Highway - Railway Grade Crossing Accident Cost in Thailand.

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Donyarit SETTASUWACHA[1], Paramet LUATHEP[2], Pichai TANEERANANON[3]

[1]PhD Student EU-Asia Road Safety Centre of Excellence "RoSCoE"
Department of Civil Engineering, Faculty of Engineering
Prince of Songkla University
E-mail: choke_ce9@hotmail.com

[2]Lecturer Department of Civil Engineering, Faculty of Engineering
Prince of Songkla University
Fax: +66(0)7444-6519
E-mail: paramet007@hotmail.com

[3]Professor Department of Civil Engineering, Faculty of Engineering
Prince of Songkla University
Fax: +66(0)7444-6519
E-mail: 2007tao@gmail.com

Abstract

Highway - railway grade crossing (HRGC) in Thailand has created seriously national safety problems for a long time. According to the State Railway of Thailand (SRT) statistics from 2006 to 2010, it shows that about 60 people are killed from over 140 cases of HRGC accidents every year. However, these serious impacts are always not expressed in monetary term of life and property losses. This paper aims to present HRGC crash situation in Thailand, based on the SRT data, and to determine unit costs of HRGC crash per casualty (and per case), classified by accident severity. In this study, three types of accident severity are classified, including fatal, injury and property damage only. The HRGC accident cost would be benefit to HRGC crash cost analysis that can be applied to evaluate appropriate safety countermeasures of HRGC in Thailand.

Keywords: Highway 1, Railway 2, Grade crossing 3, Safety 4, Accident cost 5

1. Introduction

In 2009, the World Health Organization, WHO [1] reported global status on road safety have been projected to be the fifth highest leading cause of global death by 2030, after heart disease, cerebrovascular disease, pulmonary disease and respiratory infections. Road accident is considered as a major problem in many countries. There are about 1.3 million people die on the world's roads annually.

On the Association of Southeast Asian Nations (ASEAN) scale, roads and traffic accidents create serious national impact for a long time. According to a report status paper on road safety by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) have been reported road accidents situation in ASEAN 10 countries, more than accidents 670,976 accidents, 63,101 fatalities and 154,053 injuries. [2]

In 2011, The Royal Thai Police have been reported [3] the number of road and traffic accidents situation in Thailand which are result 68,583 cases, 9,205 result in fatalities, 4,093 result in serious injuries and for 17,823 of slight injuries.

Which one of serious impact of road and traffic is highway - railway grade crossings (HRGC) accidents are usually small proportion of accidents if comparison which another vehicles, they tend to be severe when a train is involved, and

often attract a high level of public and media attentions. Every year there are average 140 cases of accidents. On some 4,000 km. of railway tracks in Thailand, resulting in more than 250 deaths for the past four year fatality, which trends are decrease from 2006 - 2009 and increase in 2010, the accident data during the last 4 years (since 2007 to 2010) shown in **Fig. 1**, the number of accidents [3] 140, 143, 132 and 155 opposite the number of fatality and injury which increasingly from 47 in 2007 and 54 in 2010.

Fig. 1 Railway crossing situation in Thailand (Source: State Railway of Thailand, 2011)

These serious events are mostly damaging both in monetary term of life and property loses. This paper aims to present HRGC crash situation in Thailand, based on SRT data, HRGC crash analysis, HRGC accident costing and to determine an average unit cost of HRGC crash per casualty (and per case), classified by accident severity, three types of accident severity are classified, including fatal, injury and property damage only. Finally, the HRGC accidents cost rate would be benefit to HRGC crash cost analysis that can be propose to evaluate appropriate safety countermeasures of HRGC in Thailand.

