ASSESSMENT OF RAILWAY SAFETY IN SOUTHEAST ASIA REGION

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ABSTRACT

This paper reports on the railway safety in Southeast Asia based on rail accidents and incidents trends. Rail transportation has many benefits, it includes fixed routes, cost-effective, safe and large capacity. It is also every country's major means of transportation. However, there are less research on causes of rail accidents and incidents, despite rail risk assessments being conducted in Great Britain, Finland and Japan. In Southeast Asia, there is no investigation for predicting rail accidents and incidents. Hence, it is vital to study the railway safety risks in this region. Data reporting is based on news or reports published for public reviews. After performing Trend Analysis, robustness is evaluated in prior to perform risk analysis using Delphi technique. Following risk analysis, the Analytic Hierarchy Process (AHP) technique-based railway safety rank is carried out which is designed by the Authors of this study. The variables are based on total number of cases and fatalities, level of robustness and risk. Ranking countries from high-risk to low-risk, the rank are as follows; Thailand, Indonesia, Vietnam, Myanmar, Philippines, Malaysia, Cambodia and Singapore.

Keywords: Southeast Asia; Railway Safety; Railway Accidents; Railway Incidents; Railway Engineering

1.0 INTRODUCTION

Rail transportation has been one of the oldest land transportations in the world. The earliest form of rail transport began in the sixth century BC near Corinth in ancient Greece. It was a system called 'Diolkos' with a 7 km-long stone-paved portage trackway that enabled boats to be moved overland across the Isthmus of Corinth on a trolley hauled by manpower along a curved route that avoids steeper gradients. The main purpose for rail transportation back then was solely focused on transferring industrial goods such as coal and ore to the warehouse and port (Lewis, 2001). As time advanced, rail technologies have evolved themselves; for instance, from hand power to horse power, wooden rails to metal rails and steam engine to electric-powered engine. As railway became the key component to swift movement of products and labor required by the industrialization that time, the transportation then expanded to the purpose of moving people to their desired destination (Spiryagin *et. al.*, 2016). As for now, rail transportation can be represented as a mode of land transportation that transfers people and goods on wheeled vehicles running on rails. Hence, it has become the most effective public transport system and each country's most significant transportation mode. This is due to the fact that rail transportation comes with a lot of advantages. Not only rail transportation is the most dependable mode of transportation as it is least effected by weather conditions unlike other modes of transportation, it is also better organized due to its fixed routes, more economical, safe and has large carrying capacity.

Since 1941, the risk assessment related to the rail industry had been carried out. Until now, the assessment focused only on collision with warning devices and track features as a factor or criterion at the railroad crossing (Ismail, 2016). It is, however, less researched in terms of factors leading to rail accidents and incidents, especially in Southeast Asian countries . Given that each nation in Southeast Asia has a different geographic and running rail system in its networks, it is difficult to develop a prediction model to investigate their independent variable or factor effect. Therefore, in Southeast Asia countries, there is no clear investigation method for forecasting rail accident and incidents. In vieabove-mentioned facts, the aim of the present study is to review the safety risin the railway system among the Southeast Asian countries. Eight countries are included in this study: Myanmar, Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam.

2.0 LITERATURE REVIEW

Rail accidents and incidents are major contributing factors to the interruption of train services and operations. The Federal Railways Administration (FRA) reports more than 300 causes of accidents, including infrastructure defects, rolling stock failures,

human factors, and other causes (Liu *et. al.,* 2018). Railways are subject to many different types of hazards, and a wide range of safety measures mitigate the risks. Railway operators and regulators have long acknowledged that some safety measures provide better value for money than others, but the railways have not implemented traditional cost-benefit analysis (CBA) as widely as highways for evaluating safety measures. The common image of a rail accident is a multi-fatal train crash or derailment, but the majority of road accidents are more prevalent (Evans, 2013). There are four major groups of accidents which are train accidents per train-kilometer, personal accidents per train kilometer, level crossing (LC) accidents per year and trespasser fatalities per year which represents the medium-term trends in accident or fatality rates.

