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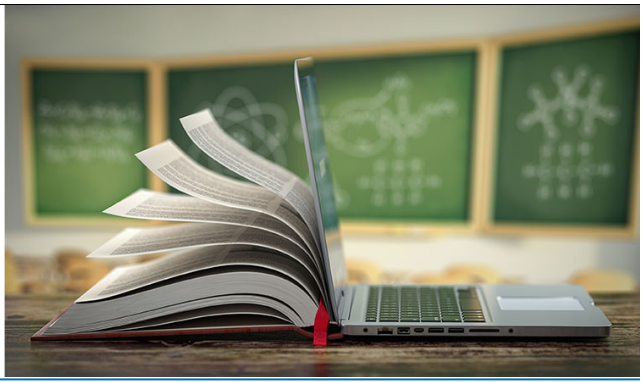

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Exploring risk associated to public road infrastructure construction projects

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Abstract. This study proposed an empirical study of risk assessment module for public road infrastructure construction projects. This study employs a case study of a public road infrastructure construction projects located at a state in East Coast of Malaysia. The projects involve the construction of new four (4) lane road along 5.875km aligned from the state route to federal route. The project will be benefited to the federal and state economic development, while for the local residents, they will benefited with reducing of traffic congestion. However, due to several uncertainties, schedule delays have occurred to the particular area. Thus, this study conducted to explore the risk associated with the project, and four delay factors and thirteen sub-factors have emerged prior to the consultations with project team experts. The delay risk assessed quantitatively employing the Analytic Hierarchy Process (AHP) technique by prioritising the risk delay factors. Design of the AHP model and the operation of the pair-wise rating was employed the super-decision software. The analysis revealed that when considering all factor concerning the goal, the project risk (0.348) captured the most prioritised risk factor that caused by land acquisition issues (0.555), followed by environmental (0.233) caused by the uncertainty of weather (0.733) , operational risk (0.309) caused by late submission of approved for construction drawing causing a delay in projects submission delay (0.396) as the last prioritised risk factors in the construction project and technical risk (0.110) caused by the new design does not consider existing drainage system causing flood (0.352). Findings of this study will beneficial to the project team, as the prioritised risk will act as their references and guidance to avoid delays and incurring of project costs.

1. Introduction

The construction industry is known as one of the significant contributions to socio-economic development. It helps in increasing economic growth and has contributed to the Malaysian Gross Domestic Product (GDP) [1]. This industry is important to the developing countries, including Malaysia, Indonesia and Thailand. Construction projects can be divided into several types including residential housing construction, institutional and commercial building, infrastructure and heavy construction and specialised industrial construction. Infrastructure and heavy construction project include highways, mass transit systems, tunnels, bridges, pipelines, drainage systems and sewerage treatment plants. Meanwhile, transportation has an important role in economic growth [2]. This due to the reason that most of these projects are owned by the government for public use and financed mostly came from the taxes paid by the citizens. Highways or road construction project are one of the public infrastructure projects that are important for social benefits. It was also further affirmed that public infrastructure is important to the development of the economic country [3], based on the premise, the Malaysia government paying much more attention to infrastructure development. Even though the appropriate measurement is taken for the road construction project, there is still a significant probability of risk to occur which places the road construction project at risk of cost, time overruns and poor quality delivery. However, every risk that occurred in the construction project may be reduced with the implementation of risk management. Risk management consists of four processes which are risk identification, risk assessment, risk response and risk mitigation [4]. Risk management can be defined as a process where potential risks in a project identified and to reduce any such threats. ISO 31000, the international organisation that provides a guideline and framework in managing risks defined risks as the effect of uncertainty on objectives. The construction industry is likely more prone to risk due to its complex features. However, the implementation of risk management in a project is still not widely used. Furthermore, the construction industry in Malaysia is lacking in awareness of that the importance of providing risk management plan in a project was resulting in delays, cost overruns and reduction of quality of projects [5]. As a result, this will affect the reputation of the organisational and financial loss of the construction project. This study seeks to explore the risks associated with public road infrastructure construction projects. This study uses a case study of public road infrastructure construction projects that were faced with a time delay located in one of the states on the East Coast of Malaysia.

