OVERVIEW OF SAFETY & HEALTH COST FRAMEWORK FOR THE CONSTRUCTION OF RAIL INFRASTRUCTURE PROJECTS

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ABSTRACT

The construction of rail infrastructure project is expanding in Malaysia to enhance and integrate the urban public transportation services. This transportation service is one of the National Key Result Areas (NKRA) which is a priority under the Government Transformation Program (ETP). Fatalities, serious injuries and damage to properties occur every year due to rapid construction of this project. Numerous studies have attempted to explain the various losses that could be incurred by companies after the occurrence of an accident. These losses are difficult to isolate, identify and evaluate. Models to analyze and calculate the costs of prevention in the construction industry are limited to apply in this area because they are based on studies carried out in the manufacturing sector. Furthermore, the traditional models for analysing these costs are limited to identifying and classifying them. Therefore, the objectives of this paper are to investigate the overall view of safety and health cost model approaches globally (i.e. UK, Australia, Singapore and Malaysia) and to identify the direction of safety and health cost framework to be practiced in Malaysia.

Keywords: *Safety and health cost, rail infrastructure, construction project*

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INTRODUCTION

Investment in infrastructure requires a significant amount of public funds. In intercity transport, most of the corridors are already in operation and investments in large projects such as, high-speed rail (HSR). It can be viewed as a purpose to reduce the cost of traveling (time and cost savings, reliability, comfort and externalities) with respect to the situation prevailing without project (De Rus, 2011).

In Malaysia, the construction of high-speed rail or also known as rail infrastructure project was started operational since 2002 for Light Rapid Transport (LRT) and Kuala Lumpur (KL) Monorail services. This construction has been managed by Syarikat Prasarana Negara Berhad, who focuses on major public transport infrastructure projects in Malaysia. This project is expanding rapidly to enhance and integrate the urban public transportation service which is one of the National Key Result Areas. This rail infrastructure project is a priority under the Government Transformation Program. However, the rapid construction of this project causes serious injuries, fatalities and damage to properties at the recent project sites.

This safety issue had also been concerned by the Institution of Engineers Malaysia (IEM) through it press statement on 1st July 2014. In view of these incidents, IEM considered the importance of highlighting the need to observe strict safety procedures in construction work especially in on-going construction sites located adjacent to public access areas.

Numerous studies have attempted to explain the various losses that could be incurred by companies after the occurrence of an accident. Many researchers found that these losses may affect the costs, such as delay in project implementation, impaired company image or market loss. Feng et al. (2015) in his discussion indicated that other cost losses to victims and their families, employers and society might be involved. At the same time, accidents and the corresponding damage to productivity, property, equipment and morale can give detrimental effects on a construction company's profit and loss statement. All of these losses should be borne by the contractor during the construction.

Moreover, based on the preliminary study conducted with the contractor companies who involve in rail infrastructure project, one of the interviewees explained that the contractor had to bear the cost of worker injury. For example, if a foreign worker died at a worksite, the cost to send his body should be incurred by the contractor itself. Another interviewee noted that during the construction, several houses suffered damages due to flooding. The contractor had to bear the costs claimed by the villagers.

However, according to Feng et al. (2014)safety culture and project hazard on construction safety performance. Data were collected using multiple techniques from 47 completed building projects in Singapore. Data were analysed using correlation analysis, regression analysis, moderation analysis and mediation analysis. The results show that: (1, the quantification, evaluation and identification of many of the losses incurred in an accident were difficult as they were "hidden". These "hidden" costs may be significant, and some may be particularly prominent in the construction industry. Jallon et al. (2011) supported the same view about the "hidden" costs as being difficult to isolate, identify, evaluate and therefore quantify. These hidden costs are often difficult to calculate due to the difficulty in applying the existing models.

It is not easy to apply the models to analyse and calculate the costs of prevention in the construction industry. This is because, firstly, they are based on studies carried out in the manufacturing sector, and secondly, the use of the traditional models which are applied for analysing these costs is limited to identifying and classifying them. López-Alonso et al. (2013) were of the opinion that these models should be tailored to each company according to its circumstances.

