การประเมินความเสี่ยงในการเกิดอุบัติเหตุบริเวณจุดตัดทางรถไฟ กรณีศึกษาสถานีรถไฟคลองแงะ-ควนเนียง จังหวัดสงขลา

THE RISK ASSESSMENT OF ACCIDENT AT HIGHWAY-RAILWAY GRADE CROSSING (HRGC): A CASE STUDY OF KHLONG NGAE-KHUAN NIANG TRAIN STATION, SONGKHLA PROVINCE

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บทคัดย่อ

อุบัติเหตุบริเวณจุดตัดทางรถไฟเป็นปัญหาที่มีความรุนแรงและเรื้อรังมานานในประเทศไทย ซึ่งในทุกปีมีจำนวนการเกิดอุบัติเหตุดังกล่าวเฉลี่ยประมาณ 146 ครั้งและมีผู้เสียชีวิตเฉลี่ย 120 ราย ปัญหาเหล่านี้ต้องได้รับการแก้ไขอย่างเร่งด่วน บทความนี้มีวัตถุประสงค์เพื่อนำเสนอความบกพร่องซึ่งนำไปสู่ปัญหาการเกิดอุบัติเหตุบริเวณจุดตัดทางรถไฟ ควบคู่กับการพัฒนารายการการตรวจสอบความปลอดภัยบริเวณจุดตัดทางรถไฟสำหรับประเทศไทย ซึ่งสามารถใช้ประเมินความเสี่ยงและอันตรายของอุบัติเหตุบริเวณจุดตัดทางรถไฟในพื้นที่ศึกษาทั้ง 10 จุด โดยเป็นจุดที่มีความเสี่ยงอันตรายในระดับรุนแรงสูง 4 จุด ได้แก่ จุดที่ 3 จุดที่ 5 จุดที่ 7 และจุดที่ 8 ซึ่งเป็นจุดที่มีความบกพร่องทางกายภาพต้องปรับปรุงด้านความปลอดภัยอย่างเร่งด่วน จุดที่มีความเสี่ยงอันตรายระดับปานกลางควรแก้ไขหรือหาวิธีลดความเสี่ยงของอันตราย 3 จุด ได้แก่ จุดที่ 1 จุดที่ 4 และจุดที่ 9 ส่วนอีก 3 จุดที่เหลือเป็นจุดที่มีความเสี่ยงอันตรายระดับต่ำที่เป็นจุดที่มีเครื่องกั้นรถไฟ ได้แก่ จุดที่ 2 จุดที่ 6 และจุดที่ 10 ตามลำดับ

คำสำคัญ: การประเมินความเสี่ยง อุบัติเหตุ จุดตัดทางรถไฟ

Abstract

Accident at Highway-Railway Grade Crossing (HRGC) is a serious and chronic problem in Thailand. Approximately 146 times each year, on average 120 deaths a year; therefore, this problem needs to be solved urgently. This article aimed to expose failures in preventing accidents at HRGC, and to develop a safety inspection checklist for HRGC in Thailand. The checklist can be used to assess the risk and danger of accidents at HRGC in 10 locations in this area of study. The highest risk locations were locations 3, 5, 7 and 8 which required an urgent safety measure. The second-highest risk locations were locations 1, 4, and 9 required to develop a mitigation strategy. The lowest risk locations were 2, 6 and 10 because traffic barriers are equipped in these areas.

Keywords: risk assessment, accident, highway-railway grade crossing

Introduction

According to the road safety situation in ASEAN, road accident causes loss of assets and has an impact on the quality of life valuation. It also accounts for 25% of deaths caused by traffic fatalities all over the world. Moreover, the death toll tends to increase from 315,000 to 316,000 between 2010 and 2013, which can be attributed to an increasing number of population and vehicle owners in the region (World Health Organization, 2016).

Based on the data obtained from the Ministry of Transport (MOT) in 2015, it was indicated that there were 69,674 road accidents, 6,356 people were killed and 18,362 were injured in motor vehicle crashes in Thailand (Ministry of Transportation, 2016). One of the causes of the traffic-related deaths is the accident at Highway – Railway Grade Crossing (HRGC). From the information of the accidents increase during 5 years (2008 – 2012) provided by State Railway of Thailand (SRT), it proves that the number of fatalities from crash between car and train is 120 on average out of 720 total accidents (State Railway of Thailand, 2013). This information also corresponds to the analysis of the severity level of the road accidents caused by vehicles studied by the Emergency Medical Institute of Thailand (EMIT). Out of 100 people who incurred accidents, the numbers of death from crash between train and vehicles such as motorbike, car and truck are 9.09, 15.38 and 14.29, respectively (Emergency Medical Institute of Thailand, 2008).

