INTERNATIONAL JOURNAL OF SUSTAINABLE CONSTRUCTION ENGINEERING AND TECHNOLOGY
VOL. 13 NO. 2 (2022) 83-90

IJSCET

http://publisher.uthm.edu.my/ojs/index.php/ijscet

ISSN : 2180-3242 e-ISSN : 2600-7959

International Journal of Sustainable Construction Engineering and Technology

Prevention Cost Components Priorities for Urban Rail Infrastructure Projects

Izatul Farrita Mohd Kamar[1*], Asmalia Che Ahmad[1], Mohmad Mohd Derus[1]

[1]Department of Built Environment Studies and Technology, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Perak Branch, 32610 Seri Iskandar, Perak, Malaysia.

*Corresponding Author

DOI: https://doi.org/10.30880/ijscet.2022.13.02.007
Received 10 April 2022; Accepted 25 April 2022; Available online 09 May 2022

Abstract: The Mass Rapid Transit (MRT) and the Light Rail Transit (LRT) have been established as the largest transport infrastructure projects in Malaysia and cost over RM40 billion. Due to the vigorous development of both projects, accidents at project sites have caused fatalities, serious injuries, and damage to properties. Many accidents have occurred during the operation of rail. In Malaysia, the latest rail accident occurred on 24th May 2021 had injured 200 people when two coaches on the Kelana Jaya LRT line collided in the capital Kuala Lumpur. Rail accidents create significant economic impacts on the country, stakeholders, and society. Studies on the prevention costs during the pre-construction stage of a project are scarce and have mainly focused on the financial losses or accident costs incurred by the contractor and victim. Among the limitations of the existing safety and health cost models is that they do not include the costs incurred by the client for the safety prevention activities. Therefore, this research aims to study the types of prevention cost components that must be the priorities for urban rail infrastructure projects. The data analysed in this study was obtained from a total of eight (8) projects involved in the MRT 1 (SBK Line) and ten (10) projects involved in the MRT 2 (SPP Line). The prevention cost components priorities were determined by the coefficient of variation (CV) percentage. The finding shows ten (10) prevention cost components, and nineteen (19) prevention cost items were allocated during the pre-construction phase. The cost components were the Plant Costs, OSH Management Costs, Housekeeping Costs, Special Work Condition Costs, Evaluation and Monitoring Costs, Emergency Response Costs, Electrical Work Costs, PPE and Training Costs, Facilities on Site Costs, and Insurance Costs. This study finds out that all these prevention cost components are important to prevent accidents for the employees when carrying out work on-site. Therefore, clients should consider the availability of these cost components in the planning and preparation phases of an urban rail infrastructure project. Thus, the most logical amount of prevention cost components can be achieved in the future project and creating the awareness of these costs to the clients.

Keywords: Safety and health, prevention costs, urban rail infrastructure projects

1. Introduction

Job-related injuries are the most common health risks in large-scale workplaces, including MRT and LRT projects, and are associated with suffering and loss at individual, community, society, and organisational levels. Fatalities, serious injuries, and damage to properties occur every year due to the rapid construction of these projects. For example, the MRT accident reports revealed that there were a thousand incident cases in the MRT 1 Project (SSP Line) since the project started in 2011. This scenario had contributed to a substantial amount of costs related to safety and health issues. In addition, it had also resulted in delays, cost overruns, and sometimes more significant consequences such as injury and loss of life (Rita & Herbet, 2021).

Numerous scholars have analysed the two recognised typologies of safety and health costs, namely, prevention

*Corresponding author: izatul739@uitm.edu.my

costs and accident costs (Mohd Kamar et al., 2018) (Feng, 2015) (Gurcanli et al., 2015) (HSE, 2015) Ibarrondo et al., 2015) (Cheng et al., 2010a) (Cheng et al., 2010b). Prevention costs are those incurred to comply with legal requirements concerning accident preventions, implement measures to prevent accidents during construction work, and improve health and safety conditions in all areas of the work performed. Preventing accident occurrence allows stakeholders to financially save more (Yilmaz & Kanit, 2018). Meanwhile, accident costs are incurred on stakeholders when an accident occurs on a construction site. The accident costs are distinguished between direct costs (insurable costs) and indirect costs (uninsurable costs) (Aminbakhsh et al., 2013).