The words "Accident / Incident" are used to describe the entire list of reportable events, referring to the "Federal Railroad Administrative Office for Safety Analysis (FRA)." These include crashes, derailments and other events involving the operation of track equipment and causing reportable harm above an established threshold, impacts at crossings between railway on-track equipment and highway users, and any other incidents or exposures that cause any person to be killed or injured, or an occupational illness to a railway employee. Such terminologies are divided into three major reportable categories (FRA, 2015):

1) Train Accidents: A safety-related event involving on-track rail equipment (both standing and moving).
2) Highway-rail grade crossing incidents: Any impact between a rail and highway user (both motor vehicles and other users of the crossing as a designated crossing site, including walkways, sidewalks, etc., associated with the crossing).
3) Other incidents: Any death, injury or occupational illness of a railroad employee that is not the result of a "train accident' or "highway-rail incident".

2.1 Southeast Asian Railway Issues

In Southeast Asian region, each country faces their own challenges and issues as each of them have different trains and operators. Table 1 presents all the issues faced by every countries' railway system in Southeast Asia region.

2.2 Robustness of Railway System

Robustness is a term where it refers to a railway system with good train and track quality which do not break down easily. This can apply to a system with a high degree of safety where incidents rarely occur and where few people are injured. It can also mean a system with an extensive network and several lines where, if there is a disruption, passengers can easily be diverted. (Andersson, 2014).

In different ways, this type of robustness can be formally described: As defined by Salido *et al*. (2008), it is "the ability to resist to 'imprecision'", by Policella (2005), it is the tolerance for "a certain degree of uncertainty" and the capability to "cope with unexpected troubles without significant modifications" by Takeuchi and Tomii (2005). Although a delay analysis generally explains and analyses the causes and locations for delays, a rigorous analysis focuses on the recovery capabilities and how the inserted margin time can be used operationally. (Andersson 2014).

According to Dewilde *et al*. (2011), in the event of minor delays, a robust schedule minimizes the actual travel time of passengers. The ability to limit secondary delays and ensure fast recovery times are necessary, but not sufficient, according to the authors, to establish a robust timetable. With respect to passengers, Schöbel and Kratz (2009) defined robustness and used the maximum initial delay possible without violating any transfers for the passengers as a robustness indicator.

Hence, from the definition above, it can be concluded that the higher the robustness of a railway network, the higher the safety level of the railway system. To further understand what is meant by robustness in railway engineering, it is depicted by Figure 1 where high robustness can be seen in Greater Kuala Lumpur. The red nodes are rail stations and red lines are the railway lines.

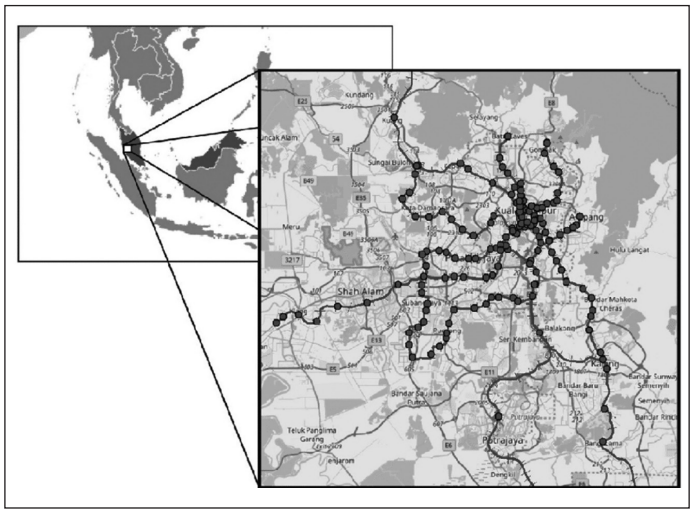

Figure 1: Robustness of railway network in Greater Kuala Lumpur (Ding. R et. al., 2018)

4.0 METHODOLOGY

The scope of this study mainly focuses on the case study of railway accident and incidents based on news or reports that had been publicly announced and published for public reviews such as The Bangkok Post (Thailand), The New Strait Times (Malaysia) and The Jakarta Post (Indonesia) in Southeast Asia. The countries include are Myanmar, Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam.

