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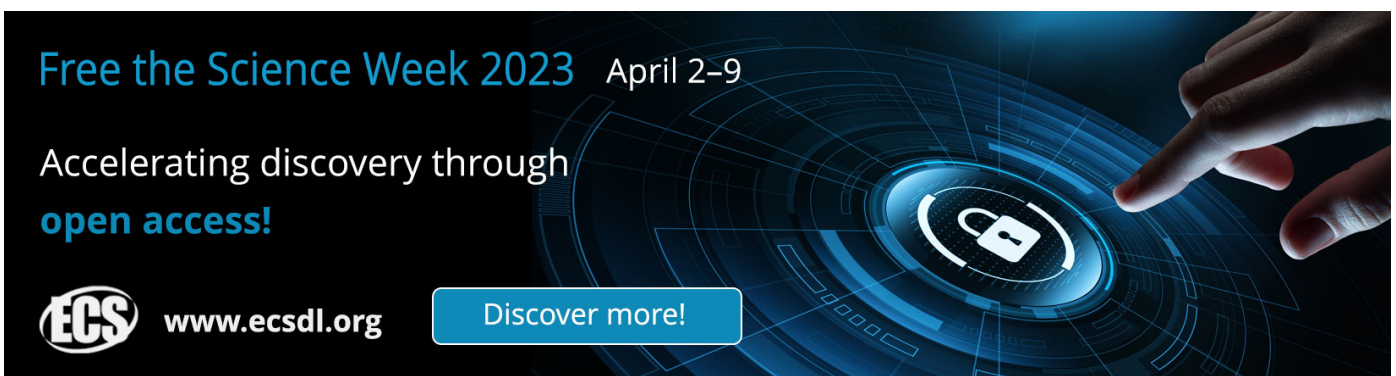
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Multicriteria Decision Model for Road Construction Project

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Abstract. Construction of roads plays an important role in linking one area to another, and also acts as a substance for the local economy. However, the limitation of study on the project performance towards the road infrastructure construction project requires more precise attention. Thus, it requires distinct responsiveness from contractors to evaluate and cope with the risks. This study aims to identify the project execution risk factors involved in the road construction project, reference to a current case study from a federal government project Public Work Department (PWD) on the East Coast of Malaysia: Upgrading 14.7 kilometre (km) federal road from the Pekan town to Sungai Miang. This study will begin with the identification of the project execution risk factors, utilizing an extensive review of the literature. Next, the gathered risk factors will go through a pilot phase validation interview with road construction experts from the public work department (PWD) and also construction practitioners that are involved directly in the project case study. Findings found seven (7) main project execution risk factors involved in the road construction project, which include resource risk, land acquisition issue, project management issue, technical risk, service utility issue, unforeseen ground condition, and force majeure risk. Among the seven (7) factors twenty-one (21) project execution risk sub-factors, were further explored that are crucial to the project. The main contribution of this study is the final multi-criteria decision model obtained from literature searching cross-referenced to the real case study that may be beneficial to the road construction project team specifically.

1. Introduction

The construction industry has more risks and uncertainty than any other industry. Adverse effects will occur if risks are not addressed appropriately, especially when it comes to road construction[1]. Due to the construction industry being so massive, unstable, and requiring huge finance, there are a lot of risks involved. This is because of the complexity of the construction process [2]. The problem is exacerbated by the fact that road construction projects typically involve complex site conditions[3]. Even though there has been a lot of research on risk management in the construction industry, there isn't much written about project risk in developing countries [3]. In the same way, [4] points out the limitations of the study on the causes of delays and how they affect the road infrastructure construction project, which needs to be looked at with more care. This is especially true as many road construction projects fail to meet time schedules and budget targets [5]– [7]. Most project delays were caused by the owner (the client) rather than contractors, consultants, or other project stakeholders, according to [8].

Risk management is important, but most construction workers who oversee it do not have the knowledge of risk management tools used in road construction projects [9]. This shows that innovative risk management tools [5] need to be used in the execution of road construction projects. Even though it is important to use good risk management tools, [10] emphasized that there is no one best way to deal with risk and that different risk-handling strategies should be used to deal with risks effectively.



