

Generating a Systematic Construction Accident Costs Calculation for Urban Rail Infrastructure Project

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Construction activities involve various risks, which can cause fatal major and minor accidents. The construction of Mass Rapid Transit (MRT), which is the most prestige urban rail infrastructure project in Malaysia, also exposed to those accidents. Both fatal and non-fatal accidents have high significance in economic burden to the MRT project stakeholders. However, it is very difficult to quantify the costs of these accidents. The objective of this study is to explore a method to calculate accident costs during the construction of urban rail infrastructure projects. To derive accident costs at construction sites, an accurate structure of the data collection system is very essential. This study is based on previous research that classifies the accident costs into two basic categories, which are direct costs and indirect costs. Measuring accident costs and providing the most specific variables are crucial as the calculations should be as detailed as possible for the accurate provision of project budget as well as cost for controlling and monitoring purposes. This study can also increase awareness of accident costs in urban rail infrastructure projects.

Keywords: Calculation Method, Accident Costs, Construction, Urban Rail Infrastructure project.

1. INTRODUCTION

Nowadays, the transportation industry infrastructure is rapidly moving towards a modern service. High speed rail (HSR) systems are already operationalised in many countries, such as Japan, England, Italy, Germany and France. Furthermore, the development of the whole European HSR network is planned. In this European context, the Commission of the European Communities (CEC) is aimed at standardising the HSR projects and concerned on safety issues (Diamantidis, Zuccarelli & Westhäuser, 2000).

In Malaysia, the operational of the urban rail transport project construction started in 2002 for Light Rapid Transport (LRT) and Kuala Lumpur (KL) Monorail services. This construction was managed by Syarikat Prasarana Negara Berhad,

which focuses on major Malaysian public transport infrastructure projects. This project is forever expanding over time to increase and participate the urban public transportation services demand; one of the *National Key Result Areas*, which is a priority under the Government Transformation Programme.

Recently, Malaysia has made another excel in the urban rail infrastructure with the completion of the Mass Rapid Transit (MRT) 1 line from Sungai Buloh to Kajang in July 2017. Other rail infrastructure projects which are currently in construction progress are the MRT 2 line, from Serdang to Putrajaya, Light Rail Transit (LRT) 3 line and LRT Bandar Utama to Klang line. These developments indicate that Malaysia is in line with other developed countries that have high-speed and modern public transportation.

On 15 December, 2016, Malaysia and Singapore have signed a consensual agreement to develop the jointly 350km HSR project. This project will reduce the travelling time between the two cities from 2 hours to approximately 90 minutes. The HSR serves as an alternative mode for public transport travel between Kuala Lumpur and Singapore. Then, in the 2017 Budget, the Malaysian Prime Minister announced the government's intention to build the East Coast Rail Project (ECRL). ECRL is identified as a high impact infrastructure project that will form the backbone of ECER's multimodal transport infrastructure. ECRL will connect many rural townships and is part of a larger plan to connect rural areas (Yong, 2017). These rail infrastructure projects will complement the existing road/expressway infrastructure of the Lebuhraya Pantai Timur and the existing KTMB East Coast Line and ports.

With this rail infrastructure project rapid development, fatalities, serious injuries and damage to properties at recent project sites will occur each year. Opposing from small and medium-sized construction projects, majority of infrastructure projects frequently comprise a diversity of different tasks and features (Shiferaw et al., 2012). Due to the unique site conditions, delay, budget overruns (Kean, 2011) and hidden transaction costs have arose (Sha, 2011). In addition, the possibility of increase in accidents for this huge project is more than other types of construction, due to many numbers of workers, large amount of plants and equipment, a lot of materials used, complicated in operations and complex activities at site (Guo et al., 2013).