Therefore, the method will be used in collecting data is called "data reporting". Data reporting is the process of collecting and submitting data which gives rise to accurate analyses of the facts on the ground. The case study reports will be covering from the year 2000 until 2020. However, the data for 2020 is only until the first quarter of the year. This selection was made due to the fact that no railway risk profile is made based on Southeast Asian countries' rail accidents and incidents.

Through the process of performing analysis, robustness assessment of each country's railway system is being done to further determine the risk of the railway system which is referred as Delphi technique risk analysis. In this study, a three-point scale risk scale to simplify the risk analysis. The three-point scale risk is shown in Table 2 with its probability and impact.

Breaking down the data into deeper level, it is expected to find the contributing factor to railway accidents and incidents. Then lastly, the country's railway safety is ranked based on a technique called Analytic Hierarchy Process (AHP). AHP is a multiple-criteria decision-making tool. This is an Eigen value approach to the pair-wise comparisons. It also provides a methodology to calibrate the numeric scale for the measurement

of quantitative as well as qualitative performances. Hence, the total number of cases, fatality number, level of robustness and level of risk will be the criteria in the AHP designed by the researchers themselves as shown in Figure 2.

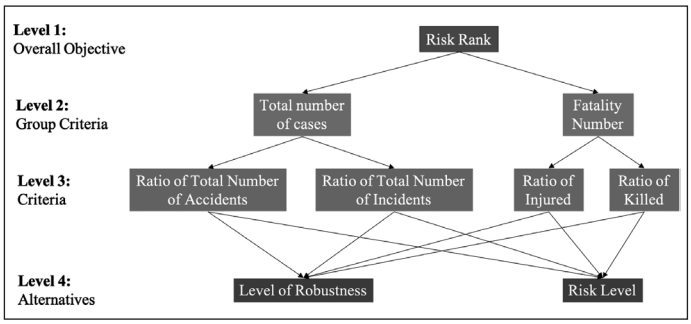

Figure 2: Analytical Hierarchy Process in determining the railway risk rank of a country

To demonstrate how the AHP for this study is being used, the country Thailand will be used as an example.

For Thailand, the total number of cases is 76 with a fatality number of 571 where 87 passengers were killed and 484 passengers were injured in the past 20 years. Focusing on the number of cases first, the ratio of a total number of accidents and the ratio of the total number of incidents is 84.44% and 15.56% respectively. It can be seen the ratio of total number of accidents is higher for Thailand which is a risk. For the ratio of casualty and ratio of injured, they are 15.24% and 84.76% respectively. Even though the ratio of casualty is lower, we are focusing on the number of accidents. Despite the ratio of casualty and ratio of injured are contrary to each other, people still were affected by the rail accidents in Thailand, and hence, adds another risk.

When it comes to the level of robustness in Thailand, it is without a doubt the robustness is high as the coverage of railway network is wide. However, the higher the level of robustness, the higher the safety system of railway system which is happened otherwise in Thailand. This is also adds another risk. Hence, that is why Thailand is ranked first in the risk rank of railway safety in Southeast Asian region.

Table 1: Railway system's issues of every country in Southeast Asia region

Country	Reference(s)	Issues	Cause of Issue
Cambodia	Irigoyen (2017)	• The Cambodian railways were in a poor physical condition because of war damage and decades of neglect. The last 48km of track towards the border with Thailand had been destroyed during the civil war.	War damages and neglection.
	Transport & Logistics News (2010)	• Railway traffic was declining because of the poor condition of tracks and equipment, which rendered the railways increasingly unreliable and slow. • The staff of the Royal Railways of Cambodia (RRC) were underpaid, and professional skills and staffing levels were deteriorating. • As a result, the railway was operating at a loss. • Neither the RRC nor the Government of Cambodia had the resources required to turn the railway around. • The Cambodian government initiated the Rehabilitation of the Railway project in 2007 in collaboration with the ADB. Its objective was to restore railway infrastructure by rehabilitating the existing track and re-establishing Cambodia's rail connection with Thailand. However, both the MPWT and ADB were ineffective in their management of essential aspects of the project's planning and implementation. • As a result, the entire Southern Line to Sihanoukville Port opened in January 2013, which was about 18 months behind schedule.	Poor condition of equipment and facility and poor management by operator and government.
Indonesia	Saragih (2015)	• PT Kereta Api Indonesia (KAI), which was regarded as a very low-performance state-owned railway company in Indonesia until 2009, under Ignatius Jonan's leadership experienced a very significant improvement in performance. • Quality of the infrastructure continued to decline; the facilities had passed the limit age of service; number of locomotives, freight cars and trains circuits decreased; quality of service was low; there were back-logs, security and passenger safety was not guaranteed. • Company was in the category of BBB (less healthy condition)	Poor condition of equipment and facility.
	Djuraid (2013)	• Before Jonan led in 2009, KAI suffered a loss of IDR 38.6 billion in 2007, and increased further to hit IDR 82.6 billion in 2008. • The challenges arising when Jonan appointed KAI to revitalize were not only from these hard aspects, but also from the soft aspects that were low discipline and self - oriented workers rather than customer - oriented, weak implementation of good corporate governance, and lack of visionary leadership	Poor management and weak implementation.

