ACCIDENT COST RATIO OF BODILY INJURY IN RAILWAY CONSTRUCTION PROJECTS

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ABSTRACT

Accidents may harm any part of the body and may lead to minor injury or even fatalities. The effects of bodily injury may incur substantial direct costs and indirect costs to companies. The applications of existing accident costs ratios seem to be unsatisfactory for rail infrastructure project due to its unique accident situation and work environment. The purpose of the paper is to determine the ratio of direct costs to indirect costs for bodily injury in railway construction projects. A total of 70 accident cases between years 2010-2017 occurred in the railway construction projects were examined. The findings of the study may offer useful insight for safety practitioners in the estimation of direct and indirect costs for bodily injury accident costs on future railway construction projects.

Keywords*: Accident Costs Ratio, Location of Bodily Injury, Railway Construction Project*

INTRODUCTION

Construction industry involved many activities, techniques, materials and hazards and this increases the probability of accident occurrences. The Department of Occupational Safety and Health in the year 2017 (DOSH, 2018) reported that industry-wide accident cases were 3,246, and 177 cases were within the construction industry. Moreover, an accident in the construction industry is a work-related event that can lead to injury or ill health or fatalities resulted from the nature of the industry, human behaviour, work-site conditions, poor management and unsafe working methods.

In railway construction projects, accidents typically emerged because of a critically hazardous environment, especially in tunneling works, for example, boring through soft soil profiles, and at the same time trying to minimise the chances of causing any disturbance to the surrounding surfaces (Guo et al., 2014). It was more significant in the case of MRT and LRT projects, where the rail alignments are purportedly constructed along congested roadways as well as within the vicinity of public transport centres. This scenario further exacerbates the occurrence of accidents on site. Moreover, in many instances, workers had to perform rail works on high platform guideways, and transportation of heavy materials such as steel beams in confined spaces. Thus, any of these activities may incur a variety of bodily injury to workers. Like any other type of construction projects, bodily injury accident costs in railway projects involved both direct and indirect costs.

Direct costs are visible costs which can be easily recognized which the employers are well aware of. On the other hand, indirect costs are hidden costs which are uninsured, and difficult to quantify during the accident event itself, and typically several times greater than direct costs (Pillay and Haupt, 2008). Estimating the direct costs is relatively straightforward and not as challenging as the indirect costs, as the latter, data relating to several additional costs and, more specifically, productivity losses is too complex. Previous studies in safety management (Heinrich, 1931), manufacturing (Rohani et al., 2015) and construction industry (Pillay, 2014; Pillay and Haupt, 2008; OSHA, 2007; Choi, 2006) had attempted to establish ratio of direct costs to indirect costs that are related to bodily injury, but none were applicable to the railway project. These ratios were typically subjected to the

situation of the accident and industry types. Consequently, the application of existing ratio in railway project to estimate the probable indirect costs is deemed inappropriate.

Therefore, the purpose of this study is to conduct an analysis of a sample of 70 MRT and LRT construction project accident reports to establish, as practically as possible; to determine the ratio of direct costs to indirect costs for bodily injury in railway construction projects. Bodily injury includes head, neck, lower limb, upper limb, trunk and others (Department of Safety and Health Malaysia, 2004). Understanding of the direct to indirect costs ratio of bodily injury may offer insight to safety practitioners in the estimation of accident costs in railway projects.

LITERATURE REVIEW

Background

The city of Kuala Lumpur has become the centre of the transportation hub for Malaysian commuters and tourists alike. Multi-modes of transportation are accessible, which incorporates multi-layer highways and major road networks with multi-intersections. The city's road networks have also become more complex and complicated over the years. Recently, the city has also gained another ground in its transportation mode because of the completion of Mass Rapid Transit Sungai Buloh-Kajang Line (MRT SBK Line). The constructions started in the year 2011 and began its operation in July 2017. On the other hand, the Light Rail Transit Line Extension project (LRT LEP), which is an extension line from Kelana Jaya station to Sri Petaling station via the Putra Heights interchange, started construction in the year 2010 and began its operations in June 2016. Further development of railway project is yet to be built in the city of Kuala Lumpur at an estimated total cost of RM105bil, with the High Speed Rail (HSR) at RM60bil and MRT 3 to cost about RM45bil.

