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AHP-BASED ANALYSIS OF THE RISK ASSESSMENT DELAY CASE STUDY OF PUBLIC ROAD CONSTRUCTION PROJECT: AN EMPIRICAL STUDY

P. Z. RAZI*, M. I. ALI, N. I. RAMLI

Faculty of Civil Engineering and Earth Resources,
Universiti Malaysia Pahang, 26300, Gambang, Pahang, Malaysia.
*Corresponding Author: putri@ump.edu.my

Abstract

This study proposes an empirical study of risk assessment module for public road construction projects. A case study of a conventional road construction project for new road access for a university that is located in East Coast Malaysia is adopted in this study. Seven delay factors and twenty-two sub-factors were designated from a review of literature and consultations with public road experts. The designate pair-wise questionnaire survey was distributed to the road project team in accordance with the Analytic Hierarchy Process (AHP) technique. The delay risk was assessed quantitatively by prioritizing the risk delay factors and conducting sensitivity analysis in determining the critical construction phase. This study identified the top five most prioritized factors as follows: technical (0.242), natural hazard (0.208), economic and financial (0.186), contractual (0.125), and socio-politics (0.105). The global weight obtained was ranked and the top-five of most prioritised sub-factors were determined as follows: fund risk (0.111), flood (0.099), heavy rain (0.092), unforeseen ground condition (0.086), and existing utility issue (0.076). Sensitivity analysis simplified from Expert Choice 11 programme revealed that the construction phase captured most of the risk, followed by project inception (planning stage), project design, and finally, project completion.

Keywords: Analytical hierarchy process (AHP), Risk, Risk delay, Road construction project, Sensitivity analysis.

1. Introduction

Construction of road plays an important role in linking one area to another and acts as a substance for the local economy. It is anticipated that 25 million km of newly surfaced roads will be globally developed by 2050. This symbolises the adequacy of encompassing the planet for more than 600 times [1]. Several types of roads are being constructed in Malaysia, which is dependent on the suitability of the location such as gravel road, bitumen paved road, concrete road (rigid pavement), and locking block paving road.

It is universally known that road construction projects entail a higher risk compared to building projects, as they require higher expenditure other than a complicated site condition. Major risks are constantly acquainted with road construction projects. Thus, it requires distinct responsiveness from contractors to evaluate and cope with their risks. Although risk in any construction cannot be disregarded, it can be reduced or conveyed from one project stakeholder to another [2]. For developing countries, road construction is contributed as an imperative element in the construction industry. This shows that the national financial plan for infrastructure improvement is mostly channelled to road construction projects [3].

In Malaysia, the implementation of risk management in construction projects is still on a small scale and has a long way to go [4]. The awareness in realizing the importance of providing risk management reports for construction projects in Malaysia is still minimal by most parties, especially for government projects. For example, construction projects of more than fifty million ringgit under the supervision of Malaysia Public Work Department are mandated to submit risk management reports. Nevertheless, the construction players, especially from the client’s perspective have beginning to slowly acknowledge risk management as an aiding instrument in handling a construction project successfully and productively [4]. Only several authors including Kaliba et al. [3], Aziz and Abdel-Hakam [5] and Mahamid [6] reported risk in the delay of the road construction project. While many studies have been conducted, particularly on the risk of road injury, accidents, and safety. Therefore, a case study is a valuable method to discover an appropriate risk provision for road construction projects. For example, Zafar et al. [7] carried out a case study on instruments to classify the crucial threat criteria causal due to failure in attaining financial aid for road projects in Federally Administrated Tribal Area (FATA) and suggests measures to overcome them. Similarly, Perera et al. [8] identified the risk accountabilities of contractual parties in order to develop risk control approaches with regards to Sri Lankan road projects. As delays in any civil engineering project in Egypt are a normal phenomenon, it is essential to study and analyse the causes of road construction [5].

2. Literature Review

Risk management has become an essential requirement for construction projects. Risk management process includes risk identification, risk assessment, and risk control. Qualitative methods and quantitative methods are utilised to assess risk. The adoption of risk management is necessary to maximise the significance of positive factors and diminish the significance of contrary factors in project goals. The adoption of risk management is crucial since it is an efficient practice of identifying, assessing, and disputing project risk [9].