Malaysia	N. Hafiza *et. al* (2013)	• Although Malaysia already has its own rail transportation system, most of the systems are limited only around the Selangor and Kuala Lumpur area	Poor robustness and interconnectivity.
	S. Starcey (2003)	• Ridership was low representing only about 20% of total passenger travel in Kuala Lumpur compared to cities in neighbouring countries, ranging from at least 40% to over 70%. • The lack of integration and thus poor accessibility and service reliability is one possible cause of the low ridership. • Many people would prefer to drive, rather than take public transport. • Due to a combination of low ridership and competition between suppliers, many of the transport companies faced serious financial difficulties for several years	Lack of integration and poor accessibility.
Myanmar	The Republic of the Union of Myanmar (2017)	• The Republic of the Union of Myanmar Railways reported that with regard to their railway infrastructure, existing railway lines are deteriorating as a result of aging, causing frequent problems such as train delays and accidents, including derailment and train separation.	Poor condition of equipment and facility.
Philippines	C. Elemia (2019)	• Philippine National Railways (PNR) is the main issue with Philippine's Railway System. • Many passengers have to bear long lines, dilapidated stations, grumpy train staff and the stress caused by unreliable trains and timetables. • The railway schedules are seldom observed, the journeys are delayed and the trains often break down. • Even if the situation is really bad, passengers still have no choice but to use the PNR because it is the fastest way to avoid traffic. • Data showed that only 15 train sets were available in January and 13 train sets were available in February to serve tens of thousands of passengers daily. The number of passengers per train is not limited, with Garduque, Garcia and Villa claiming trains are always crowded.	Poor management.
Singapore	Asean Today (2017)	• Trains reached a delay of more than five minutes, still lag behind other top-notch modern cities but not inherently a failure. • A decrease from 0.33 delays per 100,000 car-km in 2013 to 0.12 in 2016. Despite those promising figures, the overall transport performance in Singapore is still lagging behind due to the number of significant delays. • Five major disturbances surpassed or equalled 30 minutes in 2014, and nine in 2016.	Poor management.
Thailand	Bangkok Post (2012)	• The SRT has long been perceived by the public as inefficient and resistant to change. • Trains are usually late, and the majority of their machinery is old and poorly maintained. • The SRT, the worst financially performing state enterprise, operates consistently at a loss despite being invested with large amounts of property and obtaining large government budgets; in 2010, it posted a preliminary loss of 7.58 billion bah	Poor management, poor condition of equipment and facility.
	Bangkok Post (2010), Asia Sentinel (2012)	• Recurring efforts by the government to restructure and/or privatize the Union throughout the 2000s have always been strongly opposed and have made no progress.	Political issue.
	Bangkok Post (2018)	• The poor financial performance and opposition to reform of the SRT, combined with the 1997 Asian financial crisis, culminating in the imposing of strict restrictions on SRT staff. • The SRT employs about 4,000 daily workers to make up the shortfall, normally at daily wages of 300 baht. It has also forced the SRT to pay the current employees massive amounts of overtime pay.	Poor financial performance.
	Bangkok Post (2019)	• The SRT Board approved the recruitment of 1,330 new employees to bring the workforce to 15,660, which is still less than required to resolve staff shortages.	Poor management.