In general, there are limited provisions for safety and health elements in the bills of quantities. The Malaysian Standard Method of Measurement of Building Works (SMM 2) Clause B.12 states that the safety, health, and welfare of a workplace are deemed to be included in the pricing of the preliminary items. Unfortunately, the provision allocated in this clause is ambiguous and lacks specific details. According to Jallon et al. (2011), the Occupational Health & Safety (OHS) stakeholders have issues with the insufficiency of the mathematical models and complex calculations, which are needed to prove the economic benefits of safety investments.

However, construction companies are often reluctant to invest resources in preventive activities. Instead, they only concentrate on the financial losses or accident costs incurred after on-site accidents. Moreover, the limitation of the existing safety and health cost models is that the models do not include the costs that are allocated by clients for safety prevention activities. This is a significant gap that must be addressed to improve the existing safety and health cost models. Consequently, this research aims to study the types of prevention cost components that should be prioritised in urban rail infrastructure projects.

2. Determining Types of Safety Prevention Costs

Job-related injuries place a moral and economic burden on societies. The total cost related to an accident is the sum of the costs of individuals, employers, and governments, and it includes both financial and non-financial human costs (HSE, 2018). There are a variety of terms for safety and health cost typologies identified by researchers. The cost typology is a classification of cost based on the type, component, or category of the cost. Despite the arguments over the various typologies of the safety and health costs, the cost components are consistent in many literatures. For example, Teo & Feng (2011) reveal that there are various components of safety and health costs derived from studies on different industries, including furniture, forestry, chemistry, cleaning services, financial services, and manufacturing.

Lopez et al. (2013) clarify that the costs related to safety and health in the workplace can be divided into three groups: safety costs, non-safety costs, and other extraordinary costs. Scholars have analysed two well-known typologies of safety and health costs, namely prevention costs and accident costs (Lopez et al., 2013) (Gurcanli et al., 2015) (HSE, 2015) Ibarrondo et al., 2015) (Cheng et al., 2010a) (Cheng et al., 2010b). In addition, some researchers recognise safety prevention activities as an investment or a budget item of a construction project. To simplify, safety and health costs can be classified into three types: prevention, accident, and other extraordinary costs.

Safety costs are divided into prevention costs and evaluation and monitoring costs. Prevention costs are the costs incurred to comply with the legal requirements regarding accident preventions and are implemented to avoid the occurrence of accidents during the construction work, besides to improve health and safety conditions in all areas of the work performed. Concerning the evaluation and monitoring costs, these are derived from the actions taken by a company to ensure appropriate testing and maintenance of health and safety measures to minimise the risk of accident or occupational injuries (Lopez et al., 2013).

Based on the literature review, the safety and health cost items related to prevention, evaluation, and monitoring are used for preventive costs in construction projects, as listed in Table 1. The budget allocated should be sufficient for the project to achieve the goal of minimum accident cases occurring on the site. Prevention costs must be substantially increased to either achieve zero or close to zero accidents.

3. Methodology

The respondents were from Work Packages Contractors (WPC) for the Mass Rapid Rail (MRT) Sungai Buloh-Kajang (SBK) Line and Sungai Buloh-Serdang-Putrajaya (SSP) Line projects. Pilot tests were undertaken during the development of the questionnaire items, to determine their validity and reliability, and to clarify potential areas of misinterpretation of the questionnaire. A total of 20 questionnaires were distributed to representatives from academicians and construction stakeholders that related to the research topic. Based on these responses, a minor modification was made to the instrument items to improve clarity and comprehension. The selected representatives of the pilot study assessed the content, style, format, and clarity of the questions and provided feedback and suggestions for improvement. After minor adjustments and corrections, the questionnaire was finalised.

