

# Determination of Direct to Indirect Accident Cost Ratio for Railway Construction Project

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**Abstract.** Construction industry involves dangerous activities which few are exposed to a high risk of being fatal, injuries and damages to machinery and property. The construction of Mass Rapid Transit (MRT) and Light Rail Transit (LRT) have no exception to those accidents. The accident can bring economic burden to project stakeholders especially contractors and client. However, the accident cost is relatively complicated because of its “hidden” or “invisible” portion. Thus, this paper is aimed to determine the ratio of direct to indirect accident cost for railway construction projects. The study was conducted using self-administered questionnaire distributed to safety practitioners (n=11) at MRT and LRT construction projects. A total of 36 out of 43 reportable accident cases successfully collected for the study and were analysed with simple descriptive statistics. The findings show that the accident cost ratio for fatality is **1:1.22**, permanent disability is **1:1.94**, and temporary disability is **1:1.19**. The overall accident ratio for all accident classifications is **1:1.23**. The findings of the current study may impact future safety cost estimation process in determining the hidden accident costs for railway construction projects.

## 1 Introduction

Rail services in Malaysia have become a significant mode of public transportation, especially in the Klang Valley, to reduce traffic congestions in cities. The rail transportation in Malaysia starts up as a commodity transporter and later developed into an intercity train service. In July 2017, Malaysia had achieved a new achievement in public rail transportation upon the completion of Mass Rapid Transit Sungai Buloh-Kajang Line (MRT SBK Line). The construction of MRT SBK line was started in 2011 and has 31 stations and a track length of approximately 51km. The journey time was estimated 84 minutes for a train ride from Sungai Buloh to Kajang and it can accommodate 1,200 passengers at any one time. Light Rail Transit Line Extension Project (LRT-LEP) was a project under Prasarana Negara Sdn. Bhd. These train services was began its construction in 2010 and fully operated since June 2016. LRT-LEP has 12 new stations along the Kelana Jaya Line and 11 new stations along the Seri Petaling Line.

Recently, Mass Rapid Transit Sungai Buloh-Serdang-Putrajaya (MRT SSP Line) and LRT 3 were ongoing construction projects started from 2016 and may complete in 2020. In order to improve safety that relayed workplace accident, this research has been conducted to propose the accident cost ratio for railway construction projects for future railway project. In the same time, to

less the accident rate at workplace by controlling accident costs for recent construction and future projects.

Occupational Safety and Health Act (OSHA) defined an accident as an occurrence arising out of or in connection with work which results in fatal injury or non-fatal injury [1]. An estimated total of 120 million occupational accidents and more than 200,000 deaths had occurred worldwide annually which are caused by accidents. In economic terms, the International Labour Organisation (ILO) estimated that the occupational accidents total costs and work-related disease is 4% of the Gross National Product (GNP) [2]. The total GNP of the world was approximately 75,592,941 million USD in 2013, which means that worldwide the annual cost of work-related injuries and diseases is approximately 3,023,718 million USD [3].

An accident can financially impact on the organization and likewise, in the long haul give a bad reputation. Financial costs of construction accidents distinguished losses borne by clients due to an occurrence of the accident. The accident additionally brought loss of human life; worker suffers from long-haul pain, loss of worker's productivity, damages to equipment or property and furthermore influence the organization's reputation and profit.

Heinrich pioneered research on accident costs in the 1920s [4]. His results showed that the indirect costs are typically four times greater than the direct costs. The

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Heinrich's ratio of (1:4) between direct and indirect accident costs has frequently used in previous studies on safety-related literature [5]. Despite a nine-decade-old study, Heinrich's ratio continued to be reliable until the present day. However, Heinrich admitted that the accident cost ratio would not necessarily fix at 1:4. He argues that it can be different depending on an accident situation and also on the severity of the accident [6]. Table 1 summarises previous studies on accident cost ratio.