	Bangkok Post (2017), Thai PBS (2017)	• SRT also faces management issues. In February 2017, Prime Minister Prayut Chan-o-cha dismissed the governor and board of the State Railway of Thailand using his special powers under Section 44 of the provisional constitution to resolve a long list of complaints accusing SRT of lack of transparency in bids for projects and procurement deals.	Poor management and poor financial performance.
Vietnam	Muabanoto (2011)	• While the condition of the road network in the country is continually improving, train accidents still happen in Vietnam. • In 2010 there were 451 rail accidents reported across the country's railway network, resulting in 211 deaths and 284 injuries.	Poor equipment and facility.
	Japan International Cooperation Agency (2007)	• A joint Japanese-Vietnamese evaluation team reported that the poor state of the railway infrastructure was the main cause of most rail accidents, the most common of which were train crashes against vehicles and passengers, especially at illegal crossings	Poor equipment and facility.
	VietnamNet (2010), Vietnam News Service (2011)	• As of 2010, about 90% of all rail accidents occurred at level crossings without safety fencing and most were apparently caused by motorists who did not comply with traffic safety laws.	Low act in accordance by citizens.

Table 2: Three-point scale risk scale by Delphi Technique (JISC 2014)

Scale	Probability	Impact
Low	May occur occasionally	Minor impact on time, cost and quality
Medium	Is as like as not to occur	Substantial impact on time, cost and quality
High	Is almost certain to occur	Substantial impact on time, cost and quality

5.0 RESULTS

This subtopic presents the trend analysis extracted from the data collected for each country in the Southeast Asian region from the year 2000 until 2020. The trend analysis involves train accidents and incidents over a 20-year time frame.