There are several economic safety cost models from different countries such as Singapore, United Kingdom, Australia and Malaysia. However, the limitation of those economic models does not include the costs incurred by employers for compliance with work health and safety regulations and safety cost prevention activities. This is a significant gap that should be highlighted in improving these existing safety cost models.

SAFETY AND HEALTH DEVELOPMENT

Overview of Safety and Health in Construction Industry

According to Mahmoudi et al. (2014), a comprehensive and simple-to-administer tool was needed to continuously assess and promote health and safety performance in construction industry as it was regarded as one of the most hazardous industries. Construction is a highly hazardous industry that covers work on new or existing commercial, industrial or domestic buildings or structures. The argument that the construction industry is high risk is further developed by Misnan and Mohammed (2007) who emphasised the uniqueness of the construction industry as its activities are frequently outdoors where safety and health conditions are inadequate. Workers at the construction sites have to face constant change of work locations as well as the mix of workers involved. Most people tend to relate the construction industry with dangerous working environment including its high risk when they compare it to other industries.

The safety at a construction site is one of the essential issues that cannot be taken lightly. The reason for this is, even a minor accident may cause serious and enormous effects to the organisation, especially the industry that involves the use of machinery that is very much related to the issues of safety awareness. To improve it, some countries such as Australia, Singapore, and the United Kingdom have enacted legislations regulating safety work practices on site. Zeng et al. (2008) in his research found that some construction firms had initiated the use of effective safety management systems when they were introduced to the safety management approach.

Some studies have been carried out on safety performance, safety culture, safety leadership and safety compliance in the construction industry. Other researches have been conducted to study the safety cost model in the manufacturing sector while some researchers have carried out studies related to accident costs (direct and indirect costs) which focused more on the construction stage of a project. It appears that there are limited studies investigating on the safety costs involved from the pre-construction to the construction stage. Table 1 shows a summary of the studies related to safety and health management from previous researches.

Table 1: Previous Researches Related to Safety Management

	Safety Performance	Safety Culture	Safety Leadership	Safety Compliance	Safety Element	Safety Cost/Safety Investment/Cost Benefit (Construction stage)	Safety Cost/Safety Investment/Cost Benefit (Pre-Construction Stage)	Safety Cost/Safety Investment/Cost Benefit (Manufacturing Sector)	Safety Assessment
Amador-Rodezno (2005)								x	x
Oxenburgh & Marlow (2005)								x	x
Sun et al. (2006)						x			
SHASSIC (CIDB, 2008)									x
Rajendran et al. (2009)					x				
Jallon et al. a						x			
Zin & Ismail (2012)				x					
Hare & Cameron (2012)					x				
N.M., Saifullah & F., Ismail (2012)					x				
Griffin & Hu (2013)			x	x					
Feng (2013)	x	x				x			
López-Alonso et al. (2013)						x			
Feng et al. (2014)	x					x			
Gurcanli et al. (2015)							x		
Feng et al. (2015)			x			x			
OSH Calculator (DOSH, 2015)						x			

Safety and Health Management for Infrastructure Construction Projects in Malaysia

The construction industry makes up an important part of the Malaysian economy. Although this industry is relatively small, it has been extensively interrelated with many other parts of the economy, particularly for basic metal products and electrical machinery. The large infrastructure project is one of the significant categories in the development of Malaysian construction industry. This type of project has been recognised as a high complexity project with numerous construction risks, large cost involvement, highly technical requirements and divers of resources. Besides, the development of large infrastructures such as highway, railway, Mass Rapid Transit (MRT) and airport are also needed a large investment of public and private sector.

The infrastructure sector received the largest share of public sector development expenditure in every one of the Malaysian Plans (Naidu, 2008). New development of the oil and gas industry, residential in Iskandar Malaysia, and the mass-rapid transit (MRT) system in Kuala Lumpur (KL), are expected to have both immediate and indirect impact on demand for industrial, commercial and residential buildings. Construction firms are also compensating for the limited size of the domestic market by increasingly seeking overseas contracts in the Middle East, Russia and the growing ASEAN region. While in the year of 2012 and 2013, expectations were broadly positive but it was unclear whether there was the domestic demand or the labour supply to maintain strong growth in the sector over the medium to long term. Moreover, the state-directed, privately operated approach that Malaysia adopted to spur economic growth has raised questions about the connection between government and business, and concerns about ethics and efficacy. The ETP, launched in 2010, attempted to break Malaysia out of the middle-income trap and into the sphere of high-income countries by 2020 (Masrom et al., 2015)large cost involvement, highly technical requirements and divers of resources. Besides, the development of large infrastructure such as highway, railway, Mass Rapid Transit (MRT.