Accident Costs

Heinrich (1931) was considered the first researcher to have documented a systematic study of accident costs. Heinrich classified accident costs into direct and indirect costs. Heinrich discovered that the estimation of indirect costs was about four times greater than direct costs. These costs have also been classified differently by previous researchers, e.g. insured and uninsured costs (Teo and Feng, 2011), visible component and invisible component (Jallon et al., 2011). Numerous direct and indirect costs associated with an accident and the severity of the consequences of an accident is different too. In the current study, the term direct costs and indirect costs are used instead because it is popular among safety practitioners in the Malaysia construction industry. Moreover, the scientific literature often used the term direct or indirect costs, despite no clear consensus achieved on its definitions (Gosselin, 2004).

Accident Direct Costs

In previous studies, there are numerous definitions of direct costs. LaBelle (2000) defined direct costs as a visible cost which can be easily identified and readily aware of by the organisation. Lebeau and Duguay (2013) argued that the direct costs amount sometimes were measured as the sum of medical costs, rehabilitation costs, and income replacement indemnity paid to the accident victim during the disability period. On the other hand, Sun et al. (2006) defined direct costs as costs that are compensated by the insurance agency after the accident occurred.

In practice, an insurance company is obliged to cover the employer for his workers' medical and hospitalisation costs based on the amount of premium contributed, which is commonly done on a yearly basis. The Social Security Organisation (SOCSO) provides local workers with socioeconomic security, such as protection from the threat of disease, injuries or fatality at the workplace, and the Jabatan Tenaga Kerja (JTK) was responsible for handling the compensation claims made by the registered foreign workers under the Workmen's Compensation Act 1952. Table 1 presents the definition of direct costs items included in this study.

Table 1: Definition of direct costs items

Direct Cost Items	Definition	Authors
1. Medical Costs	Medical and rehabilitation costs incurred as a result of the injury	Safe Work Australia (2015)
2. Hospital Costs	Costs borne by the government through the provision of subsidized hospital, medical and pharmaceutical services.	Safe Work Australia (2015)
3.Damage/Repair Costs	Machine could be malfunction during the accident or certain parts or equipment may need replacement.	Rohani et al. (2015)
4. Fine Costs	Costs associated with successful prosecutions associated with proceedings initiated by workers` compensation authorities because of serious work-related accidents.	Safe Work Australia (2015)

(Sources: Safe Work Australia, 2015; Rohani et al., 2015)

Accident Indirect Costs

An indirect cost is also known as "hidden" costs and typically several times greater than direct costs (Pillay and Haupt, 2008). A typical example of indirect costs is, time lost by the injured employee, accident investigation costs, productivity loss costs, transportation costs, replacement or recruiting of new workers (Jo, 2014;Sahin et al., 2012 and Dias and Garcia-elias, 2006). It is more difficult to access than direct costs because the information is not often captured or quantified as it accrues. Moreover, it is more difficult to access compared to direct costs because the information is not often captured or quantified as it accrues. When estimating the indirect costs, it is common for its records to be either inaccurate or incomplete or both (Pillay and Haupt, 2008). Rohani et al. (2015) argued that it is relatively complex in estimating the indirect costs because of many visible and hidden costs to account for. It also needs detailed information to be generated on numerous types of injuries. Table 2 shows the definition of indirect costs items included in this study.