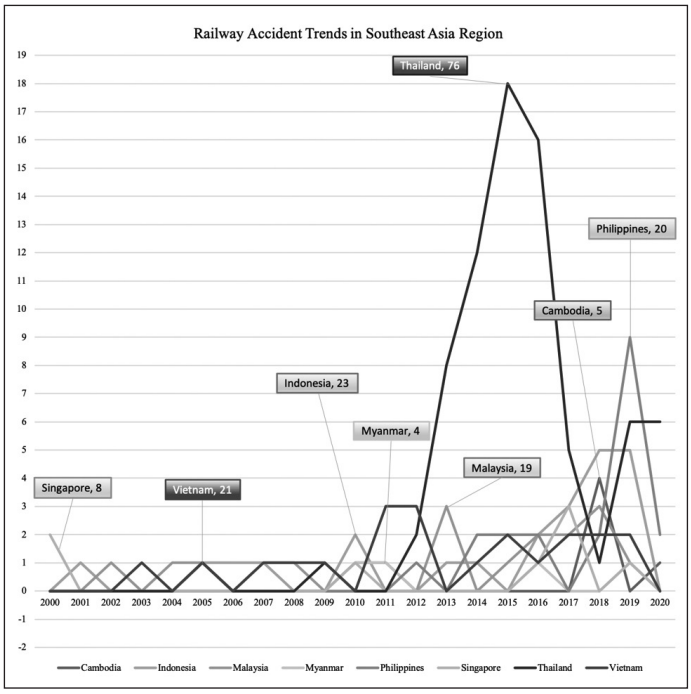

Figure 3a: Rail Accidents Trends of Countries in Southeast Asia Region

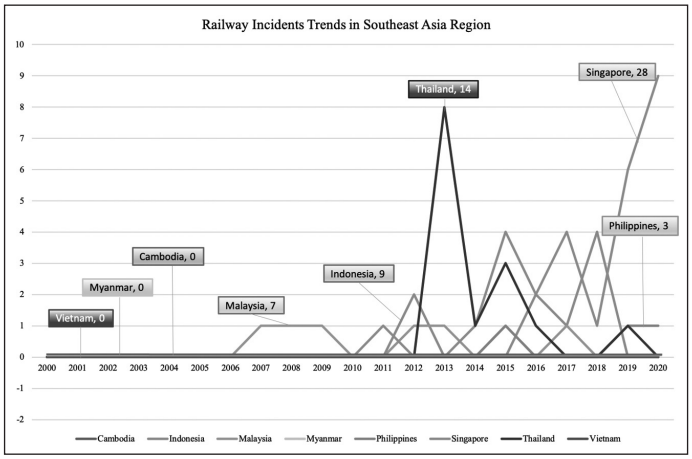

Figure 3b: Rail Incidents Trends of Countries in Southeast Asia Region

5.1.1 Cambodia

The trend analysis for Cambodia's rail accident and incident for the past 20 years is shown in Figures 3a and 3b. From the trend analysis graph, it evidently shows that there are a number or rail accidents reported but no rail incidents. The total reported rail accidents in Cambodia is five (5) cases. The rail accidents started to occur in the year 2018 with four (4) cases in a year and fluctuated drastically in 2019 with no reported cases. However in the first quarter of 2020, one (1) case was reported.

The robustness of Cambodia's railway network is undetected as the only existing railway line is from Sihanoukville to Poipet, so the robustness for Cambodia is considered low. The severity of the rail accidents can be concluded as low but every cases

reported are fatal-prone which shows that every rail accidents happened in Cambodia are low risk.

5.1.2 Indonesia

The trend analysis for Indonesia's rail accident and incident for the past 20 years is shown in Figures 3a and 3b. From the trend analysis graph, it evidently shows that there are a number or rail accidents and incidents reported. The total reported rail incidents in Indonesia is nine (9) cases while for rail accidents is 23 cases.

The total number of reported cases for Indonesia is 32 case which is considered as medium. The fatality number is 137 casualties and 434 injuries from these rail accidents which is terribly high from just 32 cases. The most tragic accident was reported in 2005 where a collision happened at Bandar Lampung and have caused seven (7) deaths and 200 injuries. The severity of the rail accidents shows that every rail accidents happened in Indonesia are high-risk.

The robustness of Indonesia's railway network is high as it covers almost all the parts in Indonesia. However, fatality number shows otherwise. This shows that no matter how high the robustness of Indonesia's railway network, every rail accidents that happened are high-risk to the passengers.

5.1.3 Malaysia

The trend analysis for Malaysia's rail accident and incident for the past 20 years is shown in Figures 3a and 3b. From the trend analysis graph, it evidently shows that there are a number or rail accidents and incidents reported. The total reported rail incidents in Malaysia is seven (7) cases while for rail accidents is 19 cases.

The total number of reported cases for Malaysia is 26 case which is considered as medium. The fatality number is 10 casualties and 78 injuries from these rail incidents and accidents which is medium. The most tragic accident was reported in 2004 where a collision happened at Tiroi-Seremban Station, Negeri Sembilan and have caused 40 injured. The severity of the rail incident accidents can be concluded as low for every rail accidents happened in Malaysia.

The robustness of Malaysia's railway network is high as it covers almost all parts of the country. However, the fatality number also shows that the high robustness of Malaysia's railway network has likely increases the railway safety. However, rail accidents and incidents still happen in Malaysia and therefore their risk is low.

5.1.4 Myanmar

The trend analysis for Myanmar's rail accident and incident for the past 20 years is shown in Figures 3a and 3b. From the trend analysis graph, it evidently shows that there are a number or rail accidents reported but no rail incidents. The total reported rail accidents in Myanmar is four (4) cases.

Even the total number of reported cases for Myanmar is low, but all of the cases are categorized as accidents that have caused passengers killed or injured. The fatality number for Cambodia is 34 being killed and 96 got injured from these rail accidents which is terribly high from just four (4) cases. The most tragic accident was reported in 2012 where a collision happened at Kantbalu, Rangoon and this accident alone caused 27 casualties and 80 injuries. The severity of the rail accidents can be concluded as which shows that every rail accidents happened in Myanmar are high-risk.

The robustness of Myanmar's railway network is high as can be seen in the railway network map. According to Andersson (2014), high robustness can be referred as a railway system with high safety level where accidents seldom occur and few people get injured. Although this can be seen from Myanmar's trend analysis, but the fatality number shows otherwise. This shows that no matter how high the robustness of Myanmar's railway network, every rail accidents that happened are high-risk to the passengers.