Project risk is an undefined occurrence or circumstance that, it occurs, may have a progressive or destructive influence on a project's goals. Mechanisms of risk examine the possibility of an occasion, the likelihood of the incidence occurred, and the influence of an occurrence. Risk management includes a six-steps method, namely, risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning and risk monitoring and control [10]. The suggested steps act as a guideline to manage the risk of any project. However, many authors simplified the six steps to risk identification, risk assessment, risk response, and risk monitoring.

2.1. Risk identification

Risk identification involves defining risks that potentially influence a project before the characteristics are documented. The project team, risk management team, subject matter experts from other parts of the company, customers, end users, project managers, stakeholders, and external experts were identified as participants in conducting the risk identification process. Risk identification involves a repetitive process. The construction team or the risk controlling team may conduct the first repetition process. The second process of repetition may be accomplished by the whole construction team and main investors. Individuals that do not contribute to the construction project may execute the ending repetition process in order to attain an unprejudiced assessment [10].

As suggested by Renuka et al. [11], Fig. 1 shows the sources of risk that divided into non-engineering risks and Engineering risks in which, Engineering risks are foreseeable and those non-engineering risks are non-foreseeable. The foreseeable factors should be forecasted during the preliminary of the project whereas the non-foreseeable factors include ambiguities; should be appraised for the successful completion of the project. The figures confirm that the process of identifying risk is a thorough process of managing problems.

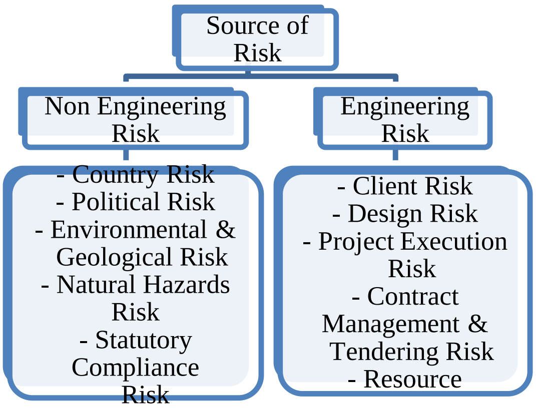

Fig. 1. Knowledge map representing the risk sources [11].

2.2. Risk assessment

One of the main practices in risk management that enables stakeholders to estimate uncertainties that may threaten project performance in terms of cost, quality, safety, and time is risk assessment [12]. Risk assessment is important in providing an effective risk assessment methodology for clients in analysing and managing risk factors [13]. Risk assessment as distinguished by Project Management Institute [10] grouped into two (2) extensive groups, namely, qualitative and quantitative analysis. The main uncertainties may be ascertained through qualitative assessment techniques including interviews, brainstorming, and checklist.

On the other hand, quantitative assessment involves data-driven techniques including Monte Carlo simulation, sensitivity analysis, and decision analysis. It is deliberated as an assessment method that consists of an explanation of each uncertainty and its influences or the particular classification of uncertainties (high/medium/low) with reflects the severity factors and the likelihood of its occurrence. Choudhry et al. [12], Sarvari et al. [14], Dey [15], and Hossen et al. [16] conducted risk assessments in their studies.

2.3. Risk response

In order to develop opportunities and reduce threats to the project's objectives, risk response is an effective procedure to be adopted in the risk management process. Risk response ensures that identified risks are appropriately mitigated [10]. As suggested by the Project Management Institute [10], there are four (4) techniques of risk response, which are risk avoidance, risk transference, risk mitigation, and risk acceptance. Trangkanont and Charoenngam [17] recorded several earlier studies and suggested for risk response plan in their study in which, suggested for a framework of the risk response strategy application for public-private partnership (PPP) projects. Tserng et al. [18] suggested that the Ontology-Based Risk Management (ORM) framework that includes risk identification, risk analysis, and risk response to enhance the risk management performance by improving the workflow and knowledge reuse. Meanwhile, Dziadosz and Rejment [19] suggested a risk response plan for generic construction projects based on the designed risk with a scale of low, medium, and high analyses.

3. Case Study

This study employs a case study of a conventional road construction project for new road access for a university located on the East Coast of Malaysia. The project connects the Federal Route (FT003) to a state route (C102) and will serve as an alternative road to the existing road. The scope of the projects comprises of upgrading the old existing road (PLB Road) to paved road as categorised by Rural 5(R5), geotechnical works, diversion of utility and re-installation work, constructing drainage system, installation of street lighting works, and road furniture works. The project is an on-going project and faced a delay in schedule. This study will conduct a risk analysis assessment in determining, which factors lead to the late delivery of the project to the project team and in which, the construction phase does the risk is prioritized the most. Analytical Hierarchy Process (AHP) as an analysis method will be adopted in this analysis.