1.1 Aim and Objectives

The aim of this paper are two main, first to present State Railway of Thailand (SRT) accident data and second is to determining the cost of HRGC accident. Which three specific objectives of this paper are as follows:

- To review the present status of HRGC accidents;
- To present HRGC accident statistics and cash analysis;
- To estimate HRGC accident cost; and

2. Literature review

HRGC can be referred to as a special form of intersection, where a railway crosses a road at grade that it constitutes of two transportation modes [4], which differ in both the geometric feature of their traveled ways and their operation. For authority at the crossing responsibility is shared between road agency and railway.

From the railway authority, State Railway of Thailand (SRT) is a government agency that is responsible for the operation, freight services, infrastructure construction and safety at HRGC. According to SRT collected accident data, 8 parameters were occurred in the structures of SRT database following as:

- Train in accident
- Date of accident
- Telegraph pole
- Location of accident
- HRGC types
- Time of accident
- Crashed details
- Casualty of accident

The accident casualty has mentions in two categories are classified in accident data as injury and fatal. SRT accident data base during five years (2006 - 2010) have found a train accident occurred average about 143 cases, 156 are injured and about 60 peoples are killed for each year or average of one death/injury per one railway crossing.

According to Office of Transportation and Traffic Policy and Planning (OTP) reported a trend of HRGC accident, injuries and fatalities in 2010 [5]. The traffic and transportation volumes in development country were increasing number of the diving public. The growing number of vehicle on the road has increasing of road - railway crashes accident. Train collision with a vehicle at HRGC still a high level and more increase of crashed frequency. The causing of life and property of the people and the country is more value for estimating.

2.1 Accident costing study

The Federal Highway Administration (FHWA) has definition of accident costs are the economic analyses for choosing among alternative improvements to existing road, street and highway system. The Accident costs also used to allocate highway safety resources among programs, evaluates safety regulation, policy marker that safety programs are beneficial [6].

The Road Safety Toolkit explains the cost of a crash [7] means the potential benefit of solutions that would reduce the number of crashes can be calculated. This provides a way to compare the benefits of proposed crash solutions with the costs of implementing them in order to provide the maximum benefit for the money available for investment. Crash costing also provides a way to compare the total impact of crashes in a local area, country, or region.

According to The World report on road traffic injury prevention [8], there gives the estimated worldwide cost of crashes. The report mentions the costs in low to middle - income countries are probably seriously underestimated because not all road crashes are reported to authorities. Total costs were estimated at US$517.8 billion.

Transportation Research Laboratory (TRL) in 2005 described two main methods for estimate crash cost values of traffic accidents which are the Human Capital (HC) and Willingness to pay (WTP) methods. The HC method has been used in developing countries such as Vietnam, Bangladesh, Thailand, Korea, Nepal, Tanzania, Zambia, Malawi and Egypt. The loss works out to the economy based on the cost of treating the person's kill or injury, loss of income, and damage to property. The WTP approach which is used in develops countries such as the UK, Sweden, Norway, Iceland, USA Germany, Denmark, New Zealand and Australia. The method based people assessment of their specific types of risk and what they would to pay to reduce or minimize of risk.

Department for International Development (DFID) has published the guideline for estimating cost of road crashes in developing countries [9] and the HC method was recommended for use in developing countries.

The studied by M. DE LEON et al. [10], have estimation of socio - economic cost of road accidents in metro manila by using HC method that focuses on the Gross Output of road accident victims, costs are classified into three main components such as victim related cost, property damage and administration cost. The monetary value of these components is estimate in accordance with four types of accident severity, fatal, serious injury, minor injury, and property damage only.

The comparison studies of method and estimate crash cost of traffic accidents are summarize with the approaches used in countries as shown in Table 1.

From this table mostly countries used the HC method for determination of traffic accident cost on their countries. In Thailand, Department of Highways (DOH) had reported on the project: The Study of Traffic Accident Cost in Thailand [10], suggestions of main advantage of the HC method is easy for calculation than WTP method, based on the assumption which human beings are a resource for economic production; prevention of accidents will then prevent the loss in productivity due to human deaths or injuries caused by accidents.