On the other hand, [11] emphasises that material price changes during the construction phase cause project costs to go up more than expected. The road construction industry has been hit hard by projects that take longer to finish and cost more than expected [5]. [3] showed that a lot of people in Nigeria are aware of risk events, but the plan and management of risk have not yet been made for the road construction projects. Consequently, [13] asserted that the high-risk exposure associated with road construction projects necessitates a heightened focus on risk analysis and management. Based on the preceding, [14] asserted that, prior to reducing the risks in road construction, it is necessary to identify the root causes and define the predominate risk factors that cause project delays during the initial phase of road construction projects. Consequently, a case study is a useful method for determining a suitable risk provision for road construction projects.

2. Case Study

The project is upgrading 14.7 kilometre (km) federal road from the Pekan town to Sungai Miang, which can be a catalyst for local economic growth. Through the project, a single two-lane road will be turned into a Rural (R3) to Rural (R5) road for 1.7 km from Pekan town to the Kampung Tanjung Agas junction, and a 13-km four-lane twin road will be built from the junction to Kampung Sungai Miang. Three bridges at Sungai Habib Hasan, Sungai Miang, and Sungai Air Tawar will be replaced by this project. Besides building three bridges, they are also put-up streetlights and improved two traffic light intersections at the Kampung Tanjung Agas junction and the Tanjung Agas Industrial junction. The project implemented by a private company, expected to be completed on February 28, 2022, is capable of smoothing traffic movement and overcoming road shoulder problems as well as narrow bridges and dangerous bends on the route connecting Pahang to Johor. The RM338 million upgrading project is part of the 240 km Highway Network Development Plan (HNDP) from Pekan to Kota Tinggi, Johor. Former 6th Malaysian Prime Minister, Dato Seri Najib Tun Razak compromised that the upgrading project is expected to drive the economic growth in Pekan town through the improvement of the road connection system from the district to the states in the South of the country whereas the routes will be upgraded in the future. Even though the improvements don't reach the southern border towns of Nenas or Endau, Mersing, they can be seen as a starting point from Pekan to the south (Johor). In the next phase, improvements and extensions will be made depending on government allocation. The project, currently in progress facing issues just as like other construction project did, including schedule time overrun, budget allocation, construction issue and others.

3. Literature Review

Risk is something that can't be avoided in construction projects [10], and events related to risk in road construction projects have a big effect on the cost, time, and quality of the project [3]. Under these conditions, [13] makes it clear that contractors need to pay extra attention to the high-risk exposure that comes with road construction projects to analyse and manage their risks.

Risk management is a way to make decisions that minimise and deal with risk in a smart and effective way.. A sufficient attention should be paid to construction risk management, as to ensure a successful project that meets the expectations of project objectives and goals [9]. To show that risk management could be used in a road construction project, [15] talked about how important risk assessment is in construction projects and suggested different ways to deal with risks that could happen at different stages of the project. One way to deal with risk is to make sure that the right people oversee each part of the project. This is especially true because risks are given to each stakeholder in the project, such as the contractor, the owner, the consultant, the consultant in charge of overseeing the consultant, and other important people involved in the construction project [17]. In similar vein, [17] and [10] asserted that, for an appropriate risk's allocation, early identification of a risk factors is crucial.

While risk identification is undeniable crucial, the way of assessing it is equally important, and act as a key in risk management process [19]. Consequently, [15], [17] advocate for the estimation of risk analysis to determine the risk's priority, utilising probability, and impact analysis. Similarly, [15] proposed a risk index (R) that serves two purposes: to evaluate sources of risk and uncertainty and to prioritise risks in road construction projects accordingly.

The following subsections will discuss those project execution risks factors associated to the road construction project.

3.1. Economic and Financial Risk

There is widespread of consensus that construction of new road infrastructure as a means of crucial contribution to economic development and growth [20], [21] and the long-term capital will affect the competitiveness of the economy [22]. Following to this contextual, considering road construction project linked to economic growth, there are certainly risks associated to the economic and financial issue. Among risks associated to economic and financial risks reported by prior studies including inflation and scope change factors [10], [12] that determine the failure to the cost and time limits. Also, contractors didn't have enough cash flow, there wasn't enough foreign currency to import materials and equipment [23], and payment processes were too slow [6], [23]. According to [23], the issue of never-ending construction time overrun in a road construction project is also driven by corrupt practices, in addition to large and unreasonable prices.

3.2. Land Acquisition Issue

Several studies have shown that getting the land was the biggest reason why a road construction project ran behind schedule [17, 24, 25]. This is because road construction projects often involve expanding roads, which limits the amount of land that can be used. Getting land is important and often the only way to do things [27, 28]. Because of this, [25] thinks that the project needs to be studied and managed in a way that considers how the ground is and how land is acquired.