2. THEORETICAL BACKGROUND

The study of accident costs was discussed for centuries, where Heinrich (1931) had pioneered in this field for more than 80 years ago. Numerous studies (Heinrich, 1959; Michaud, 1995; Neville, 1998; Monnery, 1999; Dorman, 2000; LaBelle, 2000; Siegel & Shim, 2000; Corcoran, 2002; Goetsch, 2013; Asan, n.d.; Pellicer et al., 2014; Feng et a., 2015) have summarised that the actual accident costs for the company are more higher than the direct costs or insurable costs. Issues in developing a construction accident model are the accuracy in evaluating of the indirect costs. However, the direct costs, such as hospital cost, medical treatment cost and compensation cost, are usually directly priced and insured besides being monitored ((Jallon et al., 2011).

Most construction companies and stakeholders do not systematically calculate both direct and indirect costs of accident, due to the lack of knowledge and information regarding on the compensation mechanisms involved when accidents occurred (Gavious et al., 2009). In project practice, clients, consultants and contractors have the tendency to ignore the cost of an accident, without realising the greatness of its impacts to the organisation, industry and country. This is particularly true, especially for the government projects, because of the government policies that require all projects must be insured. Most stakeholders have confidence in that most construction related items are insured and therefore there are not necessary to calculate these accident costs, which require large data collection.

Moreover, the shared economic approach in estimating benefits of safety investment assumes that accidents as undesired side effects, whereas these accident costs are assumed to be a sank costs (Oi, 1974; Thaler & Rosen, 1975). Based on this approach, a detailed safety cost from the consultants or the clients is often excluded from a contract amount. This exclusion is critical to ensure the project profitability.

Another reasons for the marginalisation of workplace accident costs by construction stakeholders consist of the difficulties in measuring, full burden work carried out by the managers, biased accounting methods and lack of quality in the safety departments (Dorman, 2000). In addition, Feng et al., (2014) and Jallon et al., (2011) revealed the quantification, evaluation and identification of many of the losses incurred in an accident are difficult as they are "hidden" costs. These "hidden" costs may be having the most significant costs incurred from that accident. They are often difficult to calculate due to complication in applying the existing models.

It is quite stressful in applying models to examine and estimate prevention costs in the construction industry. This is because, many of the research focused in the manufacturing sector, while the traditional cost models for analysing these costs are limited to recognizing and organising them. López et al., (2013) believed that the models should be 'tailor made' to each company according to conditions.

Previous studies revealed that there are a several safety and health cost models from other countries, such as United Kingdom (Health and Safety Executive, 2014), Singapore (Workplace Safety and Health Institute, 2013), Australia

(Safe Work Australia, 2015) and Malaysia (KLIACS JKKP, 2013). However, there is no study done that emphasis on the investigation of accident costs which incurred during the construction of urban rail infrastructure projects, specifically in a developing country such as Malaysia. This significant gap that is highlighted in this study is towards the development of safety cost models related with current rail infrastructure transportation trends in the country.

The objective of this study is to explore methods to calculate accident costs in the construction of urban rail infrastructure projects. The reliable evaluation of the accident costs can assist employers and workers to overcome the narrow routine economic approach adopted by them. Moreover, it also can help them to allocate the suitable items that require investment in safety measures in the strategic safety investment plan.

3. CALCULATION OF ACCIDENT COST APPROACHES

Accident costs are usually calculated with much uncertainty. Among the several sources of uncertainty in the calculation is in determining the right component of the costs. Several approaches by using formula calculations were proposed for quantifying the actual total cost of an accident. Table 1 shows several accident costs that were formulated by previous researchers.

Table 1: Accident Costs Formula Approaches from previous researchers.