2.2 Components of accident costing

The cost components of HC method into three categories: first, costs involving human beings or human costs are consists to loss of productivity, quality of life costs, medical costs and long term care costs, second, property damage costs have two categories are vehicle damage costs and non - vehicle damage costs, and third, general costs of a crash consisting to insurance administration, police administration, judicial system costs, emergency rescue service and travel delay costs. The groupings of the components are illustrated in Figure 2.

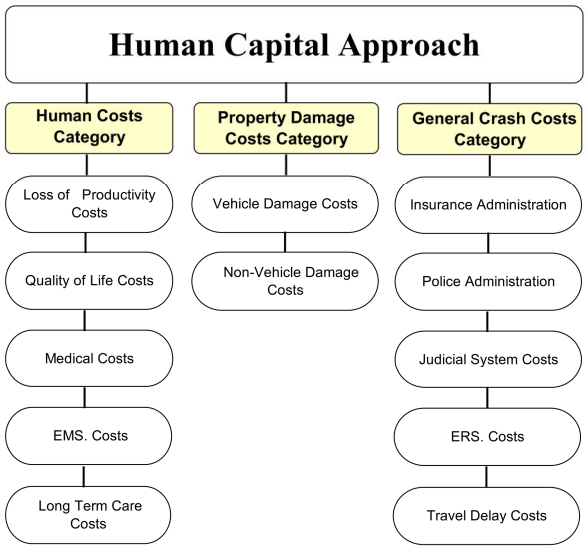

Fig. 2 Costs components by HC method
(Source: DOH, 2007)

Table 1 Comparison of costing method

Country	*Study year*	*Costing method*	*Percent GNP*	*Value US$mil (1997)*	*Source*
LAC					
Brazil	1997	HC	2.0%	15,681	IADB Review of Traffic Safety
Asia					
Vietnam	1998	HC	0.3%	72	Technical Note: Accident Costing
Bangladesh	1998	HC	0.5%	220	IDC Economics Working Paper Accident Costs
Thailand	1997	HC	2.3%	3,810	SWEROAD Road Safety Master Plan Report
Korea	1996	HC	2.6%	12,561	Elvik, 1999
Nepal	1996	HC	0.5%	24	Road Maintenance Component, TN Accident Costing 1996
Kerala, India	1993	HC	0.8%	—	Chand 'Cost of Road Accidents in India-reference to Kerala
Indonesia	1995	HC	—	691- 958	Accident Costs in Indonesia: A Review June 1997 (Draft Copy), TRL/IRE
Africa					
KwaZulu Natal	199?	HC	4.5%	—	Kwazulu-Natal Road Traffic Safety Strategy (1996-2000)
Tanzania	1996	HC	1.3%	86	1996 Road Safety Programme Tanzania Ministry of Works
Zambia	1990	HC	2.3%	189	TOI Study
Malawi	1995	HC	<5.0%	106	SWK/Iberinsa Road Safety Study, 1997
MENA					
Egypt	1993	HC/CA	0.8%	577	Aly, 'Valuation of traffic accidents in Egypt',
HMC					
UK	1998	WTP	2.1%	28,856	Road Accidents Great Britain: 1998 The Casualty Report
Sweden	1995	WTP	2.7%	6,261	Elvik, 1999
Norway	1995	HC	2.3%	3,656	Elvik, 1999
Iceland	1995	WTP	3-4%	7,175	Arnason, Nordic Road & Transport Research,1996,v8, n3
USA	1994	WTP	4.6%	358,022	NHTSA Technical Report
Germany	1994	HC	1.3%	30,173	Elvik, 1999
Denmark	1992	HC	1.1%	2,028	Elvik, 1999
New Zealand	1991	WTP	4.1%	2,441	Elvik, 1999

Source: TRL, 2000

2.3 Thailand accident costing model

Following [10], the total traffic accident cost can be calculated by

Total Traffic Accident cost = A + B + C (1)