Differing from small and medium-sized construction projects in which routine practice could be applied; major infrastructure construction projects often involved a multitude of different tasks with a range of features (Shiferaw et al., 2012). They require more complicated organisational structures to deal with a number of elements in risk management. Safety is one of the risk management elements that are common in large infrastructure projects. There were numerous cases where large infrastructure projects provided familiar examples of delay and budget overruns due to unique site conditions (Kean, 2011) and hidden transaction costs (Sha, 2011). Additionally, in large construction projects, due to the involvement of many workers, many large and heavy plants, a lot of materials, complex construction operation, multi-interface and complex management activities, the accident rate was higher than that common construction projects (Guo, Li, & Li, 2013).

In additional, Chan (2002) argued that implementing an effective safety program was one of the several success factors for large infrastructure projects. This view was also supported by (Masrom et al., 2015)large

cost involvement, highly technical requirements and divers of resources. Besides, the development of large infrastructure such as highway, railway, Mass Rapid Transit (MRT, where there were several key elements of successful criteria for infrastructure projects implementation in Malaysia that significant to the participants in prioritising project challenges more systemically. Implementing effective safety program is one of the project management actions that can contribute to the success factor of large infrastructure projects in Malaysia.

The literature review shows the findings in past research that highlighted the significance of safety and health management to infrastructure projects to prevent accident at construction site. It is very important to achieve project objectives in terms of time, cost and quality. The construction contractors should increase their safety investment for their projects. The higher the safety investment is, the better the safety performance will be. Other than that, through the allocation of safety cost, it will help clients to follow the compliance of safety and health elements in a tender document to reduce the cost losses incurred by contractors during construction.

METHODOLOGY

An in-depth and critical literature review is conducted in this study. It reviews theoretically on the safety and health cost models developed globally in the UK, Australia, Singapore and Malaysia. Based on the various developed model of safety cost calculator from different countries, the proposed initial framework for Malaysian approach is established. Further study is planned to be conducted by comprehensive empirical research in the form of questionnaires and semi-structured interview followed by the development and validation of performance assessment framework.

SYNTHESIS OF SAFETY AND HEALTH COST MODELS

Several countries have developed individual cost models to estimate the cost impact of accidents. Table 2 shows the economic cost models from different countries, which are Singapore, United Kingdom, Australia and Malaysia. All of these economic models are related to injuries and ill-health in all the

sectors, except for Malaysia where the OSH Calculator is developed for the construction sector. The costs for these models are borne by employers, workers and the community/government/societies.

The cost incurred by the contractors is divided into two; financial cost and safety investment. Financial costs are the cost that contractors have to bear due to the occurrence of construction site accidents for examples, the loss due to injured person or inefficiency of the worker who just recovered from injury upon resuming work, loss due to medical expenses, fines and legal expenses, loss of productivity of other employees, loss due to the damaged equipment and plant, damaged material or finished work, idle machinery or equipment and etc. Safety investment aims to protect the health and physical integrity of workers and the material assets of the contractor. The components of safety investment are safety administration personnel, safety equipment, safety training and promotion.

Social costs represent losses incurred by society due to the occurrence of construction site accidents. Socials cost is defined as any items that will result in the utilisation of national resources. Social costs are not based on the contractor's point of view, but are based on the society's point of view such as medical reimbursements, income tax and national insurance reduction, loss of profit on economic output individual absent from workforce, treatment and rehabilitation costs, administration of claims, investigation/ prosecution costs and etc. All of the types of cost items for these models are similar respectively.