Researcher	Formula of Accident Costs
Aaltonen et al., (1996)	Total Costs = Individual Costs + Company Costs + National Economy The Accident Consequence Tree (ACT) Method was developed based on the fault tree method for calculating accident costs.
Hammer & Price (2001)	Total Cost = Accident Prevention Costs + Legal Costs + Immeasurable Costs + Immediate Losses + Insurance Costs + Other Safety Costs + Rehabilitation Cost + Welfare Cost
Wong (2008)	Social Cost = Daily Wage x 365 days x (retire age 65 - injury age) x % disability/100 If the accident involves fatal, it will be calculated by:

	Social Cost = Daily Wage x 365 days x (retire age 65 - death age)
Gavius et al., (2009)	Total Cost = Cdirect + Cindirect + Cpayment + Cimmeasurable Where, the parameters that reflect the direct costs, indirect costs, payment costs and immeasurable costs are formulated as: Cdirect = Cdamage + Cmedical + Cfine + Cinsurance Cindirect = Ccapacity lost + Cschedule + Crecruit + Cwork time + Cwip + Cmang Cpayment = M (PaynewW ₁) $\sum_{i=0}^{W_2} B_i - NI \times W_2$ Cimmeasurable = Creputation + Cmorale
KLIACS JKKP (2013)	Total Cost = individual cost + employer cost + stakeholder cost Where, Individual cost = immediate loss of earnings + loss of future earnings + permanent afflictions + health and rehabilitation costs + administrative costs + finding a new occupation costs + Costs of housewives' work and relatives' work to take care of the injured workers
KLIACS JKKP (2013)	Employer cost = Damage Cost + Medical Cost + Fine Cost + Insurance Costs + Search and Rescue Costs + Capacity Lost + Schedule Cost + Recruiting Cost + Work Time Cost + Work in Progress Cost + Management Cost + External Investigation Cost + Accident Report Cost + Payment Cost + Immeasurable Cost Stakeholder cost = Government cost + Consultants cost + Clients cost
Health and Safety Executive (2014)	Total Cost = Individual Cost + Employer Cost + Government Cost Where, Individual cost = Loss of Income + Compensation Payments + Health and Rehabilitation Costs + Administrative Costs + Non-Financial Costs. Employer cost = Sick Pay Payments + Insurance Premiums + Production Disturbance Costs + Administrative and Legal Costs. Government cost = Costs arising from loss of earnings to the individual (benefits payments, reduction in tax and national insurance receipts) + Medical Treatment Costs and Rehabilitation Costs + Administration and Legal Costs
Pellicer et al., (2014)	CC = [0.0745*BS] + [β*BC] + [EX*NH*10-6* $\sum_{ik} NA_{ik} * CT_{ik}$] -

	$[0.75*GS*EX*NH*10-6*\sum_{jk}(DL_{jk}-1)*NA_{jk}]$ <p>Where, CC = Total Expected Cost of occupational accidents BS = Base Salary β = Ratio of safety budget invested in the prevention cost BC = Budget of the construction project EX = Exposure time at the construction site FI NH = Number of man-hours per million hours worked for the entire Spanish construction industry</p>
Pellicer et al., (2014)	NA = Number of accidents for the entire Spanish construction industry CT = Cost of the accident per type GS = Daily gross salary DL = Days of medical leave j = accident type; k = severity of the accident

Aaltonen et al., (1996) developed the Accident Consequence Tree (ACT) Method, which is based on the fault tree method for calculating the accident costs. The consequences of the accident to the injured worker, the company and the national economy were identified with the aid of the consequence tree. The ACT Method was applied to workplace accidents in 18 Finnish furniture factories of different sizes and product types.

On the other hand, the accident costs which were formulated by Hammer & Price (2001) were more general, not specific to any groups to whom the cost incurred. The accident costs were not classified into direct costs and indirect costs, which are commonly recommended by other researchers.

Wong (2008) developed the accident costs formula from the society point of view. Social costs are defined as any item that will result in the utilisation of national resources. These costs incurred for workers injury and fatal were separately formulated due to different accident severity. In addition, Tang (1997) revealed that the costs incurred by society are in broader perspective and the costs are higher than costs incurred by the contractors.