Where:

Human costs (A) = $A_1 + A_2 + A_3 + A_4 + A_5$ (2)

Property damage costs (B) = $B_1 + B_2$ (3)

General crash costs (C) = $C_1 + C_2 + C_3 + C_4 + C_5$ (4)

2.4 Traffic accident cost in Thailand

According to DOH reported in 2004, the traffic accident costing model calculation total traffic accident costs for Thailand are 153,755 million bath (about 3,460 million USD.) and has been estimated the average cost per casualty and cost per case by severity as shown in Table 2

Table 2 The average unit cost per casualty or case

Severity	Average Unit Cost (Bath)
Fatality	3,324,834
Disability	3,470,080
Serious Injury	128,433
Slight Injury	28,091
PDO case	30,871

Source: DOH, 2007

2.5 HRGC accident cost

In general, HRGC costs are involving in term of cost benefit analysis. Mostly research had studied costs of countermeasure at and benefit for selected warning devices at the HRGC, Douglas L. Cooper et al [11] indicate the costs are measured as dollars spent on upgrading and new installation devices at a HRGC, benefits are measured as the potential cost savings from lives saved and injuries and property damage prevented. To support this research, Delaware County Grade Crossing Studied [12] have definition of safety benefits are consider accident and severity as well as cost such as total costs, safety benefits especially travel time saving and environmental benefits.

3. HRGC accident in Thailand

The trend of HRGC accidents and number of severities from 2008 to 2010 has shown in Figure 3, the trend decrease from 143 cases in 2008 to 132 cases in 2009 then move to 155 cases in 2010.

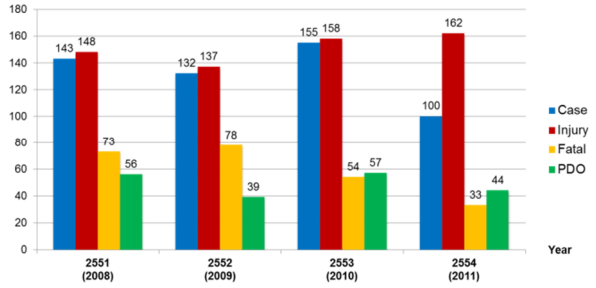

Fig. 3 The trend of HRGC collisions and severities between 2008 and 2011
(Source: SRT, 2011)

From 530 cases, 60 cases (12%) occurred at boom barriers and gates. And then the passive warning device would be 470 (88%) of the crashes. This is shown in Figure 4.

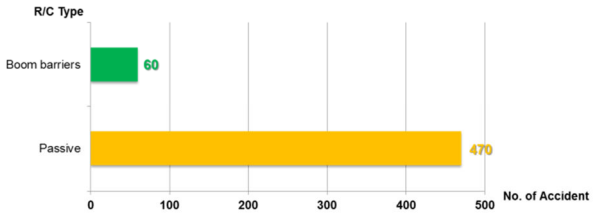

Fig. 4 HRGC accidents depend on crossing type
(Source: SRT, 2011)

The casualty on HRGC has classification which 3 categories as fatal, injury and property damage only (PDO) that shown in Figure 5.

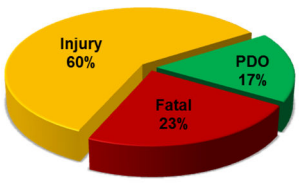

Fig. 5 The casualty crashes involving HRGC.
(Source: SRT, 2011)

An all the injuries are involved in over half 605 (60%) of all casualty crashes involving HRGC. Fatalities account for around 238 (23%) and PDO are involved in around 176 (17%) of crashes.

Which on some 4,000 km. of railway route in Thailand, covers in 47 provinces with 3 types of track, single track 3,763 km. (93.07%), double track 173 km. (4.28%) and triple track 107 km. (2.65%). There are approximately 2,463 railway grade crossings in Thailand, of these 1,923 are approved by SRT and about 540 are illegal. In Table 3 shows HRGC index in Thailand, resulting of number of HRGC, HRGC density, HRGC accidents, fatality and injury depend on average 4 years.