Personal interviews with safety personnel and structured questionnaires were the data collection techniques used to collect main data for this study. The respondents were first referred to the archival records before completing the required data in the questionnaires. The questionnaire was divided into three separate sections: Section A: Background of Project, Section B: Respondent's Particulars and Section C: Types of Prevention Cost Components for the Project. The types of questions included multiple-choice questions with a nominal scale and ordinal scale in Section A and B.

Whilst, in Section C, a ratio scale was used. The questionnaire respondents were requested to estimate the prevention costs allocated for each project.

Table 1 - Types of Prevention Cost Components and Items for Construction Projects

Safety Prevention Costs Component	Safety Prevention Costs Item	Description	Author
Insurance costs	Fixed insurance costs	The type of insurance provided to clients for a project such as Workmen Compensation, Contractor All Risk, Public Liability, etc.	JKR (2012)
Evaluation and monitoring costs	Salary-safety manager, safety officer & site safety supervisor	This cost includes the salary of Occupational Safety & Health (OSH) team.	Lopez et al. (2013), JKR (2012)
PPE & training costs	Personal protective equipment	This cost includes the types of personal protective equipment (foot, eye, head, body, hand, hearing, respiratory protection, and first-aid kit) and OSH training programmes including promotions and awards given to employees.	JKR (2012)
	OSH training		
Housekeeping costs	Housekeeping requirements	The housekeeping requirement costs include the tools and salary of the cleaners on a site.	
OSH management & documentation costs	OSH Planning	This includes the costs of documentation for OSH planning as well as the costs of OSH management reports, auditing, and inspections.	
	OSH Management		
Safe working area costs	Security hoarding, scaffolding, working platform, safety netting, catch platform (demolition works)	This cost component includes the types of safety equipment required to make the working area safe such as security hoarding, scaffolding, working platform, safety netting, safety barricades, guardrails, temporary foot walks, mild steel plate supports, ladders, safety signages, gas detector, gas cylinder, temporary lighting, etc.	
	Scaffolding design & Working Platform (Professional Engineer Approval)		
	Safety barricades/fencing/railing/screen/wire netting/toe board, guardrails, temporary foot walks		
	Working area coordinated (lifting operations, moving, shifting)		
	Prevent the breeding of mosquitoes, houseflies, rats, insects/dangerous animals		
Special work condition costs	Confined spaces/tunnel	This cost component covers the types of safety equipment for special work conditions such as in confined spaces/tunnels, traffic management & signage (outside of the site), excavation works, pylon works, and additional required safety provisions.	
	Traffic management & signage		
	Excavation works& demolition works		
Electrical work costs	Safety maintenance & maintenance report	This cost component incorporates electrical safety works such as inspection and protection work costs.	
	Safety signage		
	Inspection of all electrical tools and equipment		
Emergency response costs	Training	This cost component includes training costs (emergency drills training) and equipment and team costs (emergency management team salary).	
	Equipment and team		
Plant costs	Inspection records	This component includes the costs of crane and lifting operations (inspection records, designated person, statutory inspections, and approval by authorities) and vehicle plants and equipment (guide movement-radio communication set for signalmen and operators).	
	Designated person		
	Radio communication set for signalman & operator		
	Statutory inspection and approval by authorities		
Facilities on-site costs	Provide and maintain toilet, temporary rest areas, adequate lighting and water and pest control treatment	The cost to supply and maintain facilities on site such as toilet, rest area, canteen, etc.	