Table 2: Definition of Indirect Costs Items

Indirect Cost Items	Definition	Authors
1. Accident Costs	The costs associated with conducting an investigation into an accident and the administrative cost of collecting and reporting information on work-related incidents.	Safe Work Australia (2015)
	Staff allocated to investigating and writing up the accident report.	Haupt and Pillay (2016)
2. Replacement/ Recruiting Costs	An absent employee must be replaced to maintain productivity. Costs will be incurred to transfer, hire, and train staff.	Jallon et al. (2011)
3. Legal and Administration Costs	The employer must allocate human and financial resources to set up and monitor the file, enter data in the accident registry, compile accident statistics, issue a report, etc.	Jallon et al. (2011)
4. Schedule Costs	When the accident happened, the employer may rescheduling and coordinating the work affected. It also slowdown in production and will affect the timetable schedule.	Gavious et al.(2009)
5. Productivity Loss Costs	When accident occurs, the company may need to shut down their plant with directive from DOSH. This will require overtime when the plant set to resume its operation in order to finish the work progress.	Rohani et al. (2015)
6. Work in Progress Costs	The costs involved by worker or staff needs to consider the work progress at the same time, they may be only concerned with improving some critical unsafe to ensure that normal work progress not be affected.	Lu et al. (2016)
7. The Victims Costs (Ex-gratia payment)	Additional benefits to the injured worker beyond the Work Compensation Act: Extra financial assistance or other welfare provided by contractors.	Feng et al. (2015)
8. Management Costs	Salary cost of management and staff carry out investigation.	KLIACS_JKKP (2013)
9. Corrective Action Costs	A post-accident investigation is conducted and relevant policies and procedures are reviewed to determine if any corrective actions can be taken to similar accidents in the future.	Gambatese et al. (2017)

(Sources: Safe Work Australia, 2015; Haupt and Pillay, 2016; Jallon et al., 2011; Gavious et al., 2009; Rohani et al., 2015; Lu et al., 2016; Feng et al., 2015; KLIACS_JKKP, 2013; Gambatese et al., 2017)

Accident Cost Ratio

Table 3: Summary of Previous Studies on Accident Costs Ratio

Authors	Industry	Country	Accident Cost Ratio (Direct:Indirect)
Rohani et al. (2015)	Manufacturing Industry	Malaysia	Cause of accident: 1:1.38 ~ 1:2.52 Location of body injury: 1:1.27 ~ 1:2.23 Type of injury: 1:1.11 ~ 1:2.92
Pillay (2014)	Construction Industry	South Africa	Non-fatal: 1:1.57 Fatalities: 1:2.48
Pillay and Haupt (2008)	Construction Industry	South Africa	Struck against (Rib cage): 1:29 Fall (Fatality): 1:4 Caught in (Dislocated shoulder): 1:9 Struck by (Fracture): 1:7 Overall: 1:4

OSHA (2007)	Construction Industry	United States	Ranges 1:1 to 1:20
Choi (2006)	Construction Industry (Roofing)	United States	Ranges 1:2 to 1:20

(Sources: Rohani et al., 2015; Pillay, 2014; Pillay and Haupt, 2008; OSHA, 2007; Choi, 2006)

Table 3 summarised previous studies on the proposed accident cost ratio. Many previous researchers when studying the concept of accident costs included the direct and indirect costs and expressed it in ratio. Heinrich (1931), the first researcher in the United States who studied the accident ratio between direct and indirect costs suggested approximately 1:4. Furthermore, because of its simplicity, it has been used for many years. However, the ratio is not always constant and largely depends on the study area. In fact, there is no consensus achieved among researchers on the acceptable ratio between accident direct and indirect cost (Rohani et al., 2015).

Location of Bodily Injury

The classification for the location of the bodily injury was obtained from the Notification of Accident, Dangerous Occurrence, Occupational Poisoning & Occupational Disease under Regulations 2004 document (Department of Safety and Health Malaysia, 2004). The classification addressed in the current study includes head, neck, lower limb, upper limb, trunk and others. Table 4 summarised the location of the bodily injury.

Table 4: Summary of Bodily Injury Location

Location of Bodily Injury	Examples	References
Head	Cranium region (including the skull and brain), eye, face, nose, mouth	OSHA 1994 NADOPOD Reg. 2004, Table 12: Coding for bodily injury location
Neck	Neck region, throat, skin and tissues of the neck region	
Lower Limb	Hip, thigh, knee, leg, ankle, foot, toes	
Upper Limb	Shoulder, scapular, upper arm, hand, tendon, fingers	

Trunk	Back (tendon, ligament), spinal bone, esophagus, trachea, abdomen, urinary system	(Department of Safety and Health Malaysia, 2004)
Others	No injury (accept damage to property/equipment)	

(Sources: Department of Safety and Health Malaysia, 2004)

