented together to improve road traffic safety. For instance, the complementary tools might be road safety audit, study and gathering information about road maintenances, the use of software program and including video recording for analyzing road and accident. All complementary technique will be very great potential tool when used along the road measurement method developed in this project. Nevertheless, this road infrastructure measurement has very low cost and easy to use, yet still be the effective tools. It has been developed with hope that it will enhance road traffic safety and bring about the reduction in number of road traffic accident.

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