3. Results and Discussion

3.1 Background of Project

The data analysed in this study was obtained from eight (8) projects involved in the MRT 1 (SBK Line) and ten (10) projects involved in the MRT 2 (SPP Line). Table 2 provides the summary of each project background with details on the name of project, company, contract value, and safety budget. Based on the table, the contract value of the MRT 1 (SBK Line) Project ranged from RM499.9 million (V7) to RM1.17 billion (V4), while the MRT 2 (SPP Line) Project ranged from RM558.6 million (V207) to RM1.47 billion (V203).

Table 2 – Summary of Project Background

Project	Company	Contract Value (RM)	Safety and Health Budget (RM)	Percentage (%)
MRT 1 (SBK Line) Project	V1	1,092,330,000	7,376,135	0.68
	V2	863,390,000	12,930,090	1.50
	V3	816,240,000	11,894,383	1.46
	V4	1,172,750,000	8,645,434	0.74
	V5	974,780,000	13,021,659	1.34
	V6	764,910,000	12,134,625	1.59
	V7	499,980,000	9,218,998	1.84
	V8	951,090,000	7,257,020	0.76
MRT 2 (SSP Line) Project	V201	1,213,000,000	34,333,835	2.83
	V202	1,439,530,000	49,744,268	3.46
	V203	1,470,000,000	60,827,797	4.14
	V204	890,000,000	33,138,036	3.72
	V205	858,180,000	46,747,413	5.45
	V207	558,600,000	30,128,482	5.39
	V208	678,680,000	22,741,323	3.35
	V209	715,990,000	27,800,222	3.88
	V2010	648,000,000	24,449,645	3.77

The highest contract value for the construction projects was RM1.47 billion on the MRT 2 (SSP Line) Project, while the lowest contract value was RM499 million on the MRT 1 (SBK Line) Project, which was awarded to the V7 work packages contractor (WPC). This is because the safety and health budget for MRT 1 (SBK Line) Project was below 2% of the contract value, while the safety and health budget for MRT 2 (SSP Line) Project was more than 2% of the contract value. This scenario was resulted from the client's requirement concerning the minimum safety and health budget of 2% of the contract value for the MRT 2 (SSP Line) Project. The requirement was implemented by the contractors to improve the quality of the project by reducing the number of on-site accidents.

The previous work undertaken by [4] revealed that the percentage of the safety and health budget accounted for 1.92% of the total construction project budget. However, Pellicar et al. (2014) found that the budget accounted for approximately 5% of the total construction project cost, with higher percentages of the safety and health budget (between 6% and 8%) based on the United States insurance system. Consequently, it can be inferred that the differences in the percentage of safety and health budgets depend on the country and the requirements set by clients.

3.2 Respondent's Particulars

Table 3 illustrates the frequency and percentage of safety and health job positions, job categories, and working experiences of the respondents in this study. According to the table, safety managers made up more than half of the respondents (61.0%), followed by safety and health officers (27.8%). The remaining respondents were environment managers and site safety supervisors, which made up of 5.6% respectively. In terms of the job category, the majority of the respondents (77.2%) were middle-level management due to their position as safety managers. In most cases, the designation that someone holds in an organisation generally portrays their working experience. Accordingly, most respondents (88.8%) in this study had had working experience of more than ten years. Only 11.2% of the respondents had fewer than ten years of working experience. This demonstrates that the respondents had sound experience in safety and health costs to provide reliable data for this study.

Table 3 – Job Position, Job Category, and Years of Working Experience of the Respondents

Items	Sub-Items	Frequency (N)	Percentage (%)
Job Position	Safety Manager	11	61.0
	Environment Manager	1	5.6
	Safety & Health Officer	5	27.8
	Site Safety Supervisor	1	5.6
Job Category	Top-level management	3	16.7
	Middle-level management	13	77.2
	Low-level management	2	11.1
Working Experience	< 5 years	1	5.6
	6-10 years	1	5.6
	> 10 years	16	88.8