Figure 2 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 to the University. While Fig. 3 depicts the conventional construction contract model adopted in the project comprises of project feasibility, planning, design stage, material procurement, and contract award until the implementation and commissioning stages. As shown in Fig. 3, the project adopted a conventional construction model that seen as isolated and not integrated. The model not allowing the construction project team to develop their relationship during the project phases and to predict their project accomplishment. Also, in order to provide adequate information for effective project management and assist the project team in making a decision, it is important to furnish the project team with a database-aided system, for instance, the AHP.

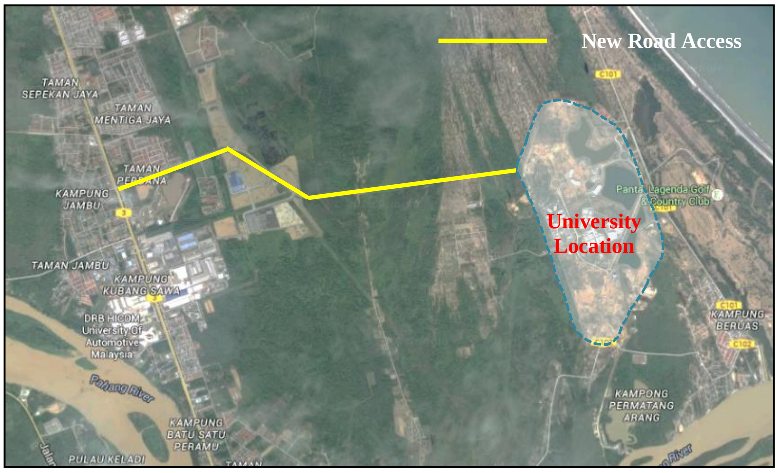

Fig. 2. Project site location.

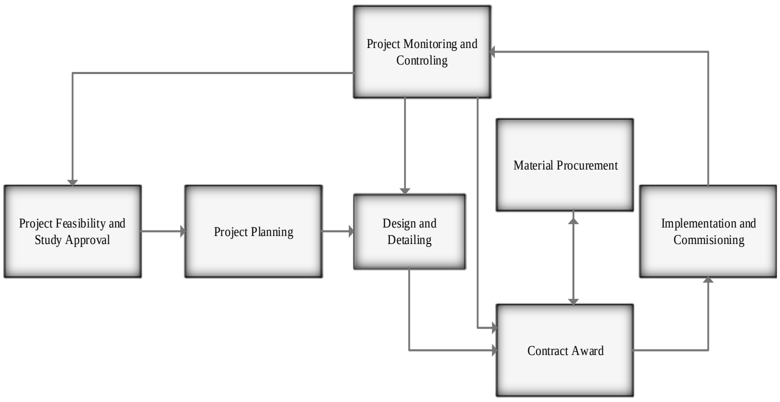

Fig. 3. A conventional contract model [20].

4. Methodology

Methods applied in this study presented here with the introduction of Analytical Hierarchy Process (AHP), procedures in computing the AHP, and pair-wise questionnaire methods adopt in AHP.

4.1. Analytical hierarchy process (AHP)

Saaty [21] introduced the Analytical Hierarchy Process known or commonly known as AHP is an approach that and has extensively become a predominant method in evaluating criteria weightings in various Multi-Criteria Decision-Making (MCDM) problems. The application of AHP methods is not only restricted to the construction industry but can also be applied in various fields including computer programming, oil and gas industry, financial and marketing as long as a decision-making process is needed. Several papers have compiled the AHP success stories in very different fields including by Han et al. [22] whom successfully applied the method in Indonesian South Highway Project, in addition, Dey [15], who adopts AHP in the pipeline construction project in the Indian oil industry. Similarly, Bitarafan et al. [23] implement AHP decision-making method for bridges construction in Iran, while Taylan et al. [24] utilize the same method for a construction project at King Abdul Aziz University. Despite its popularity, AHP is also having the drawback including its incapability to satisfactorily solve the ambiguity and vagueness associated with presenting the decision-makers sensitivity and the decision to precise ratios or numbers [25]. Similarly, based on studies by Lin et al. [26], AHP requires decision makers remain consistent in making a pair-wise comparison and the difficulty to express accurate expression due to the limitation of the nine (9) value scale.