For the causes of HRGC accidents and the crossing safety, a number of contributing factors in HRGC accidents have been identified. According to HRGC accident report of Los Angeles County Metropolitan Transportation Authority (LACMTA), there were sixteen contributing factors in the HRGC accidents (Los Angeles County Metropolitan Transportation Authority, 1999). One of the most important factors in the HRGC accidents is human factor. From the factors analysis of HRGC accidents in Canada, there were six contributors of HRGC accidents: unsafe acts, individual different, train visibility, passive sign and marking, active warning system and physical constraints (Caird et al., 2002).

Due to this problem, the Office of Transport and Traffic Policy and Planning (OTP) launched a project to establish an accident improvement plan at HRGC and the roads around long distance trains in 2009. It revealed that from the railway networks in 47 provinces, there are 2,463 railway crossings with 1,923 crossings that are authorized by SRT. However, 540 of these crossings are illegally used and not conducive for travel. In the past, the government tried to resolve this by mainly focusing on illegal crossings. In addition, safety equipment at HRGC was installed but this was not able to control the risky driving behavior of the motor vehicle drivers. Hence, there is a need to study

and develop the safety audit checklist at HRGC specifically in Thailand which should cover all safety audit topics. Safety audit checklist, therefore, is one tool that relies on engineering principle helping the safety auditors assess the risk of accident, and recognizes the failures leading to the risk or accidents in a certain area.

The purpose of this paper is to provide the concerned authorities with awareness and to take urgent actions in order to reduce the number of HRGC accident in Thailand. Three specific objectives of this paper are as follows: to study the failures leading to the accidents at HRGC, to develop the safety audit checklist for the HRGC in Thailand, and to assess the contributing factors of accidents and risks in the study areas.

Materials and Methods

Road Safety Audit (RSA) was first introduced in 1994 in England. After that, Institution of Highways and Transportation (IHT) published and described the detailed principle in order for the auditors to understand the steps of safety audit together with the assessment of the risk of road accident. The main purpose is to help the project owners or relevant people ensure that all construction and highway improvement projects are operated under safe processes such as preparation, design, operation and safety condition after the road becomes available (Institution of Highways and Transportation, 1996). Which this is consistent to Road Safety Checklist Manual purposed by the Austroads, Australia. The manual provides the importance and principle in order to examine safety of the road which the auditors need to examine covering all aspects, all day and all night. Also, the auditors must have a team to help check which team is professional and has the potential to provide solutions based on the engineering principles of road safety (Austroads, 1994).

The journal of Institute of Transportation Engineers (ITE) presented road safety audits in Australia and New Zealand by supporting the principle and proposing the guidelines on utilizing the result of the audits. After auditing, the risk was assessed to see if it led to danger or severity in order to create a preventive plan (Institute of Transportation Engineers, 1999). In 2005, the solution was proposed to any responsible functions in order to reduce the possibility of road accidents which is the responsibility of those functions (Morgan, 2005). The possible solutions are, for example, study of new design of road, safety audit while the road is being constructed, legislation and policy for road safety (The World Bank Group, 2002).

From the study of the prevention of accidents at the HRGC in Australia (Main Roads Western Australia, 2005), it is found that road safety audit can be applied to safety audit at HRGC which the aspects to be audited are layout design, physical conditions and environment, and so on. According to the review of road safety audit

conducted by the organizations in several developed countries such as Federal Highway Administration (FHWA), Transport Canada (TSC), Main Roads Western Australia (MRA), New South Wales Government (NSW), and World Road Association of the United Kingdom (WRA), it shows that there is safety audit checklist specifically for HRGC. However, when compared with the other developed countries, there is no official safety audit checklist for HRGC in Thailand. Only the road safety audit checklist for HRGC was utilized, developed and improved by the Department of Highways (DOH) and Office of Transport and Traffic Policy and Planning (OTP), in order to learn about safety in the areas as part of the safety study report. In addition, this study does not cover all issues leading to the development of safety audit checklist at HRGC (the step when railway crossing is available); therefore, the auditors need to consider the safety issues mainly for the motor vehicle driver. Also, the safety issues need to be in compliance with the safety standard at HRGC proposed by SRT as follows the Traffic Moment (T.M.).