2. Literature review

Most construction projects are economically risky, especially projects in developing countries [6]. Although, construction practitioners aware of the possible risk and its outcome, not all organisations well applied to establish risk management in their construction project [7]. Moreover, numerous studies have shown that highway construction projects have higher risks compared to other construction projects due to the geographic area and threat from underground conditions [8]. Also, the risk that related to highway and road construction projects have a significant impact on issues related to cost, time and quality of project delivery [9]. It is known that road construction projects required huge investment and to prevent costly project failures and other risks to occur, thus systematic risk management needs to be established. Implementation of risk management in the construction industry has a potential effect on project success [10]. The proper risk management should be well-established and agreed by all parties before implementing it. Eventually, different understanding during the early stage of the risk management process between the stakeholders of road projects in Sri Lanka has affected the implementation of risk management [11]. Three elements that are important in the risk management process are time, cost and quality. Furthermore, cost overrun, delays and reduction of quality can be prevented by applying the risk management to the construction projects. Besides, previous studies also have shown that there are several highway projects that exceeded their budget and time due to what have been called unforeseen events [8]. Therefore, this study provides evidence that involving public infrastructure project, particularly in road networks towards the implementation of risk management.

3. Case study

This study employs a case study of a public road infrastructure construction projects located at one of state in East Coast of Malaysia. The projects involve the construction of new four (4) lane road along 5.875km routed from the state route to federal route. The project will be benefited to the federal and state economic development, while for the local residents, they will be benefited with reducing traffic congestion. The project is an ongoing project and faced a delay in the schedule. The scope of this project involves in constructing a new four (4) lane road along 5.875 km with Urban 5 (U5) Design Standards, constructing four (4) viaducts and two (2) vehicular box culvert (vbc), installation of street lights and traffic lights, installation of street furniture, service and utilities diversion and land acquisition. This project specifically will benefit 70,000 local residents, in terms of saving their time travel and vehicle fuel costs as this project aiding in reducing the traffic congestion. The project also helps in boosting the local economy where it will open new development corridors in the respective district. Figure 1 shows the location of the case study project. As seen in the figure, the yellow line indicates the new road access to be constructed connecting state road to the federal road.

Figure 1. Project site location

4. Methodology

Methodology for this study is illustrated in Figure 2, while Figure 3 illustrates the Analytical Hierarchy Process (AHP) risk factors framework. In the initial phase of this study, a project team interview was conducted in order to gain the project team's perception and opinion of the risk factors and sub-factors that dominate project delays in terms of duration, cost of the project and quality of the project. In addition to the factors obtained from the expert opinion of the project team and the literature review, these delay factors will be used in the design of the survey instrument, i.e. the questionnaire. The questionnaire will be designed in a pair-wise questionnaire following the Analytic Hierarchy Process (AHP) method with the goal-factor-sub factors method. The weighted obtained from AHP will be ranked based on the prioritised risks associated with the case study of a public road infrastructure construction projects.