**Table 1.** Summary of previous studies on accident costs ratio.

Author	Industry	Country	Accident Cost Ratio (Direct:Indirect)
[6]	Manufacturing Industry	Malaysia	Cause of accident: <b>1:1.38 ~ 1:2.52</b> Location of body injury: <b>1:1.27 ~ 1:2.23</b> Type of injury: <b>1:1.11 ~ 1:2.92</b>
[7]	Construction Industry	South Africa	Non-fatal: <b>1:1.57</b> Fatalities: <b>1:2.48</b>
[8]	Building Construction Projects	Singapore	<b>1.5:1</b>
[9]	Construction Industry	South Africa	<b>1:4</b>
[10]	Construction Industry	United States	Ranges <b>1:1 ~ 1:20</b>
[11]	Construction Industry (Roofing)	United States	Ranges <b>1:2 ~ 1:20</b>

There are two broad categories of accident costs, i.e. direct costs and indirect costs. Some researchers proposed the term insured and uninsured costs [12]. However, the current study uses direct and indirect costs, since most of the safety practitioners in Malaysia construction industry were very familiar with these terms.

Direct cost is the cost typically known at the accident scene and this cost regularly covered by the Social Security Organisation (SOCSO) and any insurance company. In addition, those accident records can be reviewed to determine the expenditure on direct costs attributed to each injury. Direct costs usually include cost on hospital treatments, health services, rehabilitation, home health care and emergency transport [13]. On the other hand, indirect costs are those costs quantified after the accident event [6]. These kinds of costs are known as hidden costs, which are borne entirely by the employers since it is uninsurable. Examples of indirect costs include the cost for staff writing up the accident report, recruitment and training costs for replacement workers, loss in product quality after the accident, reduced productivity due to injured workers, transportation of an injured person, investigation costs and potential loss of expertise and experiences [14]. Unfortunately, the data on hidden costs are considerably more difficult to access than direct costs

because the information is not often quantified as it accrues [9].

A review of the literature on safety failed to suggest some useful and accurate accident costs ratio that is suitable for the railway construction projects in Malaysia [15]. Hence, the aim of the study is to determine the ratio of direct to indirect accident cost for railway construction projects. The study focused on accident costs that are borne by contractors that involved in viaduct project package of MRT-SBK Line and LRT-LEP construction projects.

## 2 Methodology

In the present study, the data collection process used a self-administrated accident cost questionnaire. A total of four direct costs items and eight indirect costs items were listed based on a review of the safety-related literature. The list is intended to assist respondents providing accident costs incurred based on accident reports and the respondents' estimation. If more than one accident cases in the project, the respondents were required to complete another questionnaire for other accidents cases because every accident case involved different costs.

The questionnaires were distributed to eleven (n=11) safety practitioners that comprise of safety manager and safety and health officer working under contractors for the MRT-SBK Line and LRT-LEP line.

The paper addressed three accident classifications, i.e. fatality, permanent disability, and temporary disability because only these three classifications were investigated by Department Occupational Safety and Health (DOSH) in Malaysia. Fatality implies an accident that causes the death of an employee due to work-related activity. Permanent disability implies an accident that causes injury to an employee that prevents him from regular activity including permanent disability. Temporary disability implies an accident that involves injury to an employee that prevents him from following his regular work for four days or more.

The data were analysed using the Statistical Packages for Social Science (SPSS Ver. 23). To determine the ratio of direct to indirect accident cost for railway construction projects, a descriptive analysis was applied.

## 3 Results and discussion

### 3.1 Response rate

A total of 36 out of 43 accident cases listed in the questionnaire successfully collected from the safety practitioners. The 36 accident cases comprise nine fatality cases, five permanent disability cases and 22 temporary disability cases (see Table 2).

Since the questionnaires were distributed by hand, all the identified respondents successfully gave feedback to the questionnaire. A total of 36 out of 43 accident cases listed in the questionnaire successfully completed by the safety practitioners. However, a few accident

cases items were not completed by respondents because of the unavailability of accident reports.