This study adopted a quantitative research approach where questionnaires distributed to thirty (30) respondents of the road construction project team. In this study, the AHP application simplified by using the Expert Choice software. The following are the steps for conducting the AHP method that inclusive of four (4) major steps. As AHP method deemed as a quantitative method, the explanation is focused on the method in developing the matrix of factors, making a pair-wise comparison, organisation of pairwise comparison into a square matrix and normalization of the matrix.

Step 1: Develop the matrix of factors. The problem decomposed into a hierarchy of goal, factor, sub-factor, and alternatives as shown in Fig. 4.

Figure 4 shows that the hierarchy goal is pre-determined first before the factor and sub-factor decided. The factor and sub-factors were determine based on the extensive literature review, project document review, and on-site observation. While the alternatives are set to decide, which project phases captured the most prioritized risk factors dominating delays in the construction project. The alternatives that were decided including project phase of inception, design, construction and completion. Once the AHP framework is finalized, the pair-wise questionnaire survey was prepared and distributed to the project team. The detail on the survey conducted being discussed in Section 4.2.

Step 2: Make a pairwise comparison of alternatives on a qualitative scale. Saaty [21] developed the weightings of the risk delay factors were assessed by using nine (9) scales of importance as shown in Table 1.

Step 3: The pairwise comparisons of various factors generated are organised into a square matrix.

Let $C = \{Cj \mid j = 1, 2, \ldots n\}$ be the set of criteria. Equation (1) is the pairwise comparison shown by a square and reciprocal matrix.

$$A = aij = \begin{Bmatrix} a11 & \dots & a1n \\ \vdots & \ddots & \vdots \\ an1 & \cdots & ann \end{Bmatrix} \quad (1)$$

Step 4: The principal eigenvalue and the corresponding normalized right eigenvector of the comparing matrix give the relative importance of the various factors being compared. The elements of the normalised eigenvector are termed weights with respect to the factors or sub-factors and ratings with respect to the alternatives. Equation (2) showed the formula of each matrix that needs to be normalised.

$$Aw = \lambda max.W \quad (2)$$

Saaty [21] demonstrated that $\lambda max = n$ is a necessary and sufficient condition for consistency. Inconsistency may arise when λmax deviates from n due to varying responses in the pairwise comparisons. Therefore, Saaty [21] proposed a method to measure the inconsistencies by first estimating the consistency index (CI). CI is defined in Eq. (3). Then, to obtain the consistency ratio (CR), the CI is divided by the random consistency index (RI) in Eq. (4), the value of RI as tabulated in Table 2. The CR value should not be greater than 0.1, otherwise, the pairwise comparison result should be rejected.

$$CI = \frac{(\lambda max - n)}{(n - 1)} \quad (3)$$

$$CR = \frac{CI}{RI} \quad (4)$$

Once all weighted calculate following the four steps, local weights and global weight were then being calculated. Local weight indicates the relative importance levels of factors within the group they belong to, while global weights point to the prioritization of factors with respect to road construction project delay risk. The global weight of sub-factors is calculated by multiplying the local weight of main factors and sub-factors. Hossen et al. [16] explained the similar calculation of local and global weight.

Table 1. Scale of relative importance for pair-wise comparison [27].

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favours one activity over another
5	Essential or strong importance	Experience and judgment strongly favour one activity over another
7	Very strongly importance	An activity is strongly favoured and its dominance demonstrated in practice
9	Extremely importance	Evidence favouring one over another of highest possible order of affirmation
2, 4, 6, 8	Intermediate values	When compromise is needed

Table 2. Random consistency index (RI) [27].