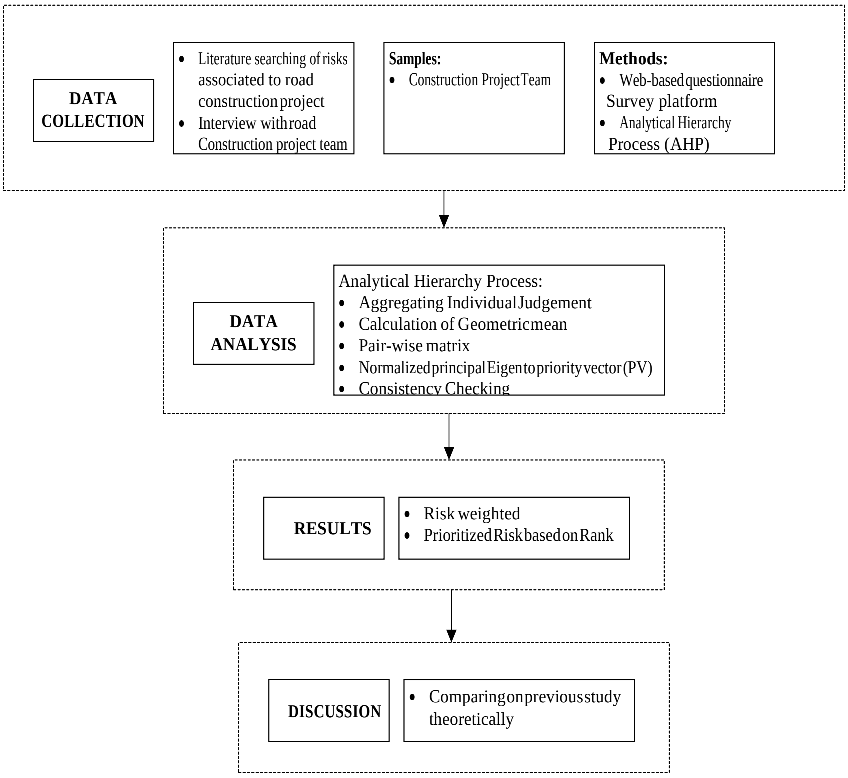

Figure 2. Research methodology flowchart

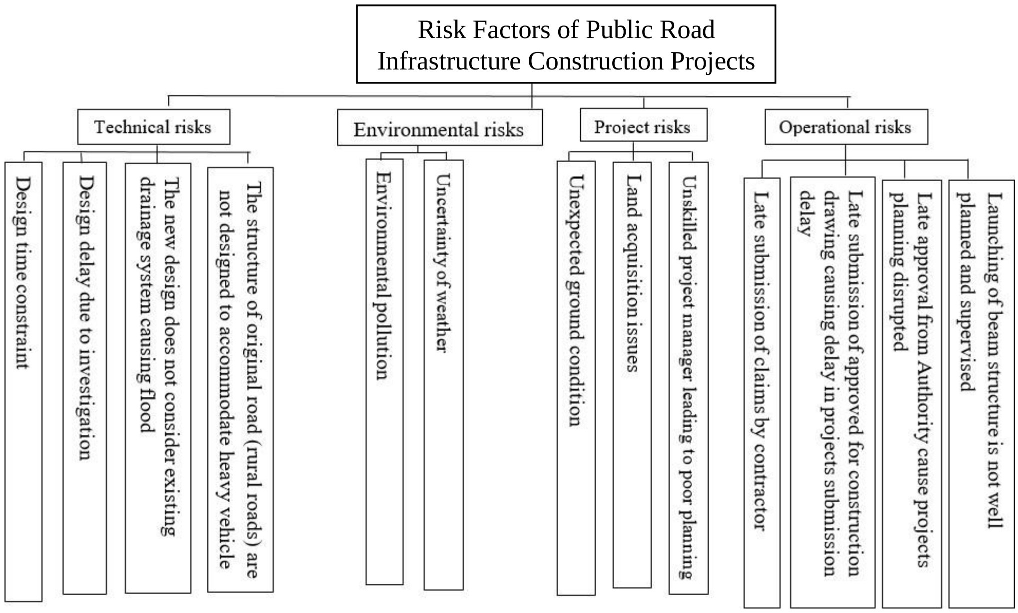

Figure 3. Risk factors hierarchy

4.1. Design of AHP model using 'Super decision Software'

The AHP Hierarchy structure, which was developed and shown in Figure 3, was then employed in the 'Super-decision Software'. The 'Super-decision Software' implements the Analytic Hierarchy Process (AHP) for decision making with dependence and feedback, a mathematical theory for decision making developed by Thomas L. Saaty [12]. Generally, the procedure for operating the 'Super-decision Software' indicated as follows: the desired model, according to the developed hierarchy created using the function of cluster and nodes. Each cluster represents the main criteria to be defined, while nodes represent the factors on each of the groups that they are belongs to. The model developed for this study depicted in Figure 4 below. The connection between goal, factors and sub-factors were created to facilitate the next procedure, i.e. pair-wise ratings.