**Table 2.** Frequency of accident cases based on accident classification.

Project	Contractor	No. of Accident Cases (Collected)	Accident Classification		
			Class 1 (Fatality)	Class 2 (Permanent Disability)	Class 3 (Temporary Disability)
MRT SBK Line	A	11	2	2	7
	B	2	-	-	2
	C	3	-	1	2
	D	5	2	-	3
	E	1	1	-	-
	F	5	2	-	3
	G	3	-	1	2
	H	2	1	-	1
Sub-Total		32	8	4	20
LRT LEP	I	1	1	-	-
	J	2	-	1	1
	K	1	-	-	1
Sub-Total		4	1	1	2
<b>Total</b>		<b>36</b>	<b>9</b>	<b>5</b>	<b>22</b>

### 3.2 Respondent profile

**Table 3.** Respondents profile (n=11).

Items	Frequency (N)	Percentage (%)
1. Job Position		
Safety Manager	7	63.6
Safety & Health Officer	4	36.4
2. Academic Qualification		
Diploma	5	45.5
Bachelor Degree	2	18.2
Masters	4	36.4
3. Working Experience		
11-15 years	5	45.5
16-20 years	1	9.1
> 20 years	5	45.5
4. Professional Qualification		
Green Book Certificate	11	100.0
5. Level of Involvement in Construction Safety Costing		
Highly Involved	4	36.4
Involved	4	36.4
Moderate Involved	2	18.2
Less Involved	1	9.1

Table 3 illustrates the summary of respondents' profile. Based on the table almost three quarter (63.6%) of the respondents are Safety Managers. More than half (54.6%) of the respondents possessed at least a Bachelor Degrees, and 36.4% have acquired qualifications at the postgraduate level. Regarding working experience, more than half (54.6%) of the respondents have more than 15 years of experience in railway construction project safety.

To be a qualified safety practitioner in the industry one must acquire a Green Book Certification and all

respondents of the study do possess one. Majority (72.8%) of respondents were actively involved in construction safety costing exercise. This imply that they have knowledge in providing the accident costs since they are actively involved in construction safety costing such as estimating the accident costs. Their understanding of accident costs is quite crucial because all their views will reflect the results of the study. Hence based on the analysis, it can be inferred that the respondents for the study have met all the requirements to address the issue of the study.

### 3.3 Accident costs ratio for railway construction projects

Table 4 presents the analysis of accident cost ratio based on the accident classifications. The current study of railway construction projects found that the total direct cost of the fatality is RM 1,143,325.00 and the total indirect cost is RM 1,396,698.00, which made up a ratio of **1:1.22**. However, the previous finding on general construction projects for fatality [7] shows that the indirect cost is two times higher than the direct cost (i.e. **1:2.4**).

The current findings of permanent disability showed that the total direct cost and indirect cost is RM 21,668.00 and RM 42,439.00, respectively, which made up a ratio of **1:1.94**. Whilst, the total direct cost of temporary disability is RM 162,905.00 and total indirect cost is RM 194,820.00, which made up a ratio of **1:1.19**. From this findings, the permanent disability and temporary disability costs are combined to form non-fatalities accident costs with ratio is **1:1.28**. In contrast to previous studies by Pillay [7] revealed that the accident cost ratio for non-fatalities is higher (i.e. **1:1.6**).

The total direct and indirect cost for the overall accident classifications for railway construction projects is RM 1,328,091.00 and RM 1,633,957.00, which made up a ratio of **1:1.23**. In contrast, the ratio in study by Teo and Feng [8] for high rise building construction in Singapore revealed the direct cost was more higher than indirect cost (i.e. **1.5:1**). The opposite finding is come from these three reasons, first, the different definitions and components of direct and indirect costs included. Secondly, the various work injury compensation and insurance policies in different countries. Thirdly, the collected of indirect costs may not be as reliable as those direct costs because the accuracy of data and estimation methods used [8].

As discuss by Teo and Feng [8] stated that there is no generally accepted ratio of direct to indirect costs. OSHA [10] suggest that in construction industry the ratio of direct costs to indirect cost ranges from as low as **1:1.0** to as high as **1:20.0**. Whereas, Choi [11] proposed that the accident costs ratio of injuries may range from **1:2.0** to **1:20.0**. This results may be explained by the fact that the accident cost ratio can be interchangeable accordingly based on type of construction projects and whether fatal or non-fatal accident [6].

**Table 4.** Accident cost ratio for fatality, permanent disability and temporary disability for MRT and LRT construction projects.