3.3 Prevention Cost Components for Urban Rail Infrastructure Projects

This analysis aims to study the types of prevention cost components for urban rail infrastructure projects. Table 4 shows the mean, standard deviation, and coefficient of variation of the Prevention Cost Components determined by the study respondents. Based on Table 4, the highest Prevention Cost Component was the Special Work Condition Costs (RM310,766,855.00) (mean = RM17,264,825.28). The second highest Prevention Cost Components was Evaluation and Monitoring Costs (RM33,217,544.00) (mean = RM1,845,419.11), followed by the Safe Working Area Costs (RM24,414,643.00) (mean=RM1,356,369.06). The lowest Prevention Cost Component incurred for this project was the Electrical Work Costs (RM=1,948,138.00) (mean = RM108,229.89). This is common with this type of work, which is rarely allocated in the viaduct guideway packages.

Table 4 – Total Cost of Prevention Cost Components

Project	Insuran-ce Costs (RM)	PPE & Training Costs (RM)	Evaluation & Monitoring Costs (RM)	OSH Manage-ment Costs (RM)	Safe Working Area Costs (RM)	Special Work Condition Costs (RM)	Electri-cal Work Costs (RM)	Plant Costs (RM)	Facilities on Site Costs (RM)	House-keeping Costs (RM)	Emerge-ncy Respon-se Costs (RM)
V1	350,000	265,000	817,420	260,000	52,000	5,395,715	1,000	-	5,000	130,000	100,000
V2	50,000	350,000	1,300,000	110,000	320,000	10,280,090	30,000	-	70,000	-	420,000
V3	667,166	479,273	854,834	102,113	988,418	8,052,511	105,000	-	321,300	-	323,768
V4	-	137,944	500,000	77,520	244,800	7,535,802	-	-	49,368	-	100,000
V5	-	587,787	1,364,139	111,044	1,091,883	8,798,026	304,000	-	317,540	-	447,240
V6	485,110	446,250	1,365,000	89,250	630,000	8,418,665	52,500	-	210,000	-	437,850
V7	212,500	232,200	230,000	90,000	275,000	7,668,898	40,000	-	20,400	-	450,000
V8	50,000	100,700	496,451	40,280	182,166	6,059,141	16,112	-	125,875	-	186,295
V201	-	1,755,805	3,850,000	132,997	748,391	23,691,717	145,626	2,072,370	1,117,709	604,908	214,311
V202	304,510	2,551,600	2,798,700	197,700	1,048,200	37,074,808	205,900	2,842,400	1,614,050	829,700	276,700
V203	500,000	2,204,000	4,656,000	309,500	14,152,240	35,070,557	168,000	1,990,000	1,177,500	540,000	60,000
V204	1,220,240	2,441,500	2,035,000	127,500	760,990	22,463,306	120,000	2,177,000	805,000	787,500	200,000
V205	371,200	2,100,500	2,035,000	287,500	668,790	37,634,423	110,000	2,065,000	805,000	630,000	40,000
V206	500,000	2,458,500	2,109,000	288,500	842,490	22,211,699	120,000	2,177,000	854,600	787,500	40,000
V207	1,500,000	3,377,000	2,072,000	299,000	1,028,175	17,206,907	136,000	2,694,000	835,400	930,000	50,000
V208	-	1,153,000	2,146,000	129,000	491,700	16,261,123	126,000	1,289,500	654,000	324,000	167,000
V209	400,000	1,260,000	2,146,000	129,000	482,150	20,084,072	116,000	1,597,000	781,000	630,000	175,000
V210	150,000	1,535,000	2,442,000	133,000	407,250	16,859,395	152,000	1,345,000	691,000	540,000	195,000
Total Cost (RM)	**6,760,726**	**23,436,059**	**33,217,544**	**2,913,904**	**24,414,643**	**310,766,855**	**1,948,138**	**20,249,270**	**10,454,742**	**6,733,608**	**3,883,164**
Mean (RM)	375,596	1,302,003	1,845,419	161,8834	1,356,369	17,264,825	108,230	1,124,959	580,819	374,089	215,731
SD (RM)	415,126	1,031,334	1,152,827	87,287	3,209,387	10,745,991	74,735	511,373	465,255	231,614	145,679
CV (%)	111	79.21	62.47	53.92	236.62	62.24	69.05	45.46	80.10	61.91	67.53