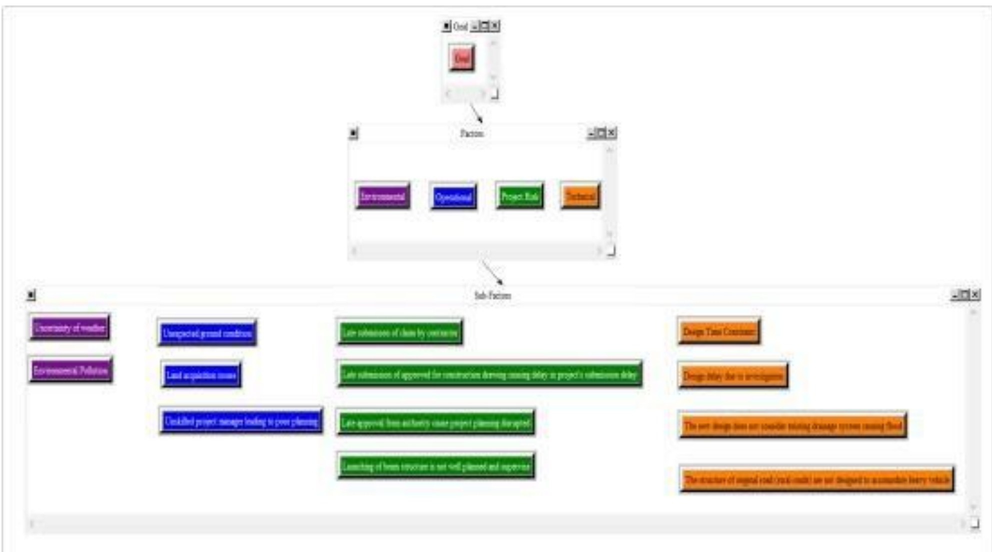

Figure 4. AHP model in *super-decision* software

Next, the operation of the pair-wise rating procedure conducted using the matrix command, and the 'geo-mean value' as shown in Figure 5. Similarly, the prioritised value was given, and results were checked for any inconsistencies, as shown in Figure 5.

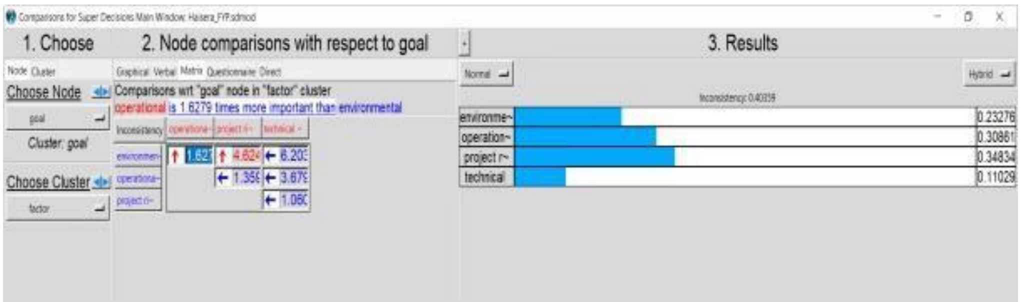

Figure 5. The pair-wise comparison

5. Results and discussion

5.1. Demographic Data

Pair-wise questionnaire following AHP method was created using a web-based survey. Out of fifty (50), online questionnaires sent, thirty (30) responded, represents of 60% response rate. The thirty (30) responded is sufficient due to targeted samples is for the project team for the public work infrastructure projects. The respondents for AHP survey consisted of civil engineers, mechanical engineers, quantity surveyor, main contractor, sub-contractor, project manager and others of road construction project team. The respondent's profile is categorised in Table 1. From the table, the highest percentage is a civil engineer at (30%), followed by quantity surveyor (20%), main- contractor (17%), sub-contractor (7%) and project manager (3%) and others are (3%) respectively. The respondents' experience shows that 57% of respondents' have experience ranging from 10 to 14 years, followed by 33% having 5 to 9 years while only 10% experience 1to 5 years of experience comes from civil engineer, sub-contractor and others.

Table 1. Respondent profile.

Profession	Experience (years)			
	1 to 5 years	5 to 9 years	10 to 14 years	Over 15 years
Civil engineers	1	7	7	-
Main-contractor	-	2	3	-
Sub-contractor	1	-	1	-
Quantity Surveyors	-	1	5	-
Project Manager	-	-	1	-
Others	1	-	-	-
Total	3	10	17	-

5.2. Risk-weighted using AHP 'Super-decision' analysis

The ranking of main factors and sub-factors is depicted in Table 2. The main factors ranked in descending order, and it shows that the most prioritised risk factor in infrastructure projects with respect to the goal is operational risk-weighted at (0.309), project risk (0.348), environmental risk (0.233), finally the technical risk at (0.110). The sub-factors weights were also ranked, and the top sub-factors will be further discussed. The table shows that uncertainty of weather (0.733) as the top risk which is the main cause most of the delayed project, followed by land acquisition issues (0.555), late submission of approved for construction drawing causing a delay in project submission delay (0.396), the new design does not consider existing drainage system causing flood (0.352), and unexpected ground condition (0.301). The problem of uncertainty of weather in the project construction was agreed by the project team as the top factor, which often led by the uncertainty of the country climate. This finding in coherence with prior studies by several researchers [13]–[16] who found that uncertainty of weather as the most prioritised risks that causing a delay in the construction project. The uncertainty of weather typically brought continuous heavy rain that caused floods, which further will disrupt the construction progress period. In most cases, it will be causing for a stops work as due to discomforting site work, especially excavation caused silt and mud to the construction area. It will worsen if it disturbs the public access road.