Gavious et al., (2009) proposed the reliable methods in estimating the costs incurred for an accident in the industrial sector, especially in relation to loss of production. The costs contained two main cost categories, which are direct costs and indirect costs. Researchers had considered all parameters that affect costs when an accident occurred, which are from the direct costs, indirect costs, payment costs and immeasurable costs.

Nevertheless, the study from KLIACS_JKKP (2013) in Malaysia, described that the formula for total cost associated with workplace injuries is made out by the three distinct groups to whom the cost falls, namely the accident victims, the victims employers and other stakeholders. This combination contributes to improving the ease of data collection and the quantity and quality of data collected. The stakeholders are responsible during the design stage of the construction. The client needs to invest for each safety prevention cost components that stated in the bill of quantities. They also need to bear the consultant's fee based on certain charges. The relevant stakeholder, when accident occurred is the government. The government needs to pay the compensation cost to the victim. Combining the costs of these three groups gives the total cost as a whole.

The Health and Safety Executive (2014) took a different approach. The formula for workplace injuries costs in Great Britain is by combining the costs from different three groups, which are individual's costs, employer costs and government costs. The actual total costs will be summarised from these groups, who borne the costs of accident.

While, Pellicer et al., (2014) developed a mathematical model as a method that would permit employers for computing the estimation for each cost category. This estimate should be applied during the construction project design phase and execution phase at the work site. However, the model still has a few limitations.

Determining a reliable correlation between prevention costs and accidents occurred at the site is difficult. Many case studies are required to gain the reliable data to suggest such a link and this correlation must be confirmed by other data. Moreover, in its current form, the model was not specific to any project type or defines project characteristics.

In short, the literature highlights the existing accident cost formulas across the globe, but their relations to the study environment for the rail infrastructure projects are limited. Diffusion of a new cost formula could provide valuable information for future estimation when accident occurred at the MRT and LRT sites.

In order to develop a systematic accident costs calculation for urban rail infrastructure projects, all existing formulas that were developed by previous researchers were considered. By doing so, the understanding of whether the existing

formula is relevant or not is used when the accident which happened were identified.

Therefore, the formula for total cost related to workplace injuries in this research is divided into employer cost, victim cost and stakeholder cost. The employer cost is further divided into two, which are direct cost and indirect cost. Direct cost is the cost that is accrued directly from the accident. The costs are typically covered by Social Security Organisation (SOCISO) and insurance company. While indirect cost is the cost item that is not covered by the worker's compensation insurance.

For the victim cost, the costs were incurred by the victim when accident happened. Usually, the cost items incurred by the victim are from the indirect costs, where it is uninsurable cost. Stakeholders cost is usually the compensation cost paid by the government agencies to the victim. This combination contributes to improving the ease of data collection and quantity and quality of data collected.

The total accident cost equation was adapted by KLIACS JKPP (2013), is given as:

Total Accident Cost = Employer Cost + Victim Cost + Stakeholders Cost

Where,

Employer Cost = Direct Cost + Indirect Cost

The total direct accident cost equation is given as:

Direct Cost = Medical Treatment Cost + Hospital Cost + Damage/Repair Cost + Fine Cost

Where,

Medical Treatment Cost - Immediate medical treatment costs. This cost includes medical equipment used when the accident happened, including the cost to refill, payment to person who arranges for emergency services and transport to the hospital and the salary of first aider.

Hospital Cost - This cost includes transportation cost to hospital, the hospitalisation costs which includes the hospital bills, payment for person who escort the victim to the hospital, payment for the person who visits the victim at the hospital and cost of follow up treatment after the victim is admitted from the hospital.

Damage/Repair Cost - The damage to machinery, material and equipment. Commonly, an accident not only involves injuries, but also comprises the damage to machinery, material and equipment. This damage can be total lost or can be repaired. The repair cost includes salary of labour to repair and cost of spare part. The cost of cleaning to ensure the site area back to operational working is also counted in this cost component.