However, the coefficient of variation result shows ten (10) prevention cost components with coefficients of variation ranging from 45.46% to 80.10%. The results show that the Plant Costs had the lowest cost variability (cv=45.46%), followed by the OSH Management Costs (cv=53.92%). The other cost components with a low cost of variability were PPE and Training Costs, Evaluation and Monitoring Costs, Special Work Condition Costs, Electrical Work Costs, Facilities on Site Costs, Housekeeping Costs, Emergency Response Costs, and Insurance Costs. Consequently, the coefficient of variation result is able to identify the types of prevention cost components that should be prioritised for urban rail infrastructure projects.

3.4 Analysis of Prevention Cost Components Priorities for Urban Rail Infrastructure Projects

The prevention cost components priorities for urban rail infrastructure projects are determined by the coefficient of variations percentage. A low coefficient of variation percentage means that the cost variability is low. Table 5 shows the types of prevention cost components that clients commonly incur. The coefficient of variation result shows ten prevention cost components with coefficient of variation ranging from 45.46% to 110.52%. Plant Costs and OSH Management and Documentation Costs had the lowest cost variability, i.e., cv=45.46% and cv=53.92%, respectively. This is exemplified in Alhajeri (2011) work, which reveals that lifting operations are one of the hazardous activities on-site. Therefore, much of the research that has been conducted to improve the safety management performance has focused on plant operation due to multi-large plant operations being difficult to control and coordinate and having the potential to easily cause an accident (Guo et al., 2013).

Table 5 –Types of prevention cost components priorities

Cost Bearers	Prevention Cost Components	Prevention Cost Items	Coefficient of Variations (%)
Client Costs	Plant Costs	Crane and Lifting Operation	45.46
		Vehicle Plant and Equipment	
	OSH Management & Documentation Costs	OSH Planning	53.92
		OSH Management	
	Housekeeping	Housekeeping Requirement	61.91
	Special Work Condition Costs	Confined Spaces/Tunnel	62.24
		Traffic management & signage (Outside of construction site)	
		Excavation Works	
		Pylon Works	
		Safety Provision of the Works	
	Evaluation & Monitoring Costs	OSH management team salary	62.47
	Emergency Response Costs	Training	67.53
		Equipment & Team	
	Electrical Work Costs	Electrical Safety	69.05
	PPE & Training Costs	Protection elements	79.21
		Safety training	
	Facilities on Site Costs	Supply & Maintenance of Facilities	80.10
	Insurance Costs	Fixed insurance costs	110.52
	Safe Working Area Costs	Safety, Health & Welfare	236.62

OSH Management and Documentation Costs consist of the costs of documentation for OSH planning and reports, auditing, and inspections in OSH management. Podgorski (2015) explains that stakeholders expect the OSH management systems to be implemented in a company because it helps prevent occupational injuries and diseases and improves on-site working conditions. Although the Housekeeping Costs involved in MRT projects were more than the other cost components, it is essential to implement and improve the housekeeping work on-site in order to reduce the number of accidents that occur (Kyriakidis et al., 2012).

Another type of prevention cost component incurred by clients during the pre-construction stage was the Special Work Condition Costs. A sum of money was allocated on the safety requirements for special work conditions, such as working in confined spaces or tunnels, the requirement for traffic management and signage outside the construction site, excavation work, and pylon work. However, differences in the special work conditions were required for the

identification of different hazards. Therefore, the costs for this cost component are determined by the client's requirements and the site conditions.