Singapore Accident Cost Model

This model was developed by Workplace Safety and Health Institute (WSH), where it reviewed the methodologies and cost models from different countries when developing this preliminary economic cost model for Singapore. In this model, the WSH Institute determined the cost of work-related injuries and ill health that would be borne by employers, workers and the community. Cost items linked to staff turnover, training of replacement workers, loss of worker output, insurance premium and legal costs incurred were computed as cost borne by employers. The cost borne by workers included expenses beyond that covered by compensation for medical treatment and rehabilitation as well as net loss of future earnings.

Cost items like social payouts, the cost of investigation, inspection and WSH promotion activities, loss of human capital for fatal cases and medical subsidies were considered as the cost borne by the community.

This model used two (2) key approaches for measuring annual work injuries and ill health, which are the incidence approach and the prevalence approach. The incidence approach measures only new cases occurring during the reference year, whereas the prevalence approach measures all new and existing cases at a given point of time in the reference year. The incidence approach measures the costs associated with injured workers or workers who had suffered ill health as a proxy for on-going cost of cases from previous reference years.

The limitation of this model is, it only measures human cost and does not take into account the cost of property damage, human pain and suffering. The analysis is based on the cost incurred after an incident had occurred. The expected future cost of new cases in the reference year is used as a proxy for the on-going cost of cases from previous years.

British Accident Cost Model

The British Accident Cost Model is estimated separately for different cost components and different cost bearers. The 'Costs to Britain' include estimates of financial (or direct) costs incurred and monetary value of the impact on quality and loss of life of affected workers (referred to as the non-financial costs), which is often the greatest impact of illness and injury. It is standard practice in the economics of public policy to place value on non-financial costs in monetary terms where possible to represent them alongside other costs.

The costs are structured into five broad categories, which are productivity costs, health and rehabilitation cost, admin and legal costs, compensation and non-financial human costs. Non-financial costs are based on the value that individuals would be willing to pay for the reduced risk of death or to avoid reductions in quality of life resulted from injury. It is, therefore, a measure of the economic value that people place on risk reduction is over and above any direct financial costs that they incur.

Since 'Costs to Britain' aim to reflect the costs of workplace illness and injury occurring today arising from current working conditions, they do not include costs of ill health cases occurring in the current year caused by historic working conditions. In particular, this excludes fatal occupational illness cases (such as cancer) since, by and large; these cases will result from past working conditions.

Australian Accident Cost Model

Similar to Singapore, Australian accident cost model only measures human cost and does not take into account the cost of property damage or human pain and suffering. Work-related injuries, illnesses and deaths impose costs on employers, workers and the community. These include both direct costs and indirect costs. Direct costs include items such as workers' compensation premiums paid by employers or payments to injured or incapacitated workers from workers' compensation jurisdictions. Indirect costs include items such as lost productivity, loss of current and future earnings, lost potential output and the cost of providing social welfare programs for injured or incapacitated workers. The level of costs borne by each economic agent varies with the severity of the injury or disease. While measures of direct costs are understandable and reasonably simple to measure, these costs cover only a fraction of the total cost of work-related injury and disease.

The methodology used was similar to Singapore model. It adopted an "ex-post" approach, measuring costs for a case after it had occurred. Under this methodology, workers' compensation premiums paid by employers are not considered as a cost to employers, rather the distribution of payments to injured workers from money received from workers' compensation premiums are considered as a transfer cost to society.

An incidence approach also provides a proxy for the on-going cost of cases from previous reference years. The incidence approach assesses the number of people entering the compensation (or medical) systems during a particular year as a result of work-related incident or illness and the costs (both current and expected future costs) associated with those cases. Since only new cases are measured under the incidence approach, the estimation of the total costs and the expected future cost of new cases over the lifetime

of a case is used to proxy the cost in the reference year of cases that were already in the system at the start of the current reference year.

Malaysian Accident Cost Model

In Malaysia, the Department of Occupational Safety and Health (DOSH) developed the OSH Calculator to assist employer estimate accident costs and also to increase employer's awareness of the costs of the workplace. In this model, the DOSH determines the cost of work-related injuries and ill health that will be borne by employer, employee and the stakeholder. In constructing the model for estimating the total cost of an industrial accident, DOSH takes into account all parameters that reflect the possible costs imposed by accident. They start by presenting the general structure of the model in which the total cost of an industrial accident is the sum of its direct costs, indirect costs, payment and immeasurable costs. The parameters that reflect the direct costs are the damage cost, medical cost, fine and insurance. The indirect costs are capacity lost, schedule cost, recruit cost and work time losses.