Fine Cost - If an accident is caused due to violations of safety procedures or even breaking the law, the company may be exposed to fines by a court or by the local authorities likes DOSH.

While, the total indirect accident cost equation is given as:

Indirect Cost = Accident Report Cost + Replacement Cost + Legal and Administration Cost + Schedule Cost + Productivity Cost + Work in Progress Cost + Compensation to Victim Cost + Uninsured Medical Cost + Management Cost + Prevention Cost

Where,

Accident Report Cost – This includes the costs of printing, binding and photocopy when preparing the accident report.

Replacement Cost – The cost includes hiring training for new worker, who replaced the injured ones.

Legal and Administration Cost – Consists of legal proceeding cost and the cost of administrative works to prepare the report, such as the salary and the time cost to prepare the report, including recordkeeping and filling works.

Schedule Cost - When an accident happened, a slowdown in production will affect the timetable schedule. The solution that the company will create by rescheduling the work programme. The cost to reproduce new schedule and coordinating it is accounted in this cost component.

Productivity Loss Cost – This cost component consists of capacity loss (slowdown in production, machinery and equipment idling), time lost (time lost by injured and other workers, extra hours employed for overtime) and reduced productivity due to injured worker absence for several days, including the day to follow up treatment.

Work in Progress Cost - Consists of the cost of recovering works and investigation tools. The recovering works include the cost of additional inventory and recovering works.

Compensation to Victim Cost – The amount of money that the employer has to spend for the victim. These costs include the cost to send back victim's body to his country, the costs of escort staffs, including their transportation, accommodation and all expenses during their task and the ex gratia payment to the victim's family.

Uninsured Medical Cost – Usually this cost component relates to the traditional treatment like massage for the injured body.

Management Cost - Consists the cost of health, safety and environment committees to investigate the accident occurred. This cost includes their salary on doing the investigation, meeting and interviews with the victim and other workers.

Prevention Cost - This cost component consists of ad hoc safety training for corrective action. The costs consist of training fee (trainer cost including any equipment used during the training), transportation cost and lodging cost during the training period.

For the victim cost equation is given as:

$$\text{Victim Cost} = \text{Take Care Cost} + \text{Unpaid Leave Salary}$$

Where,

Take Care Cost – This includes the costs of 'housewives work' or 'relatives work' to take care of injured worker, and the unpaid leave salary had to bear by the injured worker during his medical leave.

The total other stakeholders cost equation is given as:

$$\text{Stakeholders Cost} = \text{Labour Department} + \text{CIDB} + \text{SOCISO} + \text{Insurance Company}$$

The stakeholder's cost – The compensation costs paid by the government agencies to the victim. For the local workers, they can have claimed from the Construction Industry Development Board (CIDB), Social Security Organisation (SOCISO) and Insurance Company if an accident happened to them. While for foreign workers, they can claim from the Labour Department

(JTK), CIDB and Insurance Company when an accident occurred.

4. SIMULATION OF COST ACCIDENT CALCULATION

In this section, the cost of accident was simulated to prove the viability of the generated calculation formula. The accident cost uses real data taken from one of the accident cases of MRT 1 Project. The MRT 1 Project begins from Sungai Buloh and runs through the city centre of Kuala Lumpur of before ending in Kajang. The construction of the first line commenced in July 2011 and it was start operation on 16 Dec 2016. There are 31 stations, with 51km line involved for the first MRT line Project. Six types of packages in the MRT 1 project, namely viaduct/guideway package, underground, advance, system, bus depot and depot. Since the types of work for each package in the MRT 1 construction varies, the work packages contractors (WPC) from viaduct (guideway) package were selected as a sample of the study. The reason being that the viaduct (guideway) package is the main package for the MRT 1 project, where it also covers the construction of stations.