Table 3 Thailand HRGC data between 2008 and 2011

Index	
Route (km.)	4,429
Number of HRGC	2,463
HRGC density (per km.)	0.55
Avg. distance between HRGC (km.)	1.8
HRGC Accident (cases)	560
Fatality	63
Injury	156
Fatality rate (per 100 population)	12
Injury rate (per 100 population)	28

For the vehicle type in HRGC accidents can be distribution in accident data, over 358 (65%) of HRGC accidents occur in Passenger cars, 90 (17%) result in Motorcycle, around 37 (7%) in Truck and with only 2% for each of vehicle such as Pickup, Pushcart and Agriculture vehicle (E-tan). One thing that found in database is rate of person who lives outside residence area and not familiar on route, the number plates that shown in Figure 6 rate of outside area are involved in 306 (58%) and inside area are around 224 (42%) of total accidents.

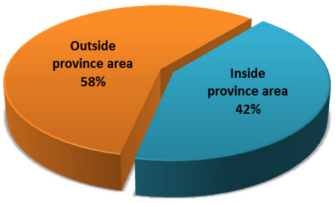

Fig. 6 Vehicle type in HRGC accident. (Source: SRT, 2011)

The Regional involving HRGC accidents are occurred in 6 regional of Thailand. This is shown in Figure 7. Central is highly region 126 cases (24%) to a railway crossing accidents. Northeastern of Thailand is the second region that to more a HRGC accident with 122 cases (23%) of accidents. Third is Southern of Thailand around 110 cases (20%). Fourth is West region of Thailand, involved in 101 cases (19%) of accidents.

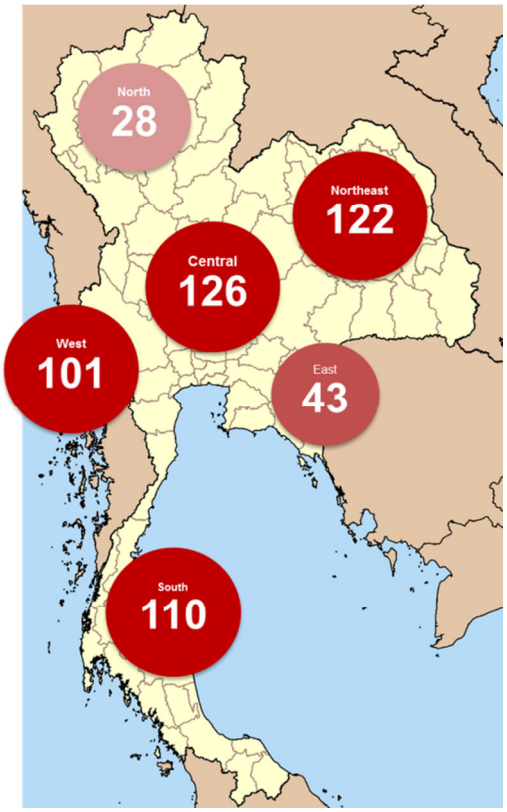

Fig. 7 The HRGC accidents depend on region. (Source: SRT, 2011)

3.1 HRGC accident cost in Thailand

The study of HRGC accident costs in Thailand are new issue and specific approach for estimate damage both in term of life and property. From the SRT database, there are collected accident data with three categories, number of accident, fatality and Injury. For the PDO, there are not collected in the database but can found in detail of cases with nobody people died and injury of HRGC accident. This study are using HC method and following accident costing model in Thailand.

The estimating of HRGC accident costs are recommended the detail of cost components in accident costs model. The costs items in each category are following as in Table 4 relate cost involved to three main categories, Category A the human costs, Category B property damage costs and Category C general costs as well.