Immeasurable costs are the damage done to the company's reputation that may result in customers turn to competitive suppliers, and morale cost is defined as the impact on the morale of the workers. An accident may hurt the workers' morale and motivation, causing absence from work, tardiness and a higher rate of worker substitution. Moreover, workers may demand salary increases for endangerment in the work place. Since this is a psychological and an emotional cost, the numerical estimation of this damage is currently not measurable.

All of these models are used only to estimate the accident cost. The safety items costs required at the pre-construction stage are not covered in that research. Moreover, the limitation of those economic models does not include the costs incurred by employers for compliance with work health and safety regulations and prevention activities.

This study is an attempt to fill the gap in existing safety cost models. Therefore, based on the input gathered from the existing models, the development of safety and health cost framework for the construction of rail infrastructure projects will be established. It will cover all of the safety

costs involved, from the pre-construction stage to the construction stage. All of the costs incurred will be taken into consideration to enable the relevant stakeholders to identify and prioritize potential levers to reduce the cost of poor health and safety practices by using a more strategic approach.

Table 2: The Safety Cost Models from Different Countries

VARIABLES	SAFETY COST ITEMS			
	Singapore Accident Cost Model (WSHI, 2013)	British Accident Cost Model (HSE, 2013)	Australian Accident Cost Model (Australian Safety and Compensation Council, 2009)	Malaysian Accident Cost Model (OSH Calculator) (DOSH, 2015)
Cost Bearer/ Cost Incurred Employers	Staff Turnover Costs Training costs Loss of Output Insurance Premiums Legal costs	Money outflows Medical cost National insurance Work reorganisation Recruitment and induction costs for replacement staff Insurance premiums Proportion of corporate private health insurance premiums attributable to work related illness/injury Administration of insurance and compensation claims Investigation/prosecution-internal costs + legal costs Fines paid	Overtime payments Employer excess payments Sick leave Staff turnover Medical Legal Fines and penalties Investigation costs	Direct Cost (Damage) Machines damage Material damage Equipment damage Cleaning Recovery Direct Cost (Medical) Evacuation to hospital Treatment at site Hospitalisation Medical equipment bought Direct Cost Fine Insurance Search and rescue Indirect Cost Capacity lost because of accident Schedule Recruiting Work time to investigate Effect on work progress Management External investigation Accident report submitted Payment Immeasurable cost Company's reputation Workers' morale

Cost Bearer/ Cost Incurred Workers	Net loss of future earnings (future earnings less compensations) Additional costs of medical Treatments Rehabilitation costs	<u>Money outflows</u> Loss of gross family earnings (-) Out of pocket funeral, travel, prescription, home expenses (-) Proportion of individual private health insurance premiums attributable to work-related illness/injury (-) Administration of insurance, compensation and benefit claims (-) Insurance company profit margin costs on other insurance products (-) <u>Money inflows</u> Medical cost (+) State benefit receipts (+) Income tax and National Insurance saving reduction (+)	Loss of income Private insurance Legal cost Travelling Medical Career costs	Administrative costs Hospital admission costs Health CARE costs Costs of spouses work to take care Rehabilitation costs Reduce in income costs Temporary stop working/ no pay Immediate loss of earnings Finding a new occupation costs Loss of future earnings Permanent afflictions Early retirement cost
Cost Bearer/ Cost Incurred Community/ Government/ Society	Social payouts Investigation/ inspection costs Fatal loss of human capital Medical subsidy	<u>Money outflows</u> Medical reimbursements (-) State benefit payments (-) Income tax and National Insurance reduction (-) Loss of profit on economic output individual absent from workforce (-) Treatment and rehabilitation costs (-) Administration of claims (-) Investigation/Prosecution costs (-) <u>Money inflows</u> Treatment and rehabilitation of private insurance claims (+) Fines received (+)	Compensation or welfare (due to no job) Tax losses Medical Compensations Legal cost Claim investigation cost Travel compensation Career payments	NA
Methodology	Cost-of-illness estimates Incidence method Prevalence method	Costs to Britain Model ('the cost model')	Incidence method Lifetime cost approach 'Ex-post approach'	NA
Types of Sector	All types of work that are related to injuries	All types of work that are related to injuries	All types of work that are related to injuries	Construction industry