There are 8 WPC (viaduct/guideway) in MRT 1 Project. The data was presented in the following table based on an accident occurred during the construction of the MRT 1 Project for viaduct (guideway) package which had caused injury to one foreign worker working as a labourer. The data were collected from the past accident records and accident reporting documents. Emergency Response Vehicle evacuated the injured worker to the nearest hospital. This accident was classified under Class 2 (LTI resulting in permanent disability) accident. The victim was admitted in the hospital for seven (7) days. Later, the victim obtained a medical leave for thirty (30) days due to his injury. In those four (4) weeks, the company did not recruited an outsourcing worker. The co-workers replaced the injured worker to carry out the works at site.

To investigate the accident, the Health, Safety & Environment (HSE) team members, which consists of managers, safety personnel (safety manager, safety officer, site safety supervisor) and site supervisor were appointed to participate. The investigation was a dedicated one (1) to two (2) working days, and after information was gathered from witnesses, the safety personnel will prepare the initial accident report.

4.1 EMPLOYER COST (DIRECT COST)

Direct cost = RM120 + RM6,770 + RM5,000 + RM20,000 = RM11,890

Table 2: The direct cost for employer.

Parameter	Value (RM)	Remarks
Medical Treatment Cost	120	RM120 salary of first aider per day or other person to arrange for emergency services and transport.
Hospital Cost	6,770	RM50 fuel transportation cost + RM6,050 medical cost at hospital (RM2,000 admission fee, RM150 x 7 days for operation fee & RM3,000 for major surgery fee) + RM160 salary of staff who escort victim to hospital + RM160 salary of staff visit at the hospital + RM350 follow up treatment fee.
Damage/Repair Cost	5,000	The damage to the materials, equipment and machines.
Fine Cost	20,000	Fine by authority (DOSH)

4.2 EMPLOYER COST (INDIRECT COST)

Indirect cost = RM120 + RM2,800 + RM3,000 + RM1,120 + RM8,152 + 5,000 = RM31,840

Table 3: The indirect cost for employer.

Parameter	Value (RM)	Remarks
Accident Report Cost	120	RM15 (printing and binding of report) x 8 copies for Client, PDP, DOSH, Insurance Company & Safety Department.
Replacement Cost	-	Usually, there is no replacement of new workers. Other workers will cover the jobs that is carried out by the victim.
Legal and Administration Cost	2,800	RM300 salary of safety personnel (day) + RM100 salary of safety/administrative clerk x 7 days of preparing/writing report.
Schedule Cost	3,000	Cost to reproduce new schedule due to the accident. Example, proposed new traffic plan management plan, where it involved the cost to certify the drawing.
Productivity Loss Cost	1,120	RM640 time lost by other workers because of the accident + RM400 extra hours employed to recover production + RM80 lost productivity due to follow

Work in Progress Cost	-	up treatment (victim salary/day). The additional work hours that are needed to replace the injured worker (it depends on the policy of the company if there are recruiting new workers or letting the co-worker to work extra hours).
Compensation to Victim Cost	-	The amount of money that the employer had to spend for the victim. These costs included the cost to send back victim's body to his country, the costs of escort staffs including their transportation, accommodation and all the expenses during their task and the ex gratia payment to the victim's family. Usually, this cost component will involve for the class 1 accident (fatality).
Uninsured Medical Cost	-	The victim only goes for the hospital treatment rather than traditional treatment such as massage treatment.
Management Cost	8,152	Salary (per day) x time spent estimated for the HSE committee members to do the investigation works (interviewing, attending meeting).
Prevention Cost	5,000	The costs consist of salary of workers who are attending the training x number of days of training + training fee (trainer cost including any equipment used during the training) + transportation cost + lodging cost during the training period.

4.3 VICTIM COST

Victim cost = RM2,400

Table 4: The indirect cost for victim.