Number of factors	1	2	3	4	5	6	7	8	9
Random Index (RI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

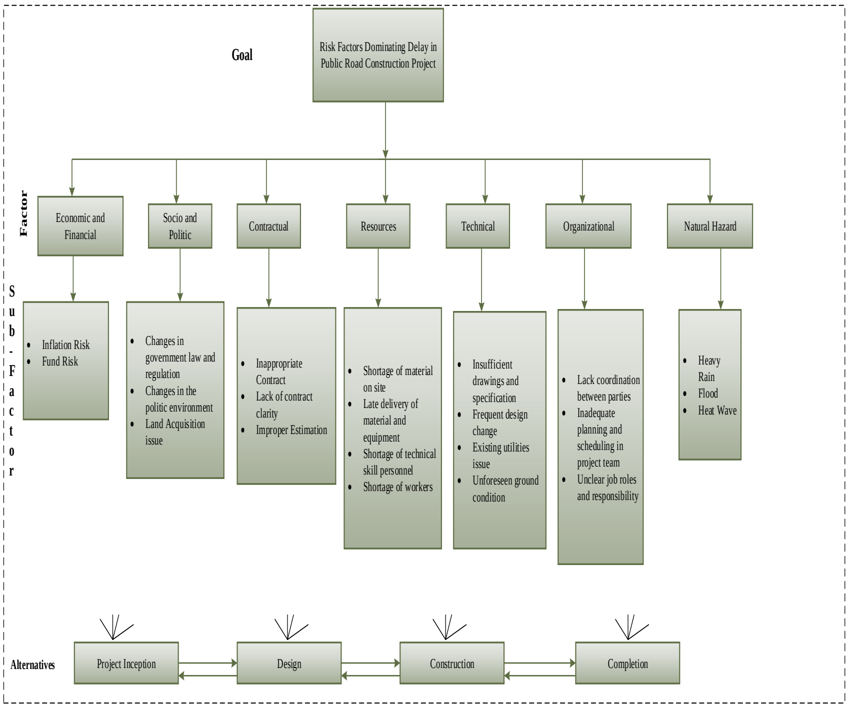

Fig. 4. AHP framework decision.

4.2. AHP questionnaire survey

The questionnaire survey, which was designed with a pair-wise comparison based on the AHP method, is designed to determine the prioritisation of risks that caused time overruns in road construction projects. The questionnaire was distributed to thirty participants who are experts in the project team and they were given two weeks to carefully answer the questionnaires. The response rate for the questionnaire survey was 100%. According to Saaty and Ozdemir [28], in the case of AHP analysis, there are no pre-set rules to determine the acceptable sample size of experts. One expert judge may be sufficient unless political practicality requires that several judges from different constituencies are necessary.

As the AHP method might be unfamiliar to most of the respondents, the researcher conveyed a detailed explanation of the purpose of conducting the survey and the application of AHP. The respondents were required to compare the importance of two pairwise factors and to rate the scale of importance as referred in Table 1 of the chosen factor.

The questionnaire was divided into two sections. Section 1 inquired on the general information of the respondents while Section 2 examined the determination of the risk prioritisation based on AHP pair-wise format.

Section 1 consists of nine questions with a mixture of open format questions, multiple-choice questions, and yes/no questions. For open format question, respondents are required to fill in their name, email and company or department that they work for. For the multiple-choice questions, respondents choose their profession, years of experience, and academic qualification. The yes/no questions inquired if they encountered risk in the project and whether the project implements risk management practice. Finally, the final questions in Section 1, which requested the respondents to choose between four phases of the construction project (inception, design, construction, and completion) where risk management should be implemented.

5. Results and Discussion

5.1. Section one of questionnaire: General information

The respondents for the AHP survey consisted of civil engineers, assistant engineers, the main contractor, project manager, quantity surveyor, and sub-contractor of the road construction project team. The respondents' profile is tabulated in Table 3. From the table, the highest proportion is a civil engineer (30%), followed by an assistant engineer (20%), main contractor (13.33%), as sub-contractor (16.67%), while project manager and quantity surveyor (10%) respectively were actively involved in the project team. The respondents' experiences show that 43.33% of the respondents have experiences ranging from 6 years to 10 years, followed by 30% having 11 years to 15 years, 16.67% have more than 25 years experiences while only 10% that merely comes from sub-contractors have 1 to 5 years of experience. Figure 5 shows the respondent academic qualification. As seen in the figure, out of thirty respondent in the project team, nineteen of the respondents' hold a Bachelor Degree in Engineering, followed by ten of the respondents who hold a Diploma in Engineering while only one respondent holds a Master Degree in Engineering. The respondents asked whether or not they encounter any risk in the project, 77% of the respondent agreed that they faced risk in the project while the remaining 23% answered that they did not encounter any risk in the project. Additionally, while asking whether the project implemented any risk management practices, 53% responded that they do implement risk management in the project while the remaining 47% responded that there is no implementation of risk management in the project. Alamgir et al. [1] agreed that the importance of risk assessment in a road or highway project as a thorough assessment of the risk impact of large-scale road and highway projects is highly important.