5.1.5 Philippines

The trend analysis for Philippines's rail accident and incident for the past 20 years is shown in Figures 3a and 3b. From the trend analysis graph, it evidently shows that there are a number or rail accidents and incidents reported. The total reported rail incidents in Philippines is three (3) cases while for rail accidents is 20 cases.

The total number of reported cases for Philippines is 23 case which is considered as medium. The fatality number is eight (8) being killed and 72 got injured from these rail incidents and accidents which is medium. There are no tragic accidents that involved a lot of lives but the most tragic accident to date until now happened in 2019 where a power trip caused rectifier substations located between Anonas and Katipunan stations and in the Santolan depot to catch fire and cutting the line's power supply in the area (Yahoo Philippines News 2019). Although there were no fatalities from the reported event, it is still considered an accident as it involved the damage of the trains, facility and the system itself. Therefore, the severity of the rail incident accidents can be concluded as low for every rail accidents happened in Philippines.

The robustness of Philippines's railway network is medium as it can only be seen in the Manila area where it is the capital city of Philippines. Railway lines that are likely to cover the whole country are still under construction. However, the fatality number also shows that the high robustness of Philippines's railway network has put a positive effect on the country's railway safety. However, rail accidents and incidents still happen in Philippines and therefore their risk is low.

5.1.6 Singapore

The trend analysis for Singapore's rail accident and incident for the past 20 years is shown in Figures 3a and 3b. From the trend analysis graph, it evidently shows that there are a number or rail accidents and incidents reported. The total reported rail incidents in Singapore is 28 cases while for rail accidents is eight (8) cases. Singapore is the only country in the Southeast region that the total number of rail incidents exceeded the total number of rail accidents.

The total number of reported cases for Singapore is 36 case which is considered as medium. Nevertheless, the fatality number is low with five (5) killed and 43 injured to be compared with the total number of reported cases in Singapore. So far the only tragic accident in Singapore is a collision in 2017 at Joo Koon MRT Station that caused 38 passengers to be injured but no passengers were killed (Strait Times 2017). Therefore, the severity of the rail incident accidents can be concluded as low for every rail accidents happened in Singapore.

The robustness of Singapore's railway network is high as it covers almost all parts of the country. Hence, the theory

developed by Andersson (2014) where high robustness in a railway system equates to high safety level is proven through Singapore's fatality number. Therefore, the risk of railway system in Singapore is low.

5.1.7 Thailand

The trend analysis for Thailand's rail accident and incident for the past 20 years is shown in Figures 3a and 3b. From the trend analysis graph, it evidently shows that there are a number or rail accidents and incidents reported. The total reported rail incidents in Thailand is 14 cases while for rail accidents is 76 cases.

The total number of reported cases for Thailand is 90 case which is the highest among other countries in Southeast Asian region. The fatality numbers are 87 casualties and 484 injuries which is outrageously high too. Almost every week there will be rail accidents or incident reported in Thailand news to the point that the reporters came out with the headline, "*Another day, another train-car collision*" (Bangkok Post 2014). Therefore, the severity of the rail incident accidents in Thailand can be concluded as high.

The robustness of Thailand's railway network is high as all parts of the country are covered with railway lines. However, as seen from Thailand's trend analysis and the fatality number, this proves otherwise. The high robustness of Thailand's railway network does not promise the safety of their railway system, hence, every rail accidents and incidents that happened are high-risk to the passengers.

Figure 10: Ranked railway safety map

5.1.8 Vietnam

The trend analysis for Vietnam's rail accident and incident for the past 20 years is shown in Figures 3a and 3b. From the trend analysis graph, it evidently shows that there are a number or rail accidents reported but no rail incidents. The total reported rail accidents in Myanmar is 21 cases.

The robustness of Vietnam's railway network can only be seen at the Hanoi area which is the uptown area of Vietnam. Even though there are three (3) train services with medium to high fatality number in Vietnam, but every rail accident that happened have caused at least one (1) passenger to be killed. The severity of the rail accidents can be concluded as which shows that every rail accidents happened in Myanmar are medium risky.

5.9 Summary of Results

Table 3 presents the summary of results of trend analysis of countries in Southeast Asian region with computation of ratio of killed, ratio of injured, ratio of total number of accidents and ratio of total number of incidents. Lastly, the railway safety for every country is ranked from the most risky railway system to the least risky railway system.