Table 4 Cost components for accident cost model

	Cost Element	Estimating Formula
Category A	Loss of Productivity (A_1)	1) Lost of productivity in term of income loss from fatalities = [No. fatalities by age range] x [foregone income] 2) Lost of productivity in term of income loss from serious injuries to disabilities (no work) = [No. serious injuries to disabilities by age range] x [foregone income, if abilities can not work] 3) Lost output in terms of income loss from serious injuries to disabilities (work) = [No. serious injuries to disabilities by age range] x [foregone income, if abilities can work] * *Assume effectiveness reduced by 30%* 4) Lost output in terms of income loss from injuries = [No. of injuries]$_{severity}$ x [No. of day in Hospital] x [average wage per day] 5) Lost output in terms of income loss involving those relatives and friends who take care of the injured and the disabled = [No. of injuries]$_{severity}$ x [No. of day to take care] x [average wage per day] * *No. of carer to injury = 1:1*
	Quality of Life Costs (A_2)	Total quality of life costs = [No. of crashes]$_{severity}$ x [estimated added percentage of quality of life costs]$_{severity}$
	Medical Costs (A_3)	Total medical costs = [No. of casualties]$_{severity}$ x [average hospitalization expenses]$_{severity}$
	EMS Costs (A_4)	Total EMS costs = [No. of EMS cases]$_{severity}$ x [average EMS costs]$_{severity}$
	Long Term Care Costs (A_5)	Total Long Term Care Costs = [No. of disabilities] x [average the long-term medical and rehabilitation cost + average the cost in terms of lost output by those relatives and friends who spend time taking care of the disabled, both working and non-working]
Category B	Vehicle Damage Costs (B_1)	Total vehicle damage costs = [No. of crashes]$_{severity}$ x [average vehicle damage costs]$_{severity}$
	Non-Vehicle Damage Costs (B_2)	Total non-vehicle damage costs = [No. of crashes]$_{severity}$ x [average non-vehicle damage costs]$_{severity}$
Category C	Insurance Costs (C_1)	Total insurance administrative costs = [No. of crashes]$_{severity}$ x [average insurance administrative costs]$_{severity}$
	Police Costs (C_2)	Total police administrative costs = [No. of attendances by police]$_{severity}$ x [average insurance administrative costs]$_{severity}$
	Judicial System Costs (C_3)	Total judicial system costs = [No. of attendances by court cases]$_{severity}$ x [average judicial system costs]$_{severity}$
	ERS Costs (C_4)	Total ERS costs = [No. of ERS cases]$_{severity}$ x [average ERS costs]$_{severity}$
	Travel Delay Costs (C_5)	Total travel delay costs = [No. of crashes]$_{severity}$ x [average travel delay costs]$_{severity}$

Source: DOH, 2007

The number of severities costs and cost components are result in Table 5 traffic accident costs in Thailand.

Table 5 Traffic accident cost in Thailand

Cost Component	Severities (Baht)				
	Fatality	Disability	Serious	Slight	PDO
A_1	1,414,415	1108937	3,741	520	-
A_2	992,662	1,304,880	11,139	158	-
A_3	12,155	6,826	18,391	569	-
A_4	733	-	1,023	-	-
A_5	-	335,421	-	-	-
Sub Cost	2,419,965	2,756,064	34,294	1,247	0
B_1	215,212	-	106,209	-	18,676
B_2	1,723	-	2,647.5	3,864	8,671
Sub Cost	216,935	-	108,857	3,864	27,347
C_1	2,166	-	2,141	2,018	3,507
C_2	4,424	-	4,424	4,424	4,424
C_3	33,420	-	33,420	33,420	33,420
C_4	1,690	-	1,690	-	-
C_5	31,570	-	20,292	12,293	9,344
Sub Cost	73,270	-	61,967	52,155	50,695
Total Cost	2,710,170	2,756,064	205,118	57,266	78,042
	5,806,660				

To the average cost per casualty and cost per case by severity can be determined by dividing the total cost by the number of total number of casualties and cases by severity, the results can be summarized in Table 6 and covert in year 2012 by using economic growth rate.