This study used the results from research paper which develop the safety audit checklist at HRGC (Settasuwacha & Luathep, 2005) and Risk Assessment by adopting 4x4 risk matrix in order to assess 2 aspects which are frequency as shown in Table 1 and 2. In Table 3 expand the risk severity as very severe mean high – speed, multi-vehicle crash on a freeway. Severe mean high or medium-speed vehicle/vehicle collision. Slightly severe mean some low – speed vehicle collisions. Very slightly severe mean some low – speed vehicle collisions/ Pedestrian walks into object (no head injury) (Austroads, 2002) and presented audit process in Figure 1. It can be drawn that this development of safety audit checklist of HRGC in Thailand can help consider other safety issues not found in the previous road safety audits (alignment and sight distance, layout and cross section, traffic signals, signs, lightings, boom barriers, and pavement surface). From the safety checklists in several expert for road safety management countries such as Australia, United Kingdom and United State. Seven audit topics have been selected to compared and developed as shown in Table 4.

Table 1 The resulting level of risk

Levels of severity	Frequency of accident			
	Often	Sometimes	Seldom	Never
Very severe	Unacceptable	Unacceptable	Unacceptable	High
Severe	Unacceptable	Unacceptable	High	Moderate
Slightly severe	Unacceptable	High	Moderate	Low
Very slightly severe	High	Moderate	Low	Low

Source Adapted from Austroads, (2002)

Table 2 Treatment

Level of risk	Suggested solution approach
Unacceptable	Must solve urgently.
High	Should solve or mitigate the risk to be at low level even though cost of solving is high.
Moderate	Should solve or mitigate the risk to be at low level if cost of solving is moderate.
Low	Should still solve or mitigate the risk if cost of solving is low.

Source Adapted from Austroads, (2002)

Table 3 Accident severity

Level of severity	Description
Very severe	Might have high number of death
Severe	Death or severe injury
Slightly severe	Slightly severe injury
Very slightly severe	Slightly severe injury or slightly damaged assets

Source Adapted from Austroads, (2002)

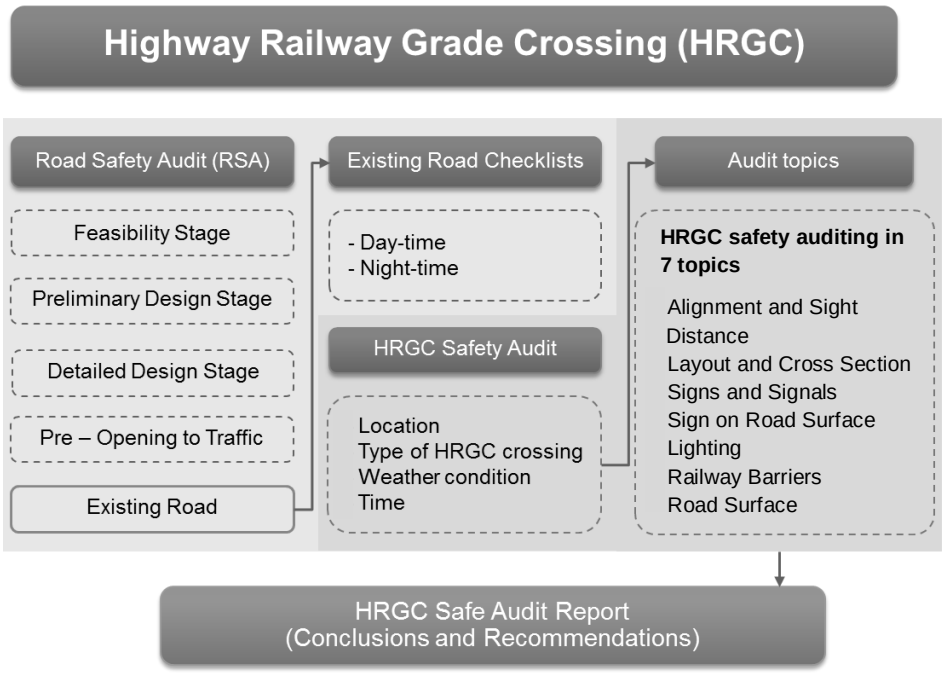

Figure 1 New process of HRGC safety audit in Thailand.