A total of 60% respondents in the project team agreed that risk management should be implemented at all stages of the construction project (inception, design, construction, and completion) while 36.7% responded that risk management should be implemented in the construction stages. The remaining 3.3% chose other stages were risk management should be implemented. Bing et al. [29] addressed that risk provision framework should be implemented in the initial phases of development.

Table 3. Respondent profile.

Profession	Experience (years)			
	1 to 5 years	6 to 10 years	11 to 15 years	Over 25 years
Civil Engineer	0	4	5	0
Assistant Engineer	0	4	0	2
Main Contractor	0	1	1	2
Project Manager	0	1	1	1
Quantity Surveyor	0	2	1	0
Sub-Contractor	3	1	1	0

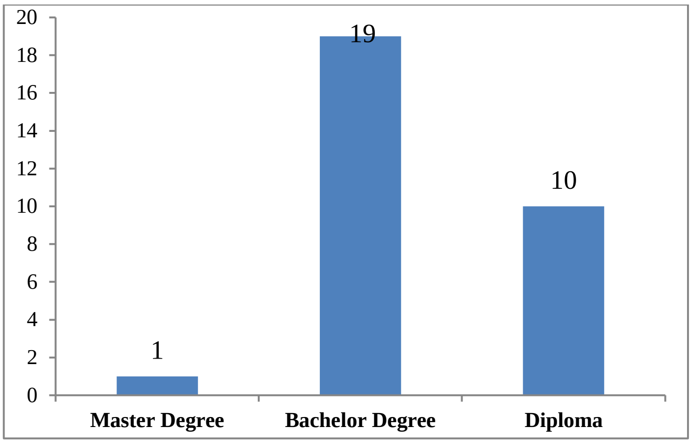

Fig. 5. Respondent academic qualification.

5.2. Prioritized risk factors

The ranking of main factors and sub-factors shown in Table 4. The main factors ranked in a descending order and it shows that the most prioritised risk factor in the road construction project with respect to goal is technical (0.242), followed by natural hazards (0.208), economic and financial (0.186), contractual (0.125), socio-politics (0.105), organisational (0.086), and resources (0.047). The sub-factors global weights were also ranked and the top-five sub-factors will be further discussed. Table 4 shows fund risk (0.111) as the prioritised risk, which caused time overrun in the project, followed by flood (0.099), heavy rain (0.092), unforeseen ground condition (0.086), and existing utility issue (0.076). The issue of fund risk in the project team was agreed by the project team as the most prioritised factor, which often led to time overrun as the project is funded by the federal budget, which is controlled, by the country climate and global economy. In the Malaysia context, Shehu et al. [30] discovered that the main criterion in causing time overrun in the Malaysian construction sector is poor finance. Aziz and Abdel-Hakam [5] gathered a similar outcome that found owner financial problem (the government) considered as the first cause causing a delay in road projects in their country, Egypt. Similarly, Choudhry et al. [12] discovered fiscal risks as the main criterion affecting bridge construction budget and project aims in Pakistan.

The second highest risk in the project is flooded factors that fall under natural hazard. The flood risk factor is contributed by the location of the project that is located on the East Coast of Malaysia. It faces the northeast monsoon between the months of October and March. The northeast monsoon brings in more rainfall that originates from China and the North Pacific. In addition, the third risk of the project is heavy rainfall and this is further worsened by the project location as in Fig. 2 nearby the coastal area. The area was also reported to be the located in the riskiest flood area during continuous heavy rainfalls. This finding by Kim and Choi [31] determined the causes of low performance in most Korea project outcomes from flood factors.

Heavy rain that continuously occurred during the construction period may result in various site problems including stops work due to discomforting condition at the site as well as safety issues. Furthermore, earth excavations may collapse and caused silt and mud to the construction area. It will worsen if it disturbs the public access road. On the other hand, before the project starts to resume, the project team needs to postpone their job until saturates materials, with earth moving, must be dry first. Then, the problem might also cause materials to become contaminated and mixed together. The roads will also be inaccessible and equipment can become bogged down. Delays are caused while the areas are pumped to be dry. Looking at the scenario, it can be affirmed that inclement weather for a particular project area can seriously delay many construction projects. However, weather condition is an uncontrollable risk and is entirely beyond the control of the project team. However, the adverse effect may be mitigated by project scheduling and proper organisation of the project site.