3.3. Project Management Issue

From figuring out the risks of the project to handing it over to the owner, the project management phase is the most important part of building a road. Incorrect estimates of project costs, demand, and other effects are a major source of risk in project management [31]. Studies have found that one of the risks of project management problems in a road building project is that the project team doesn't communicate well, that quality control and performance control aren't well managed, that the project isn't planned and scheduled well, and that the site isn't managed and supervised well. [31] said that the organisation structure of that contractor was one of the most difficult things to deal with when it came to project management skills. One of the biggest complaints was that the contractors didn't have enough experience [8]. Worst case is when a contractor doesn't know what they're doing and doesn't use their resources well or isn't well organised [26, 32], which causes the project to cost more and take longer than planned.

3.4. Technical Factors

Technical risk factor [29], [12] that escalated schedule delays in road construction project as reported by prior studies inclusive risks of defective design [10], [32]. While [3] accounted that risk impacting road construction project in Nigeria is design changes and inaccurate design details, [22] agreeing that those design issue is the outcome of shortage of technical personnel, likely lacking on the technical expertise. In the same way, [32] said that the most common things that cause road projects to be late in Sri Lanka are mistakes and inaccuracies in the design work, as well as changes in requirements and scopes that require re-design [8]. As technical factors are quite critical and important in road construction projects that cover a wide range of technical aspects such as road technical, drains and drainage, utility systems etc., technical risk factors such as flaws in design and lack of expertise need to be identified from initial phase of the project, hence failures and delays of construction projects could be mitigate. To stress this possibility, [26] contemplated for a better pre-qualification and selection systems during initial phase, as well as to hire technical experts as consultant team.

3.5. Relocation of Utilities

Underground utility infrastructure includes the water supply, drainage, electric power, heating lines, communications, gas, garbage, and other municipal pipelines [8], [34]. Prior studies, that including [23], [35] notified relocation of utility are characterized as high risk as uncertainties and complexity occurs as project site, thus leading to cost and time overrun. The relocation of utilities is especially important and difficult in road and bridge construction projects, as it requires the efficient coordination of multiple parties [36], particularly the public authorities [35], [36]. The leading issues for the relocation of underground utilities is the lack of coordination among the parties involved, as each underground utility has different direct jurisdiction [36].

3.6. Unforeseen Ground Conditions

In the project execution phase, the geotechnics or unforeseen ground conditions in the project was identified as a major challenges by prior studies [10], [26], [32], [37]. While topography was an important factor affecting the development of roads [28], however major risks assessed for the ground conditions that including contaminated soil and unstable soil condition [3], that hindered contractors on many circumstances.

3.7. Natural Risks

In many parts of the world, natural disasters such as floods, tornados, hurricanes, volcanic eruptions, earthquakes, and land-slides have led to considerable loss of human life and affected terrific socio-economic costs, this is no exception for infrastructure construction projects including roads and bridges. Among natural risks reported by prior studies including project site flooding and landslide [3], heavy rain and flood [12], [36], [25], [37]. Natural risks also known as "Acts of God," will have major impact during the construction phase [10].

3.8. Positioning this Study

Even though there has been a lot of research on risk management in the building industry, there isn't much written about project risk in developing countries [3]. In the same way, current study points out necessity on studying what causes delays and how they affect a road infrastructure construction project [4]. This is something that needs more careful attention. This is especially true since many roads building projects don't finish on time or on budget [5–7]. Most project delays were caused by the client (owner) rather than contractors, consultants, or other project stakeholders [8].

Because of this, studies have shown that there isn't enough risk management in the road construction industry, even though it's important to make sure that projects are finished on time, on budget, and without sacrificing quality or safety. To provide with that knowledge, emerging risks associated to a road construction project should be explored and identified. Also, as to ensure the relevancy and validity of the assessed project risk factors, this paper filling that gap by: (1) Identifying Road project execution risk factors, and (2) to develop multi-criteria decision-making model utilizing the Analytical Hierarchy Process (AHP).

4. Analytical Hierarchy Process (AHP)

It was decided that the best method to adopt for this study is using AHP. According to [7] there are three main phases of the AHP model methodology which are including arrange problems in the hierarchy structure, arranging priorities for each element problem, rating synthesis and consistency of AHP. It is a multi-criteria decision method that permits subjective as well as objective factors to be deliberated in the decision-making process. The AHP permits the vigorous involvement of decision-makers in getting reconciliation and helps to decide on a rational basis. For this reason, AHP was considered one of the great tools since introduced in 1988, still practical until this millennium era. The main strength of AHP is its ability to consider the subjective opinions of decision-makers. AHP has a feature that made it attractive for

combining with other methodologies that are usually developed to deal with objective data. Furthermore, AHP is a quantifying tool that provides an effective and precise means of choosing options evident in many disciplines [8].