Table 4 The comparison of the safety checklists at HRGC from different organizations.

Audit topics	DOH	OTP	FHWA	MTA	MRA	NSW	WRA
Alignment and sight distance	×	✓	✓	✓	✓	✓	✓
Layout and cross section	×	✓	✓	✓	✓	✓	✓
Signs and signals	✓	✓	✓	✓	✓	✓	✓
Signs on road surface	×	✓	✓	✓	✓	✓	✓
Lightings	✓	×	✓	✓	✓	✓	✓
Railway barriers	✓	✓	✓	✓	✓	✓	✓
Road surface	✓	✓	✓	✓	✓	✓	✓

Remark DOH – Department of Highways, Thailand (Department of Highways, 2007).
OTP – Office of Transport and Traffic Policy and Planning, Thailand (Office of Transport and Traffic Policy and Planning, 2006).
FHWA – Federal Highway Administration, United State of America (Federal Highway Administration, 2007).
MTA – Metropolitan Transportation Authority, United State of America (Metropolitan Transportation Authority, 1999).
MRA – Main Road Western Australia, Australia (Main Road Western Australia, 1997).
NSW – New South Wales Government, Australia (New South Wales Government, 2002).
WRA – World Road Association of the United Kingdom, United Kingdom (World Road Association of the United Kingdom, 2011).

Results

For the study and the risk assessment of the accidents at HRGC, from Khlong Ngae station to Khuan Niang station (Ban Phru – Khlong Hae –Sa Dao) with 35-kilometer distance, presented in Figure 2, it illustrates that there are many accidents that transpire along this route. Also, this route has various types of barriers and crossings including illegal crossings which are not allowed by SRT. For safety audit team, there are 4 auditors in this project which one has experience in HRGC safety conditions, two as transportation and traffic engineers and last is technician. In this study, 10 locations in this route are selected and classified into 2 groups which are (1) 5 locations that accidents occurred and (2) other 5 locations that recorded no accidents, in order to define the factors influencing the comparison of danger leading to accidents at HRGC in all conditions.

Figure 2 Study site locations (Khlong Ngae station to Khuan Niang station)

Table 5 Physical conditions of HRGC (Khlong Ngae station to Khuan Niang station)

Audit locations	Type of crossing	Past accidents	Type of road	Crossing degree (°C)	Crossing slope (%)	T.M.
Khlong Ngae station						
LOC. 1	Sign	Yes	Asphalt	45	0	4,2240
LOC. 2	Barrier	No	Asphalt	45	0	56,256
LOC. 3	Illegal	Yes	Asphalt	90	0	3,264
LOC. 4	Signal	Yes	Concrete	90	>5	3,840
LOC. 5	Illegal	Yes	Asphalt	90	<5	3,072
LOC. 6	Barrier	No	Asphalt	45	<5	2,688
LOC. 7	Illegal	Yes	Asphalt	90	0	1,920
LOC. 8	Illegal	Yes	Asphalt	90	0	1,728
LOC. 9	Sign	No	Asphalt	90	<5	4,608
LOC. 10	Barrier	No	Asphalt	45	0	44,064
Khuan Niang station						

According to the safety audit at HRGC in order to assess risk of accidents in this area, the safety issues and solutions can be concluded as shown in Table 6 – 8.

Table 6 Risk factors leading to accidents at HRGC

Risk factors	Audit results	Recommendations
Alignment and sight distance 	Sight distance is not enough for the driver's vision. Trees and weeds grow and obscure vision of train and vehicle drivers. Layout is not appropriate for the speed at the crossing.	Install Rumble strips to warn and reduce speed of vehicles before they come closely to crossing area. Cut down trees and weeds to improve vision. Improve crossing layout to be more consistent to the speed designed.
Layout and geometric design 	Lanes and pavements are not wide enough for traffic capacity. Shape and radius of turning are not appropriate for vehicle drivers.	Review the design and need for installation of standard pavement.
Warning sign and signal 	Lack of stop sign in some points. Damaged signs are founded. Stop sign is not standard. Duplication of stop sign installation is found.	Install stop sign to conform with standard and law.
Pavement marking 	No stop lines or lack of road separation lines. Signs are worn out and faded which cannot be seen clearly.	Install clear signs on pavement, stop line and separate lines. Use Thermoplastic colour for painting and installation to increase vision efficiency.
Road surface 	Surface is rough and seriously damaged. There are gaps between road and railway which can be harmful.	Improve surface and close gaps between road and railway for safety.