Site condition risk is not static. All too often, during the construction period, contractors will encounter sub-surface conditions that diverge from the established information provided earlier. Unforeseen ground conditions and existing utility issue are the following prioritised risks in the road construction project. Prior to the commencement of a construction project, a site investigation (SI) shall be conducted by the contractor and must be satisfied by the project team to ensure that the nature of ground and subsoil are ready for commenced. Otherwise, the designers will advise for any treatment on the ground condition. Discovering unforeseen ground condition or undetected sub-surface condition are mostly due to the lack of thorough ground investigation, which was carried out at the early stage of a road construction project. This ultimately caused the time overrun, the rise in the contract price from variation order, hazardous working area, and invalidated design assumptions.

Similarly, for the most infrastructure project, a utility issue in the construction project is certainly a never-ending story. Existing utility issue is ranked as the fifth prioritised risk factor, which caused time overrun in the road construction project. The existing underground electric power cable, existing main water reticulation pipe, and existing sewerage pipeline issue repeatedly occur in most infrastructure projects. Ever since the utilities are located on the sub-surface, the problems are realised during the on-going construction that ultimately caused the delay in time delivery, higher cost due to the diversion of the existing utility, and hazardous working area for the workers when involving high voltage electric cable. The same problems were reported by Vilventhan and Kalidindi [32], where they apprehended that the main cause of late delivery prevailing in Indian infrastructure projects is the diversion of utilities. Elawi et al. [33] Summarised that haphazard underground utilities (line services) are among the factors that contributed to infrastructure projects delay in Mecca, Saudi Arabia. Kamanga and Steyn [34] remarked that the delay in relocating utilities is amid the top ten causes of delay in Malawi construction projects.

Table 4. Rank of factors and sub-factors.

Factors (rank)	Sub-factors	Local weight	Global weight	(Rank)
Technical, 0.242 (1)	Unforeseen ground conditions	0.357	0.086	(4)
	Existing utilities issue	0.313	0.076	(5)
	Insufficient drawings and specification	0.202	0.049	(8)
	Frequent design change	0.129	0.031	(13)
Natural hazards, 0.208 (2)	Flood	0.475	0.099	(2)
	Heavy rain	0.441	0.092	(3)
	Heat wave	0.084	0.020	(17)
Economic and financial, 0.186 (3)	Fund risk inflation risk	0.595 0.405	0.111 0.075	(1) (6)
Contractual, 0.125 (4)	Lack of contract clarity	0.592	0.074	(7)
	Inappropriate contract	0.276	0.035	(12)
	Improper estimation	0.132	0.017	(19)
Socio-politics, 0.105 (5)	Land acquisition issue	0.378	0.040	(9)
	Changes in government law and regulations	0.343	0.036	(10)
	Changes in politics and environment	0.279	0.029	(14)
Organizational, 0.086 (6)	Lack coordination between parties	0.403	0.035	(11)
	Inadequate planning and scheduling in project team	0.311	0.027	(15)
	Unclear job roles and responsibility	0.287	0.025	(16)
Resources, 0.047 (7)	Shortage of material on site	0.428	0.020	(18)
	Late delivery of material and equipment	0.281	0.013	(20)
	Shortage of technical skill personnel	0.154	0.007	(21)
	Shortage of workers	0.137	0.006	(22)

5.3. Prioritized risk phases in project

Respondents from the project team were also assessed and it was revealed that the risk that occurred during the construction phases was the most prioritised. Figure 6 below shows the sensitivity analyses with respect to the factors produced by the Expert Choice 11 programme. There is a possibility that this figure can assist the project team to determine, which scale is the most critical phase in a construction project for each factor that leads to the delay of a project.

Based to the sensitivity analysis, it is obviously shown that the construction phase concurred the most sensitive project phase in the on-going project that may due to various risks encountered during implementation of the project including heavy rain that cause flooding to the site, lack coordination of project team and shortage material on site. This is shown with the highest factor was a natural hazard and is followed by organisation and resources. Boateng et al. [35] addressed that the risks during the construction phase may severely impact the overall project management processes. The importance of risk on project performance during the construction phase must not be underestimated. Risk during the construction phase could cause the project to overrun in time and cost and quality deficiency. Referring to the figure, a dramatic decrease is seen when dealing with technical factor during the construction phases.