Table 6 The average and estimated unit costs per casualty or case in 2004 and 2012, respectively

Severity	Avg. Unit Cost in 2004 (Baht)	Estimated Unit Cost in 2011 (Baht)
Fatality	3,015,791	5,277,634
Injury	2,894,345	5,065,119
PDO	78,976	138,208

The distribution of total costs classified by three cost categories, human costs around 2,243 million baht, general crash costs 127 million baht and PDO 48 million baht that shown in Figure 8. The total costs of HRGC are classified by severity as shown in Figure 9. Last, the costs components can be illustrated in Figure 10.

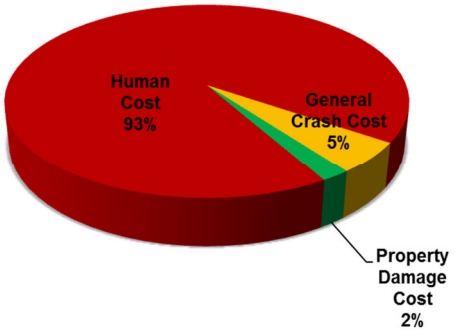

Fig. 8 Three cost categories from HRGC accidents in Thailand.

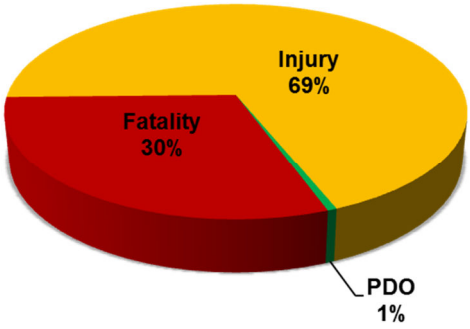

Fig. 9 HRGC accident costs categories by severity

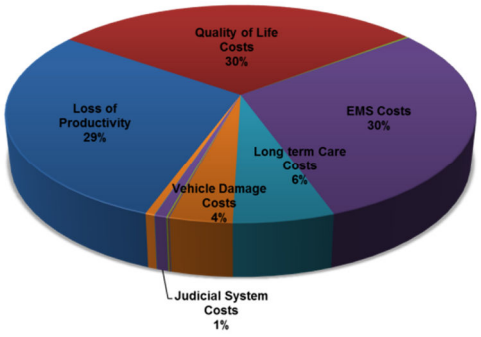

Fig. 9 Component costs from HRGC accident

4. Conclusion

The SRT accident database, there are useful and more advantage for study situation of the HRGC accidents in Thailand. The HRGC accidents are resulted by number of case, number of fatality and number of injury. Which trends of accident are decreasing during year 2007 to 2009, the number of accidents 140, 143 and 132 opposite the number of fatality and injury which increasing from 47 to 78 for fatality. For severity index of HRGC are show in term of fatalities (12) and injuries (28) by 100 populations. These serious events are mostly preventable.

The HRGC accident costs in Thailand are new issue for study. This paper estimates of the recent study of HRGC accident costs by using the HC method. The total costs of HRGC accident for the year 2004 are 2,482 million baht or around US$55 million and move to 4,344 million baht (US$140 million) by economic growth rate or approximately around 0.4 percent of GPD of Thailand in year 2011.

Moreover, there are estimate average costs per casualty and cases by crash severity are 5,277,634 baht per fatality, 5,065,119 baht per injury and 138,208 baht per PDO case (exclude locomotive cost).

For recommendation, HRGC accidents cost would be benefit to HRGC accident costs analysis that can be applied to evaluate appropriate safety countermeasures of HRGC in Thailand.

Moreover, there are estimate average costs per casualty and cases by crash severity are 4,754,120 baht per fatality, 4,153,009 baht per injury and 117,063 baht per PDO case.

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