METHODOLOGY

The study was conducted using quantitative research approach. Through the Notification of Accident, Dangerous Occurrence, Occupational Poisoning & Occupational Disease (under Regulations 2004) document, a list of bodily injuries were included in the questionnaire to identify the ratio between its direct and indirect costs. The questionnaire consisted of four sections; the first section asked for organisation background information, the second section asked for respondents' profile, the third and fourth section request respondents to provide the direct and indirect costs based on accidents report of the project they were involved in. The study employed a purposive random sampling technique to obtain respondents with a background in safety involving railway projects. The selection of the respondents was based on their involvement in an accident. The questionnaire survey was distributed by hand to safety practitioners at the MRT SBK Line and LRT LEP construction projects. The respondents were requested to provide information on accident direct and indirect costs through review of previous accident records for the project or provide an estimation of the costs when information was unavailable. The accidents cost data for the study was limited to reportable accident cases that are notified to and recorded with the Department of Occupational Safety and Health (DOSH). A total of 109 reportable accident cases were successfully identified. However, only 70 of the reported accidents cases were valid for further analysis. The study analyses the reportable accident cases according to the location of the bodily injury. The scope of this study was the guideways (viaduct) project package because this package has the highest rate of accident cases. The MRT guideways package recorded 640 (52.4%) out of 1,223 accident cases, and the LRT guideways package recorded 171 (80.3%) out of 213 accident cases.

RESULTS AND DISCUSSIONS

Demographic Information

Table 5 summarised the respondents' background information. Analysis of the feedback shows that more than half (63.6%) of the respondents were Safety Managers, while others were Safety and Health Officers. They have vast working experience in construction projects, 45.5% of the respondents have working experience of more than 20 years. The result of the survey also shows that more than half (54.6%) of the respondents had completed their Bachelor`s Degree and 36.4% of them had also acquired additional postgraduate qualifications, such as Masters. Background information data also showed that all respondents have Green Book Certification and therefore they are qualified safety practitioners.

Table 5: Respondent`s Background Information (n=11)

Items	Sub-Items	Frequency (N)	Percentage (%)
1. Job Position	Safety Manager Safety & Health Officer	7 4	63.6 36.4
2. Academic Qualification	Diploma Bachelor Degree Masters	5 2 4	45.5 18.2 36.4
3. Working Experience	3. Working Experience 11-15 years 16-20 years > 20 years	5 1 5	45.5 9.1 45.5
4. Professional Qualification	Green Book Certificate	11	100.0
5. Level of Involvement in Construction Safety	Highly Involved Involved Moderate Involved	9 1 1	81.8 9.1 9.1
6. Level of Involvement in Construction Safety Costing	Highly Involved Involved Moderate Involved Less Involved	4 4 2 1	36.4 36.4 18.2 9.1

The respondents` demographic information reveals that the majority (81.8%) of respondents were highly involved in construction safety activities. These inferred that respondents were knowledgeable on safety matters including accidents at the workplace. The statistics showed that all questionnaire items were successfully completed by the experienced safety practitioners. They were also actively involved in safety estimations as more than half (72.8%) of respondents were good in accident estimation. Their views were very important and valuable to establish the findings.

Response and retention rate

Table 6: Frequency of Accident Cases Based on the Location of Bodily injury (n=70)

Project		Location of Bodily Injury					
		Head	Neck	Lower Limb	Upper Limb	Trunk	Others
MRT SBK Line	A	1	1	4	4	1	6
	B	-	-	-	1	1	5
	C	1	-	-	1	1	1
	D	2	-	1	1	1	8
	E	-	-	-	-	1	5
	F	1	-	1	2	1	2
	G	-	-	1	2	-	1
	H	-	-	-	1	1	-
Sub-Total		**5**	**1**	**7**	**12**	**7**	**28**
LRT LEP	I	-	-	-	-	1	-
	J	-	-	1	-	1	3
	K	1	-	-	-	-	3
Sub-Total		**1**	**0**	**1**	**0**	**2**	**6**
Total		6	1	8	12	9	34
Overall Total		70					

Table 6 shows the frequency of accident cases based on the location of bodily injury in the MRT SBK Line and LRT LEP guideways construction packages. Of the 70 accident cases, six accident cases for a head injury, one accident case for the neck, eight accident cases for a lower limb, twelve accident cases for upper limb, nine accident cases for trunk and 34 accident

cases for others (damage to property/equipment). A total of 109 reported accident cases were successfully identified with 68 cases from MRT and 41 cases from LRT respectively. However, 39 (36%) accident cases items in the questionnaire were left blank by the respondent due to unavailability of accident reports. As a result, only 70 (64%) accident cases were valid for analysis.