Parameter	Value (RM)	Remarks
Take Care Cost	-	Majority of accidents happened to the foreign workers. No spouse of relative taken care cost to them. So, this cost component was not calculated in the victim cost.
Unpaid Leave Salary Cost	RM2,400	This cost component was incurred by the foreign workers when they cannot work at site. The cost was calculated based on the victim's salary (per

day) x days of unpaid leave. For this case, the victim's salary RM80 x 30 days of unpaid leave.

Victim Cost	RM2,400	-	2.58
Stakeholder Cost	RM46,976	-	50.45

Total Cost	Accident	RM93,106	100.00
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4.4 STAKEHOLDERS COST

$$\text{Stakeholder cost} = \text{RM13,287} + \text{RM3,289} + \text{RM30,400} = \text{RM46,976}$$

Table 5: The stakeholder cost.

Parameter	Value (RM)	Remarks
Labour Departmet	RM13,287	Majority accidents happened to the foreign workers. Labour Department was considered to the active and registered foreign construction workers.
SOCSCO	-	This cost component was contributed to the local workers. The compensation was paid based on the medical benefit,
CIDB	RM3,289	temporary/permanent disablement benefit and funeral.
Insurance Company	RM30,400	All personnel working in construction sites must obtain a green card before entering the construction site. CIDB green card is automatically covered by a special insurance scheme that insures the construction personnel against death and accidents. Workers' compensation is a form of insurance providing wage replacement and medical benefits to employees injured. MRT Corporation Sdn. Bhd. as a client was provided this insurance for MRT project.

The total accident cost for the above case was estimated around RM93,106. Even in a small accident case, the indirect cost weights 72.81%. The result showed that the indirect costs were 3.73 times larger than the direct ones, yet most companies do not regularly calculate these costs. This finding further reinforced the notion that the costs of an accident incurred by the employee are related to previous studies. The Heinrich's ratio of (1:4) between direct and indirect accident costs has frequently used in previous studies on safety-related literature (Manuele, 2011).

In contrast to previous studies by Pillay and Haupt (2008), revealed that the accident cost ratio for non-fatalities is higher (i.e. 1:1.6). While the latest study from (Nur et al., 2019), found that for the permanent disability accident cases, it 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. As discuss by Teo and Feng (2011) stated that there is no generally accepted ratio of direct to indirect costs. OSHA (2007) 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 (2006) proposed that the accident costs ratio of injuries may range from 1:2.0 to 1:20.0. Hence, the accident cost ratio is not necessarily fixed. The total accident costs incurred by this company were lost much more money than was expected.

5. CONCLUSION

This paper provides a cost estimation method to calculate accident costs in the construction of urban rail infrastructure projects in Malaysia. It is based on a theoretical approach that classifies these costs in two categories i.e. direct and indirect costs based on the different cost bearers, who are employer, victim and stakeholder. A method of estimating the cost components for each category is proposed even though there are a few other approaches of a model that formulates accident costs. It provides a mathematical formulation for the calculation of the different types of costs component that intervene in the accident cases.

This generation of systematic calculation of accident costs was significantly designed for the construction projects of urban rail infrastructure.

4.5 TOTAL ACCIDENT COST

Table 6: The total accident costs including employer cost, victim cost and stakeholder

Parameter	Value (RM)	Sub-percentage (%)	Percentage (%)
Employer Cost	RM11,890	27.19	
i) Direct Cost			
ii) Indirect Cost	RM31,840	72.81	
Total	RM43,730	-	46.97
Employer Cost			

This formula could heighten the importance about the effect of an accident to the employer's company economic and budgeting. In addition, it could enrich awareness in improving preventive measures for a construction project. A reliable evaluation of the cost of accidents for the construction of urban rail infrastructure projects could help work packages contractors (WPC) to plan the investment in safety measures appropriately according to the related accident cost components. Most significantly, this formula could provide valuable information for the future estimation of accident costs occurred for incoming rail infrastructure project in Malaysia, such as HSR, ECRL, MRT2, MRT3 and LRT3.

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