5. Multi-criteria decision-making model

There has been a lot of research on risk management, but it hasn't even begun to address the underlying risk of on-site construction activities in reference to actual case studies [9]. It is also uncommon to publish the creation of a framework or model for risk analysis that aids policymakers and decision-makers. If any, it may possible conducted internally without requiring referral. Therefore, this paper, upon reviewing in details the project executing risk factors, it tends to then develop the multi-criteria decision making models, whereas all the risk sub-factors were further explored with the captured risk factors. The final multi-criteria decision model shown in Figure 1 obtained from literature searching cross-referenced to the real case study that may be beneficial to the road construction project team specifically. Figure 1 entails on all the risk sub-factors among all captured twenty-one (21) risks that belong to its category. Shown in the figure, seven (7) main factors determined from literature of the project execution risk factors in road construction project, which including resource risk, land acquisition issue, project management issue, technical risk, service utilities issue, unforeseen ground conditions and force majeure risk. Each of the factors further explored by reviewing literature of past studies and cross-refereed to the project case study, and twenty-one (21) sub-factors project execution risk sub-factors were discovered, that are crucial to the project.

6. Conclusion

This paper use a thorough and focus review of the literature in trying to figure out what is the project execution risk factors for the road construction project. Seven (7) main project execution risk factors were found to be involved in building the road: economic and financial risk, land acquisition issue, project management issue, technical factors, moving utilities, unexpected ground conditions, and natural risks. Among the factors, twenty-one (21) project execution risk sub-factors were explored, that including that are crucial to the project. The main contribution of this study is the final multi-criteria decision model that obtained from literature searching cross-referenced to real case study that may be beneficial to the road construction project team specifically.

7. Acknowledgement

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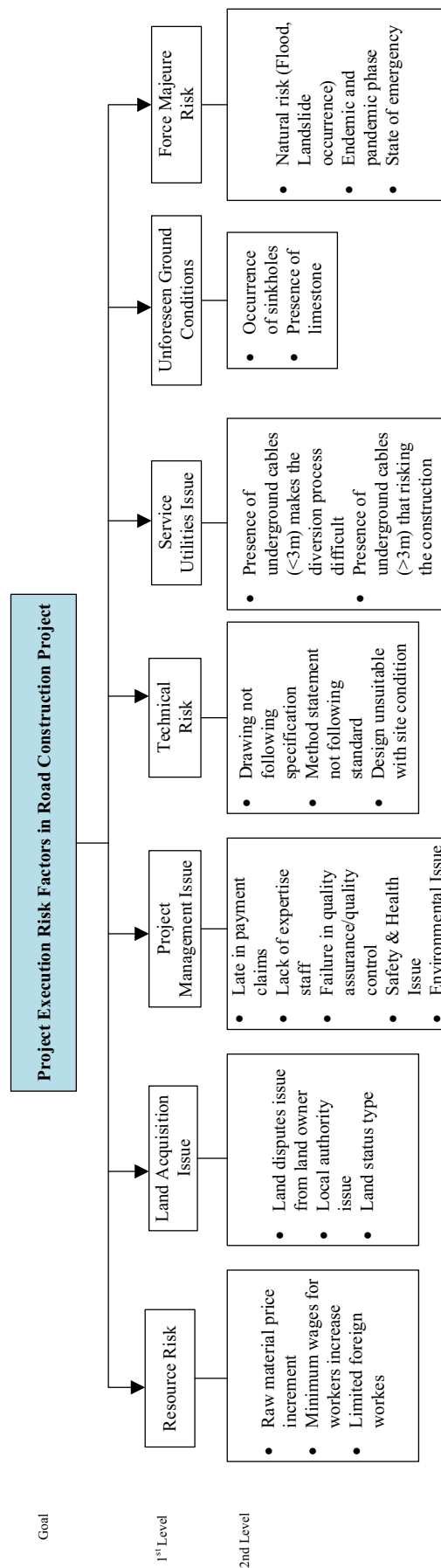


Figure 1. Multi-criteria decision making model of project execution risk factors in road construction project

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