Accident Costs Ratio

Some accidents can involve injury to any part of the body and the part(s) of the body affected by an accident could determine the severity such as minor injury, moderate injury, serious injury and fatal. Table 7 presents the analysis of accident cost ratio based on the location of the bodily injury. The total direct costs and indirect costs for the head are RM 49,073.00 and RM146, 651.00 respectively, which formed a cost ratio of 1:3.0. The result suggests that the head injury indirect costs were threefold the direct cost.

The total direct costs and indirect costs for the neck are RM 1,069,000.00 and RM 875,156.00 respectively, which made up a cost ratio of 1:0.8. The result suggests that the neck injury indirect costs were about half the direct costs. One point which is worth pondering in this study sample is that the total accident costs of neck injury are the highest among other bodily injuries (RM 1,944,156.00). Previous researchers also reported that fatalities and other severe injuries were common in accidents, which involved body parts such as head, trunk, internal organs or multiple body parts (Dumrak et al., 2013; Zhang et al., 2009; López Arquillos et al., 2012). Ling et al. (2009) established that the head and trunk were the most vulnerable areas. The vertical construction such as guideway railway projects have a high possibility of head injuries. For an example, the materials or tools fall from the height and also involved heavy lifting plant and machineries (e.g. tower crane).

Injury to the lower limb showed total direct costs and indirect costs of RM 26,405.00 and RM 69,931.00 respectively and, these formed an accident cost ratio of 1:2.6. The result showed that the indirect cost for lower limb injury is 2.6 times the direct costs. Compared to the result of the upper limb indirect costs, which is 1.1 times the direct costs. The result showed that it was still common to have activities in railway projects performed by hand.

Findings in Alinaitwe, Mwakali and Hansson (2007) study showed that upper limbs (e.g. arm, finger and hand) were most affected by accidents with a proportion of 24.9% of their construction building projects samples.

The accident costs ratio for the trunk is 1:3.9, and it is the highest ratio compared to the rest of the bodily injury. The result showed that the indirect cost for the trunk injury is nearly four times the direct costs.

"No injury" indicates that the worker involved in an accident did not sustain any injury but had caused damage to property or equipment. For example, in the study sample, a damaged CCTV bracket occurred during lifting of rebar works by mobile crane due to miscommunication between the operator and signalman that caused the operator to over lift the rebar and hit the CCTV bracket. Hence, there were no medical and hospital costs involved in the direct costs. The findings showed that the total direct cost and indirect cost of "no injury" were RM 502,420.00 and RM 248,111.00 respectively and, this formed an accident cost ratio of 1:0.5. The result showed that indirect costs for "no injury" were half of the direct costs. One significant finding of "no injury" in the study sample was that the number of cases is significantly high (n=34) compared to other types of bodily injury even though the accident costs ratio is the lowest.

The overall total for direct cost and indirect costs for bodily injury is RM 1,830,511.00 and RM 1,884,250.00 respectively and formed an overall accident cost ratio of 1:1.0. The finding of the current study showed that the spread of the bodily injury accident costs ratio was considerably wide (1:0.5 - 1:3.9) compared to (Rohani et al., 2015) findings which were of range between 1:1.27 to 1:2.23. To be more precise, the ratio for respective locations of bodily injury are fingers (1:1.64), hand (1:2.23), leg (1:1.27), forearm (1:2.07) and face (1:1.42).

Variations in the findings of accident ratios may be due to various factors, such as the nature of items included in the direct and indirect costs, types of insurance policy or compensation, the accuracy of data especially indirect costs and estimation method used for direct costs and indirect cost (Teo and Feng, 2011).