The second sensitive project phase is during the planning stage, i.e., project inception and contractual captured the most factors led to the delay in the project. Lack of contract clarity provided for the project caused several disputes due to contractual matters thus, dragging the project time delivery, and cost overrun. Haugen et al. [36] listed several challenges faced by the client during the inception of the road project including inadequacies in the technical design and lack of control of the sub-contractors. Similarly, Tumi et al. [37] discovered improper planning as the foremost criterion in deferment of construction projects in Benghazi city of Libya. Li et al. [38] identified the planning deficiency is the most top major cause in China expressway projects. Nevertheless, design phases were remarked as the third highest and obviously technical factors entailed during the design phases. The completion phases (handing over stage) mark the lowest of the project phases that will contribute risk in delaying the project with the highest factor corresponding to socio and politics.

Based on the result obtained, it can be deduced that risk occurred in most situations during construction does not matter from inception, design, construction until the completion of the project. Since risk itself is unique and challenging, managing risk should start not when the construction begins. Preventive measures during inception (planning) phases until the completion of the project should be created and implemented.

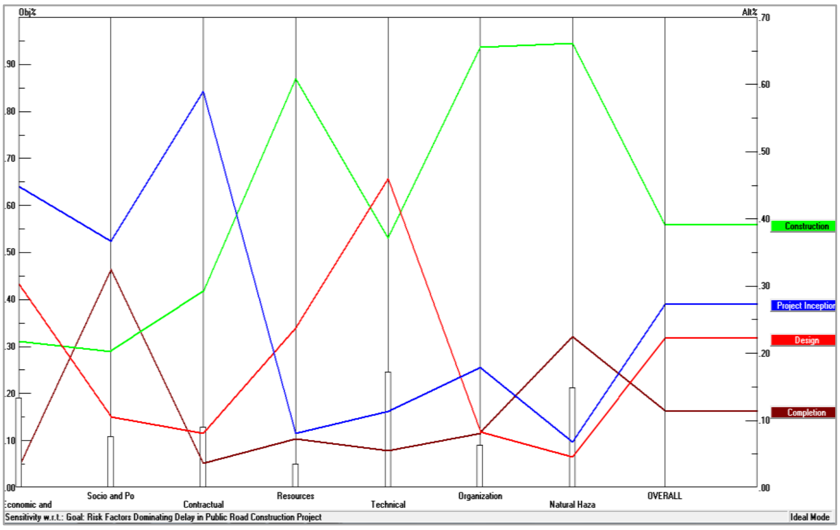

Fig. 6. Sensitivity analysis of project phase-factor.

6. Conclusion

This study proposes 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 with respect to the goal, the technical factor (0.242) captured the most prioritised risk factor that caused by unforeseen ground condition (0.086), followed by natural hazard (0.208) caused by the flood (0.099) as the second and economic and financial (0.186) caused by fund risk (0.111) as the third prioritized risk factors in the construction project.

In addition, a sensitivity analysis was carried out to study the impact of the different factor areas in determining the project construction phases. The sensitivity analysis, shown that the construction phase concurred the most sensitive project phase in the on-going project that may due to various risks encountered during implementation of the project including heavy rain that causes flooding to the site project, lack coordination of project team and shortage material on site. The second sensitive project phase is during the planning phase, i.e., project inception and contractual captured the most factors led to the delay in the project. Lack of document contract clarity provided for the project might cause disputes among project team that due to contractual matters. Under those circumstances, it will drag the project time delivery, and cost overrun. In addition, this study highlights that risk factors having a great impact on the economic and financial aspect of the project such as fund risk provided by the federal government were considered the most important by the road construction project team. Nevertheless, this study is only captured the risk identification stage in determining the prioritized risk factors and the most sensitive project phase among the encountered risks. Future studies are recommended to include the risk responses and risk monitoring for the cycle of risk management report.

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 others mega development construction projects.

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Nomenclatures

A	Determinant of matrix
aij	Element of matrix
λmax	Largest Eigenvalue
w	Weight vector

Abbreviations

AHP	Analytical Hierarchy Process
CI	Consistency Index
CR	Consistency Ratio
MCDM	Multi-Criteria Decision Makin
RI	Random Index

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