The Evaluation and Monitoring Costs was another cost component that was commonly incurred on these two projects. This cost component consisted of the salary for the OSH team, i.e., the salary of the safety managers, safety officers and site safety supervisors. The cost depended on the construction period taken to complete the project. The results are parallel to the previous work carried out by (Yilmaz & Kanit, 2018) (Lopez et al., 2013) (Zou et al., 2010) (Feng, 2015), which reveal that the safety committee costs are one of the components of prevention costs.

Therefore, the above are the types of prevention cost components prioritised in eight (8) projects involved in the MRT 1 (SBK Line) and ten (10) projects involved in the MRT 2 (SPP Line). These cost components should be highlighted in the cost allocation by clients in the pre-construction phase of the MRT and LRT projects. This is exemplified in work undertaken by other research where the safety staffing costs, safety training costs (outsourced and in-house training), safety equipment, and facilities costs (personal protective equipment, material and machinery, and manpower), OSH management costs (safety committee salary), safety promotion and incentive costs, costs of new technologies, methods or tools designed for safety are all cost components of total safety prevention or safety investment (Yilmaz & Kanit 2018). Nunez (2019) also agrees that the firms' investments in occupational health and safety can increase their stock of human capital, as does, for example, investment in workers' training.

Although the Safe Working Area Costs had the highest cost variability, this cost component is one of the prevention costs components that should be allocated by clients. The cost consists of the types of safety equipment, (e.g., security hoarding, scaffolding, working platform, safety netting, safety barricades, guardrails, temporary handrails, and safety signage). This safety equipment is important to keep workers safe while working on-site. Prevention costs are usually estimated during the bidding for the construction project by the contractors. Therefore, the estimation of the prevention costs is justified on economic terms. On the other hand, the prevention costs are allocated based on the client's required budget. Usually, large projects need a bigger budget for safety preventions compared to smaller projects.

This research findings will help the relevant stakeholders and related government agencies, such as the Department of Safety and Health (DOSH) Malaysia, Mass Rapid Transit (MRT) Corporation Sdn Bhd, Prasarana Berhad, Construction Industry Development Board (CIDB), Project Delivery Partner (PDP); MMC-Gamuda KVMRT Sdn Bhd and MRCB-GK Sdn Bhd, to develop a new safety and health costs model for future urban rail infrastructure projects in order to minimise the negative cost losses incurred by the clients.

4. Conclusion

In preparation of a project budget, clients must allocate ten (10) prevention cost components and nineteen (19) prevention cost items during the pre-construction phase. These cost components are the Plant Costs, OSH Management Costs, Housekeeping Costs, Special Work Condition Costs, Evaluation and Monitoring Costs, Emergency Response Costs, Electrical Work Costs, PPE and Training Costs, Facilities on Site Costs, and Insurance Costs. All these cost components are to be a priority during the pre-construction phase in future urban rail infrastructure projects considering their importance in preventing accidents for the employees on-site. Clients should consider the availability of these cost components during the planning and preparation phases.

Acknowledgement

We wish to thanked and acknowledge the fund support of research grant from MyRA Research Grant (PhD Graduate) (Project code: 600-RMC/GPM LPHD 5/3 (061/2021)) funded by the Universiti Teknologi MARA, Perak Branch.

References

Alhajeri, M. (2011). *Health and Safety in the Construction Industry*: *Challenges and Solutions in the UAE* (Doctoral Dissertation). Coventry University.

Aminbakhsh, S., Gunduz, M., & Sonmez, R. (2013). Safety risk assessment using analytic hierarchy process (AHP) during planning and budgeting of construction projects. *Journal of Safety Research, 46*, 99-105.

Cheng, C. W., Leu, S. S., Lin, C. C., & Fan, C. (2010a). Characteristic analysis of occupational accidents at small construction enterprises. *Safety Science*, *48*(6), 698–707.

Cheng, C. W., Lin, C. C., & Leu, S. S. (2010b). Use of association rules to explore cause-effect relationships in occupational accidents in the Taiwan construction industry. *Safety Science*, *48*(4), 436–444.