Accident Costs Items	Accident Classification			Overall (RM) n=36
	Fatality (RM) n=9	Permanent Disability (RM) n=5	Temporary Disability (RM) n=22	
<b>Direct Costs</b>				
1. Medical Costs	2,541.00	663.00	3,503.00	6,707.00
2. Hospital Costs	50,784.00	21,198.00	125,202.00	197,184.00
3. Damages/Repair Costs	1,070,000.00	0.00	34,200.00	1,104,200.00
4. Fine Costs	20,000.00	0.00	0.00	20,000.00
<b>Total Direct Costs</b>	<b>1,143,325.00</b>	<b>21,861.00</b>	<b>162,905.00</b>	<b>1,328,091.00</b>
<b>Indirect Costs</b>				
1. Accident Report Costs	1,060.00	500.00	2,800.00	4,360.00
2. Replacement/ Recruiting Costs	5,550.00	0.00	0.00	5,550.00
3. Legal & Administration Costs	22,727.00	10,394.00	35,954.00	69,075.00
4. Schedule Costs	6,000.00	0.00	3,000.00	9,000.00
5. Productivity Loss Costs	904,783.00	2,562.00	,387.00	945,732.00
6. Victim Costs (Ex-Gratia Payment)	389,920.00	1,040.00	58,410.00	449,370.00
7. Management Costs	37,428.00	19,559.00	42,358.00	99,345.00
8. Corrective Action Costs	29,230.00	8,384.00	13,911.00	51,525.00
<b>Total Indirect Costs</b>	<b>1,396,698.00</b>	<b>42,439.00</b>	<b>194,820.00</b>	<b>1,633,957.00</b>
<b>Total Accident Costs</b>	<b>2,540,023.00</b>	<b>64,300.00</b>	<b>357,725.00</b>	<b>2,954,830.00</b>
<b>Accident Cost Ratio (Direct : Indirect)</b>	<b>1:1.22</b>	<b>1:1.94</b>	<b>1:1.19</b>	<b>1:1.23</b>

In railway construction projects context, every accident classifications has different accident costs ratio. This is because, the first reason may be due to, the difference of costs allocation incurred for direct and indirect costs. The second reason is the railway construction projects (i.e. MRT and LRT) is unique in terms of technology construction methods and work environment. For instance, the rail alignments are purportedly constructed along congested roadways and working at high platform guideway in city centre which is very high risk to both construction workers and public. All the above situations might contribute to the differences in the accident cost ratio.

Another significant finding from the current study is that the total accident cost for fatality is RM 2,540,023.00, which is more than the permanent disability (RM 64,300.00) and temporary disability (RM 357,725.00) even though the number of accident case for fatality is less than the temporary disability accident cases. But, the results from previous study Sun and Zou, [16] showed that the serious accident such as fatality in construction industry give impact on economic performance because once the serious accident involved, it contributes to a high accident costs. The results from Sun and Zou [16] shows that the total accident

cost for fatality is RM 4,663,399.50, permanent disability RM 5,006,931.80 and temporary disability RM 773,648.30. Therefore, the result of the current study is in tandem with previous studies where fatality contributed to highest accident costs in the construction industry.

## 4 Conclusions

As concluding remarks, the accident cost ratio is not necessarily fix at **1:4** as suggested by Heinrich, as such the ratio can be varied based on three factors, i.e. the different definitions and components of direct and indirect costs included, types of injury compensation and insurance in different countries and lastly the collected of indirect costs because the accuracy of data and estimation methods used. The result indicates that, the accident costs ratio for fatality is **1:1.22**, permanent disability is **1:1.94** and temporary disability is **1:1.19**. The overall accident cost ratio for rail infrastructure construction project is **1:1.23**. The highest accident cost spent is fatality, and the common type of accident cases is temporary disability.

The findings from this study make contributions to existing safety-related literature in the aspect of accident

costs ratio for railway construction projects, particularly in MRT and LRT projects, as previous studies had solely focused on accident cost ratio in general construction projects. The findings may also be adopted by the railway construction project's safety practitioners as a basis for estimating the budget of future project accident costs according to accident classification (i.e. fatality, permanent disability, temporary disability).

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