Implementation (Project Phase)	All phases	All phases	All phases	Construction phase
Limitation	Not included the cost of property damage and human pain and suffering	Not included the costs of ill health cases occurring in the current year caused by historic working conditions Excludes fatal occupational illness cases (such as cancer), which these cases will result from past working conditions	Not included the cost of employees injury (such as damage to property and loss of company image) Not included the costs incurred by employers for compliance with work h&s regulations and prevention activities	Not specific

A Proposed Initial Framework of Safety and Health Cost for Rail Infrastructure Projects in Malaysia

Figure 1 represents the proposed conceptual framework of safety and health cost for the construction of rail infrastructure projects. This proposed conceptual framework is developed based on the models adopted from various countries (the United Kingdom, Australia, Singapore and Malaysia). Three main approaches that have emerged for dealing with safety cost components are referred as the direct cost, indirect cost and extraordinary cost. The direct accident costs are typically the costs covered by SOCSO and insurance company. These costs are usually insurable, and they are quite easy to calculate. Indirect costs are the consequences of an accident that can be costly. They are more difficult to calculate and tend not to be insured. The extraordinary cost includes all losses caused by events that cannot be prevented by the technical or human resources available in construction works, or totally unavoidable, such as natural disasters. However, there are limited studies on extraordinary cost addressed for the construction industry. Although this cost rarely happens, the allocation for this item is significant as it may contribute to vast financial losses to contractors.

The costs for this framework were borne by the employer, employee and government/society. All of these costs have different types of safety components involved in different phases of construction. These cost components will be specified according to the safety requirements for the construction of rail infrastructure projects, which differs from building

construction, where they specify the safety requirements for workers, public and requirements from authorities. From that, the safety and health cost framework will be developed for the purpose of assisting clients to abide by the full compliance of safety and health cost elements in a tender document.

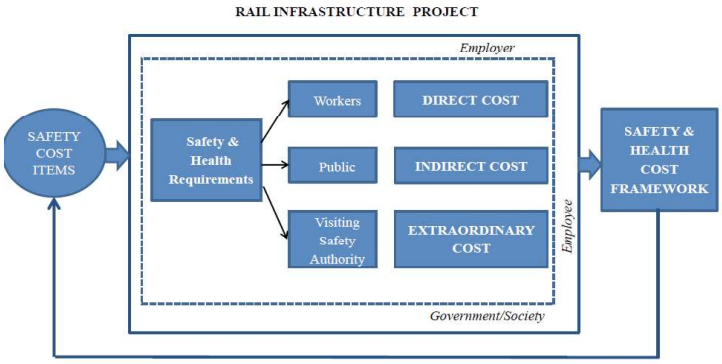

Figure 1: Safety & Health Cost Conceptual Framework

CONCLUSION

The research presented in this paper is initially and part of an ongoing PhD research at the Faculty of Architecture, Planning and Surveying, UiTM. This paper anticipates reviewing, synthesizing and developing a framework of safety and health cost for rail infrastructure projects in Malaysia based on the various models of safety cost from the UK, Australia, Singapore and Malaysia. It also intends to identify the direction and the usefulness of safety and health cost framework to be practiced for rail infrastructure projects in Malaysia. Most of the models are applied for general types of the sector related to injuries. In Malaysia, the existing model only covers the estimated accident cost during construction. The safety items costs required at the pre-construction stage are not covered by those models. Moreover, the limitation of those safety cost models does not include the costs incurred by employers for compliance with work health and safety regulations and prevention activities. As a result, the study found gaps through the listed weakness; therefore, it is vital to develop a framework that will cover all of the safety costs involved, from the pre-construction

stage to the construction stage. All of the costs incurred will be taken into consideration to enable the relevant stakeholders to identify and prioritize potential levers to reduce the cost of poor health and safety practices by using a more strategic approach.

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