Feng, Y. (2015). Mathematical models for determining the minimum level of voluntary safety investments for building projects. *Journal of Construction Engineering and Management*, *141*(7), 1-11.

Feng, Y., Zhang, S., & Wu, P. (2015). Factors influencing workplace accident costs of building projects. *Safety Science*, *72*, 97–104.

Guo, H. L., Li, H., & Li, V. (2013). VP-based safety management in large-scale construction projects: A conceptual framework. *Automation in Construction Journal*, *34*, 16–24.

Gurcanli, G. E., Bilir, S., & Sevim, M. (2015). Activity-based risk assessment and safety cost estimation for residential building construction projects. *Safety Science*, *80*, 1–12.

HSE (2015). *Costs to Britain of workplace fatalities and self-reported injuries and ill health, 2016/17*. Retrieved on 12 July 2017, from http://www.hse.gov.uk/statistics/pdf/cost-to-britain.pdf.

HSE (2018). *Costs to Britain of workplace fatalities and self-reported injuries and ill health, 2016/17*. Retrieved on 12 July 2017, from http://www.hse.gov.uk/statistics/

Ibarrondo-Davila, M.P., Lopez-Alonso, M., & Rubio-Gamez, M.C. (2015). Managerial accounting for safety management. The case of a Spanish construction company. *Safety Science*. *79*, 116–125.

Jallon, R., Imbeau, D., & De Marcellis-Warin, N. (2011). Development of an indirect-cost calculation model suitable for workplace use. *Journal of Safety Research*, *42*(3), 149–164.

JKR (Jabatan Kerja Raya Malaysia). (2012). *List of quantities of occupational safety and health management*. Retrieved on 22 March 2018 from https://mafiadoc.com/senarai-kuantiti-pengurusan-keselamatan- dan-kesihatan-jkr_5a35b7a81723dd8cda00ea63.html.

Kyriakidis, M., Hirsch, R., & Majumdar, A. (2012). Metro railway safety: An analysis of accident precursors. *Safety Science*, *50*(7), 1535–1548.

Lopez-Alonso, M., Ibarrondo-Davila, M. P., Rubio-Gamez, M. C., & Munoz, T. G. (2013). The impact of health and safety investment on construction company costs. *Safety Science*, *60*, 151–159.

Mohd Kamar, I.F., Che Ahmad, A., & Mohd Derus, M. (2019). Exploring the occupational safety and health cost typologies in the construction of Malaysia urban rail infrastructure projects. *Geographia Technica Journal*, *14*, 221-231.

Nunez, I. (2019). The effect of human capital on occupational health and safety investment : An empirical analysis of Spanish firms. *Human Resource Management Journal*, 131–146. pdf/cost-to-britain.pdf.

Pellicer, E., Carvajal, G. I., Rubio, M. C., & Catala, J. (2014). A method to estimate occupational health and safety costs in construction projects. *KSCE Journal of Civil Engineering*, *18*(7), 1955–1965.

Podgorski, D. (2015). Measuring operational performance of OSH management system - A demonstration of AHP-based selection of leading key performance indicators. *Safety Science*, *73*, 146–166.

Rita, L.S., & Herbet, H.E. (2021). Lessons from accidents during tunnel construction. *Tunnelling and Underground Space Technology*, 113.

Teo, E. A.-L., & Feng, Y. (2011). The indirect effect of safety investment on safety performance for building projects. *Architectural Science Review*, *54*(1), 65–80.

Yilmaz, M., & Kanit, R. (2018). A practical tool for estimating compulsory OHS costs of residential building construction projects in Turkey. *Safety Science*, *101*, 326–331.

Zou, P. X. W., Sun, A. C. S., Long, B., & Marix-Evans, P. (2010). Return on investment of safety risk management system in construction, *CIB World Congress, May 2010*, (pp. 199–214). The Lowry-Salford Quays, UK.