Table 7: Accident Costs Ratio of Bodily Injury

Accident Costs	Location of Bodily Injury						Overall (RM)
Direct Costs Items	Head (RM)	Neck (RM)	Lower Limb (RM)	Upper Limb (RM)	Trunk (RM)	No Injury (RM)	Overall (RM)
1. Medical Costs	1,678.00	900.00	895.00	2,230.00	989.00	0.00	6,707.00
2. Hospital Costs	18,380.00	3,100.00	25,410.00	39,946.00	110,348.00	0.00	197,184.00
3. Damages/ Repair Costs	9,000.00	1,065,000.00	100.00	20,000.00	5,100.00	502,420.00	1,606,620.00
4. Fine Costs	20,000.00	0.00	0.00	0.00	0.00	0.00	20,000.00
Total Direct Costs	**49,073.00**	**1,069,000.00**	**26,405.00**	**62,176.00**	**121,437.00**	**502,420.00**	**1,830,511.00**
Indirect Costs Items							
1. Accident Report Cost	520.00	120.00	990.00	1,640.00	1,090.00	3,530.00	7,890.00
2. Replacement/ Recruiting Costs	1,500.00	0.00	0.00	0.00	4,050.00	0.00	5,550.00
3. Legal & Administration Costs	10,605.00	2,800.00	16,129.00	18,965.00	20,576.00	83,349.00	152,424.00
4. Schedule Costs	9,000.00	0.00	0.00	0.00	0.00	0.00	9,000.00
5. Productivity Loss Costs	47,380.00	775,520.00	28,367.00	7,211.00	88,414.00	70,595.00	1,016,567.00
6. Work in Progress	0.00	0.00	0.00	928.00	0.00	0.00	928.00
7. Victim Costs (Ex-Gratia Payments)	43,000.00	75,000.00	1,795.00	7,880.00	320,145.00	0.00	449,370.00
8. Management Costs	27,702.00	4,626.00	20,346.00	21,457.00	26,228.00	69,979.00	170,338.00
9. Corrective Action Costs	6,944.00	17,090.00	2,304.00	10,066.00	15,121.00	20,658.00	72,183.00
Total Indirect Costs	**146,651.00**	**875,156.00**	**69,931.00**	**68,147.00**	**475,624.00**	**248,111.00**	**1,884,250.00**
Total Accident Costs	**195,709.00**	**1,944,156.00**	**96,336.00**	**130,323.00**	**597,061.00**	**750,531.00**	**3,714,761.00**
Accident Cost Ratio							
(Direct: Indirect)	**1:3.0**	**1:0.8**	**1:2.6**	**1:1.1**	**1:3.9**	**1:0.5**	**1:1.0**

It can be concluded that the results from bodily injury location can be used to support post-accident rehabilitation and management by providing information about which part of the body can generally be injured due to accidents. This will assist safety managers to understand the type of injury related to the accident and the severity of accident. The findings can also motivate construction workers to take more safety measures.

CONCLUSION

This paper presented results of analysis on 70 accident cases occurred at the MRT SBK Line and LRT LEP construction project recorded by Department of Safety and Health (DOSH) between 2010-2017. The study analyses the direct and indirect cost of six locations of bodily injuries, i.e. heads, necks, lower-limbs, upper-limbs, and trunks, and no injury, i.e. damage to property/ equipment. The result indicates that the ratio of accident cost for the location of bodily injury in railway range from 1:0.5 to 1:3.9. The highest accidents cost ratio involved the trunk and the lowest is no injury, i.e. damage to property/equipment. The common accident cases involved the trunk and upper-limb injury. It is undeniable that these body parts are frequently exposed to danger in any construction activity especially. The study results suggest the nature of accident and industry type strongly influenced the ratio of direct to indirect costs. Hence, theorising a single ratio established in one study for all accident cases and industries type is inaccurate. The findings offer employers, contractors and safety practitioners the appropriate accident costs ratio for indirect costs based on the proportion of direct costs for future railway project accidents costs estimates. The findings inform contractors on the locations of bodily injury that incur high direct and indirect costs proportion, hence the necessary action could be taken to prevent serious bodily injury on workers in railway projects.

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