Table 2. Ranks of Risk Factors and Sub-factors

Risk Factors	Risk Sub-factors	Weighted	Rank
Technical, 0.110 (4)	Design time constraint	0.191	(10)
	Design delay due to investigation	0.290	(6)
	The new design does not consider the existing drainage system causing flood	0.352	(4)
	The structure of the original road (rural roads) are not designed to accommodate heavy vehicle	0.166	(11)
Environmental, 0.233 (3)	Environmental pollution	0.267	(7)
	Uncertainty of weather	0.733	(1)
Project, 0.348 (1)	Unexpected ground condition	0.301	(5)
	Land acquisition issues	0.555	(2)
	Unskilled project manager leading to poor planning	0.145	(13)
Operational, 0.309 (2)	Late submission of claims by contractor	0.244	(8)
	Late submission of approved for construction drawing causing delay in projects submission delay	0.396	(3)
	Late approval from Authority cause projects planning disrupted	0.168	(12)
	Launching of beam structure is not well planned and supervised	0.191	(9)

The second highest risk in the project is land acquisition issues is a common problem to build roads and the land acquisition problem is the major factor behind project delays as multiple authorities are involved with difficulty in acquiring land in rural and forest areas cited as the major reason. The federal government usually approaches state governments to identify land parcels and negotiates the purchase price with the owners, who are usually far-flung rural landowners. Unclear land titles, absent or incomplete revenue records in villages and the fragmented nature of rural landholdings complicate the sale process with a large number of families having to be compensated for their land. Due to the fact that acquiring land for road projects is one of the major hurdles in creating infrastructure, private developers should embrace this measure as it is a great initiative to solve the problem partially. Late submission of approved for construction drawing causing a delay in projects submission delay. Prior study reported on the approval of drawings as the top causes of delay in the UAE construction industry [17]. Similarly, late on approval of drawings under the consultant related factors that causing a delay in the construction project [18]. This is much brought by the effects of the design delays has become an essential and important part of the consultant's tasks. Determining, recognising and identifying the various causes of the delay during the design and the construction is the responsibility of the consultant engineer to avoid any delay in the project time. The experts of construction design management should investigate deeper to find new techniques and implications to avoid delay. The new design does not consider the existing drainage system causing flood and public participation in the development of principles for future flood management has helped both stakeholders and engineers [19]. The results demonstrate the importance of assessing the impacts of climate change for implementing appropriate flood seen as events with negative consequences that occur beyond the control of human being [20]. Moreover, floods constitute a significant risk for construction that contributes to cost escalation [21].

6. Conclusion

This study proposed an empirical study of risk assessment module adopting the AHP method for public road construction projects. From the present analysis, the following conclusion might be drawn. The analysis revealed that when considering all factor concerning the goal, the project risk (0.348) captured the most prioritised risk factor that caused by land acquisition issues (0.555), followed by environmental (0.233) caused by the uncertainty of weather (0.733), operational risk (0.309) caused by late submission of approved for construction drawing causing a delay in projects submission delay (0.396) as the last prioritised risk factors in the construction project and technical risk (0.110) caused by the new design does not consider existing drainage system causing flood (0.352). In addition, under these circumstances, the delivery time of the project will be delayed and costs overrun. The study also points out that risk factors that have a significant impact on the economic and financial aspects of the project, such as the federal government's funding risk, have been considered to be the most important part of the road construction project team. However, this study only captures the risk identification stage in determining the priority risk factors of the project phase among the risks encountered. Future studies are recommended to include risk monitoring for the risk management report cycle. The findings of this study may be limited or subjected to the case study of this road construction project only. However, this finding may also be applicable to a similar scale road construction project. Further work is called upon to adapt the risks associated with larger infrastructure projects not limited to the road construction, including mixed-development of cities, power plant construction project, railway construction and other mega-development construction project.

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