Table 7 Summary of safety issues at HRGC in the study areas

Safety issues	Audit locations									
	1	2	3	4	5	6	7	8	9	10
Alignment and sight distance	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗
Layout and cross section	✗	✓	✓	✓	✗	✓	✗	✗	✗	✓
Signs and signals	✗	✓	✗	✗	✗	✓	✗	✗	✓	✓
Signs on road surface	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓
Lightings	✗	✓	✗	✓	✗	✗	✗	✗	✗	✓
Railway barriers	✗	✓	✗	✓	✗	✓	✗	✗	✗	✓
Road surface	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓

Remark ✓ In accordance to standard
✗ Not in accordance to standard

Table 8 Problems and recommendations

Risk factors		Occurrence of accident and risk			
Location	Problems	Expected accident	Frequency	Severity	Risk
LOC. 1	Physical condition of crossing is dangerous, inadequate signs and equipment.	Danger to vehicles crossing.	Sometimes	Severe	Unacceptable
LOC. 2	Inadequate sight distance.	Drivers are obscured by weeds and trees on the sideways.	Never	Slightly severe	Low
LOC. 3	Illegal crossing, inadequate sight distance, all safety facility.	Illegal crossing is highly dangerous for all vehicles.	Sometimes	Severe	Unacceptable
LOC. 4	Signs on the road surface are worn out and damaged.	Danger to vehicles passing by at night.	Sometimes	Severe	Moderate
LOC. 5	Dangerous Illegal crossing.	Illegal crossing is highly dangerous.	Sometimes	Severe	Unacceptable

Table 8 (Cont.)

Risk factors			Occurrence of accident and risk		
Location	Problems	Expected accident	Frequency	Severity	Risk
LOC. 6	Inadequate sight distance, signs are worn out.	Weeds obscure vision, and slope is obstacle for passing the crossing.	Never	Slightly severe	Moderate
LOC. 7	Dangerous Illegal crossing.	Illegal crossing is highly dangerous.	Sometimes	Severe	Unacceptable
LOC. 8	Dangerous Illegal crossing.	Illegal crossing is highly dangerous.	Sometimes	Severe	Unacceptable
LOC. 9	Physical condition of crossing is inappropriate, signs are worn out and not standard.	Danger to vehicles passing by.	Never	Severe	Unacceptable
LOC. 10	Inadequate sight distance.	Crossing way is not appropriate.	Sometimes	Slightly severe	Low

Conclusions

The development of safety audit checklist at the railway crossing in Thailand can rely on the Road Safety Audit (RSA) by adopting the step when the road is available to improve and develop the audit checklist. When compared with the other developed countries which specifically solved the safety issues at HRGC, additional audit topics are added which are equipment and safety barrier at HRGC, behavior, lighting and so on in order to define the factors leading to accidents, and to define the dangerous locations. The factors ranged from the high risk factor which needs to be resolved immediately to the low risk factor.

For the danger at HRGC leading to accidents occurring at HRGC allowed by RSA and not allowed by RSA (illegal crossings), it demonstrates that Traffic Moment (T.M.) is not appropriately used for safety management at HRGC. From the study, all 10 locations are obviously opposed to the standard of HRGC. For providing the equipment to prevent accidents, additional safety aspects should be considered rather than the number of

vehicles and the number of trains in a day such as alignment and sight distance, physical conditions of HRGC, signs and warning signals, signs on the road surface, road surface.

According to the recommendations from the assessment of the risk of accidents at 10 locations of HRGC, 5 locations that accidents occurred and others recorded no accidents. The investigation found that both of location groups, the new safety audit checklist can make the point where there is a risk of accident. Especially the point where there have been no accidents before. This form can identify deficiencies and risks that can raise a major accident at HRGC. The result proves that there are 4 locations with the highest risk which are locations 3, 5, 7 and 8 that need safety improvement immediately. There are 3 locations with moderate risk, these are locations 1, 4, and 9 with risk that needs to be mitigated or resolved. For the other 3 locations which are locations 2, 6 and 10, the risk is at low level because these points are consists of the barrier. The recommendations are proposed to the responsible organizations such as State Railway of Thailand (SRT), Department of Highways (DOH) and Department of Rural Roads (DRR) in order to recognize the importance of safety, and to develop the safety audit checklist manual for HRGC to help assess the risk from any factors as causes of accidents.

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