6.0 DISCUSSION

To get a clearer picture from Table 3, a ranked railway safety map is created solely made to show from the most risky railway system to the least risky railway system.

To justify the railway safety rank in the last column in Table 3, the ranks are based on the AHP designed by the researchers themselves by taking account five criteria which are; number of accident and incident, fatality number, level of robustness, level of risk and ratio of killed and injured.

Taking the most risky country, Thailand is ranked first in the risk rank. Not only the case in Thailand are high, but the fatality number is high too. The percentage of rail accident itself is 84.44, so it can be concluded that every rail trip in the future, it possess high risk to their passengers. Level of robustness can only be determined by looking closely at the railway network. According to Andersson (2014), high robustness equates to high safety in railway system but the cases in Thailand proves the theory otherwise.

Table 3: . Summary results of trend analysis of countries in Southeast Asian region

Country	Level of Robustness	Level of Risk	Ratio of Killed (%)	Ratio of Injured (%)	Ratio of Total Number of Accidents (%)	Ratio of Total Number of Incidents (%)	Railway Safety Rank
Cambodia	Low	Low	50	50	100	0	7
Indonesia	High	High	23.99	76.01	71.88	28.13	2
Malaysia	High	Low	11.36	88.64	73.08	26.92	6
Myanmar	High	Medium	26.15	73.85	100	0	4
Philippines	Medium	Low	10	90	86.96	13.04	5
Singapore	High	Low	10.42	89.58	22.22	77.78	8
Thailand	High	High	15.24	84.76	84.44	15.56	1
Vietnam	Medium	Medium	23.04	76.96	100	0	3

While for the least risky railway system in Southeast Asia, it is Singapore. Singapore is the only country that has the highest rail incidents with 77.78% of the data. Rail incidents do not cause injury or death so that is partially soothing. However, Singapore tends to face a lot of frustration from the users, not only the station is crowded with enraged users but also a nuisance to the users, operators and facility itself. Nevertheless, that is the only problem that Singapore railway system faces; delays. Since most of the cases are incidents, it is believed that they would be no fatality number. That's why it is concluded that every trip in Singapore in the future is of low risk. Not to mention the robustness of their railway system is astounding. So this proves Andersson's theory.

In terms of which country that has the best and comprehensive data, it would be Thailand. Most of the news for Thailand are gathered from their local news which is The Bangkok Post. Since rail accidents and incidents happens quite often in Thailand, the reporter wrote a detailed news report regarding with the rail accidents and incidents. So it can be stated that the news they published are mostly complete as they publicly announce the type of accident, how did it happen and what are the causes.

When it comes to which country exhibits the best trend, it is without a doubt that Singapore has the best trend. Singapore is the only country in Southeast Asia region that has more incidents than accidents. The researcher's judgement on why it has the best trend is because the trend for rail accident does not surpass the trend for rail incidents.

The country that can be seen here that has the potential to be the best in the region is Singapore. For country that seems to be seen as regressing would be Cambodia since the robustness seen from the map is very low. The only railway line in Cambodia is from Silhanoukville to Poipet. Like in every other countries, their future railway projects would be at least in the planning but there are no plans found for Cambodia's future railway projects.

7.0 CONCLUSION AND RECOMMENDATIONS

The situation of all countries has been studied which produced the trend analysis to identify thoroughly the medium-trend risk of each country. Through the process of performing analysis, robustness assessment of each country's railway system had been done to further determine the risk of each railway system.

This study is expected to be used as a tool or a benchmark for regular rail users, railway operators and policy makers. This is to notify and report to regular rail users to know the risk they face every day when using their countries' rail transportation, railway operators to improve their facility, infrastructure, management and customer service and also policy makers to further understand the issues related to their own railway system.

This study also hopes that railway operators and government authorities will shift their focus and further understand the criticalness of railway safety. Hence, improvements of railway safety with all the issues being addressed is expected for a better experience and safety for the people of each country.

As for recommendations, further study is needed to gather accurate sets of data from each country. These sets of data may be obtained from railway companies or operators so a much more complex statistical approach can be done to further analyse the railway safety in Southeast Asia.

8.0 ACKNOWLEDGEMENTS

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