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Risk assessment framework on time impact: Infrastructure projects in soft soil during construction stage

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Abstract. With the growth of economy and population, there is an increase in infrastructure construction projects. As such, it is unavoidable to have construction projects on soft soil. Without proper risk management plan, construction projects are vulnerable to different types of risks which will have negative impact on project's time, cost and quality. Literature review showed that little or none of the research is focused on the risk assessment on the infrastructure project in soft soil. Hence, the aim of this research is to propose a risk assessment framework in infrastructure projects in soft soil during the construction stage. This research was focused on the impact of risks on project time and internal risk factors. The research method was Analytical Hierarchy Process and the sample population was experienced industry experts who have experience in infrastructure projects. Analysis was completed and result showed that for internal factors, the five most significant risks on time element are lack of special equipment, potential contractual disputes and claims, shortage of skilled workers, delay/lack of materials supply, and insolvency of contractor/sub-contractor. Results indicated that resources risk factor play a critical role on project time frame in infrastructure projects in soft soil during the construction stage.

1. Introduction

The construction industry in Malaysia is developing steadily. A lot of rural areas are being developed to improve the living lifestyle and the overall development of the land. Infrastructure development in a country is influenced by a few factors, such as physical make-up of country, the growing economy, and the socio-economy disparities between each state [1]. Since the independence, Malaysia has been growing at a steadily good pace, this encourages more development in the country. New and old infrastructures are being developed, modernized and refurbished to serve the community even better. In addition, together with the congestion of population around the country, it increases the changes of construction work on soft soil area.

Infrastructure plays an important role in a country's development. According to MSG Experts [2], countries that are more advanced are seen to have better physical infrastructure such as better roads, stations, and other form of infrastructures as well. Infrastructure opens up the connectivity within the country as well as the connectivity to the outside world, thus encouraging more trades to occur.

There are several failures of infrastructures on soft soil throughout the years and there are a number of the cases are not reported to the authorities or released to the public as a fear of losing business and reputation [3]. It is believed that there are more actual cases than the number it is reported. Most of the failure cases are a result from the unaware of the excess pore water pressure from the soil when it is loaded [3]. According to an article written by [4], soil that are having low shear strength and permeability but high in compressive ability is considered as soft soil. Normally, there are a few situations that will be faced during the construction on soft soil. One of the situations is the site having insufficient bearing capacity. The other risks on the construction on soft soil are such as having continuous settlement after construction, unstable during excavation and embankment construction, and others as well [4].

Risk management is very vital in a construction project as it helps to reduce loss and maximize the profit [5]. Risk management system is used in many fields because it ensures a smooth operation of work and improves the efficiency as most of the possible risks that may happen are being identified and counter measures are implemented to prevent distuption to work as much as possible. As the construction process takes a long time to complete, thus it is very vulnerable of having time and cost overrun [5].

2. Research aim and scopes

2.1. Research aim

The research aim is to propose a risk assessment framework in infrastructure projects in soft soil during the construction stage based on time element.

2.2. Research scope

The scope of this research was focused on general infrastructures such as bridges, tunnels, roads, and sewerage system on soft soil. The risk factors are focused on time element only as this factor is one of the most influential element in a construction project. The research boundary is within the West and East Malaysia. The soft soil in this research refers to such as peat soil, loam soil, clay soil, and other soft soils available in Malaysia. Finally, this research focused on the construction stage.

3. Literature review

Based on the literature review, numerous studies focused on assessing risks in infrastructure projects. For examples, [6] focused on assessing risk and uncertainty inherent in Chinese highway projects and [7] focused on the application of risk assessment framework in a cross-sea route project in China. However, little or none of the studies focus on risk assessment in infrastructure projects in soft soil. Internal risks were covered in this research which is defined as risks that are caused by project team members. Table 1 indicates the internal risks extracted from some main literature. A total of 21 internal risks were identified and were categorized under 4 main groups, namely, resources risk, technical risk, project and client-related risk and legal risk as showed in Figure 1.

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Table 1. Internal Risk Factors

Internal risks	Literature								
	A	B	C	D	E	F	G	H	I
Lack of special equipment	o								
Delay/lack of material supply	o								o
Shortage of skilled worker	o								
Poor/lack of soil treatment				o	o				
Poor/lack of site safety measures							o	o	
Poor site investigation		o							
Poor project planning		o							
Poor site management		o							
Delay due to contractor, sub-con, supplier, client, consultant			o						
Inexperienced contractor		o	o					o	
Bad workmanship	o							o	o
Inexperienced project manager			o						o
Technical difficulties in utilities diversions		o							
Complexity of project			o			o		o	
Project scope change/scope ambiguity		o							
Client's financial difficulties			o						
Tight project schedule			o					o	
Unrealistic/inadequate budgets			o						
Potential of contractual disputes and claims	o								
Problems in dispute settlement			o						
Insolvency of contractor/sub-contractor			o						

Notes:
A = [6]; **B** = [8]; **C** = [9]; **D** = [10]; **E** = [3]; **F** = [11]; **G** = [12]; **H** = [13]; **I** = [14]

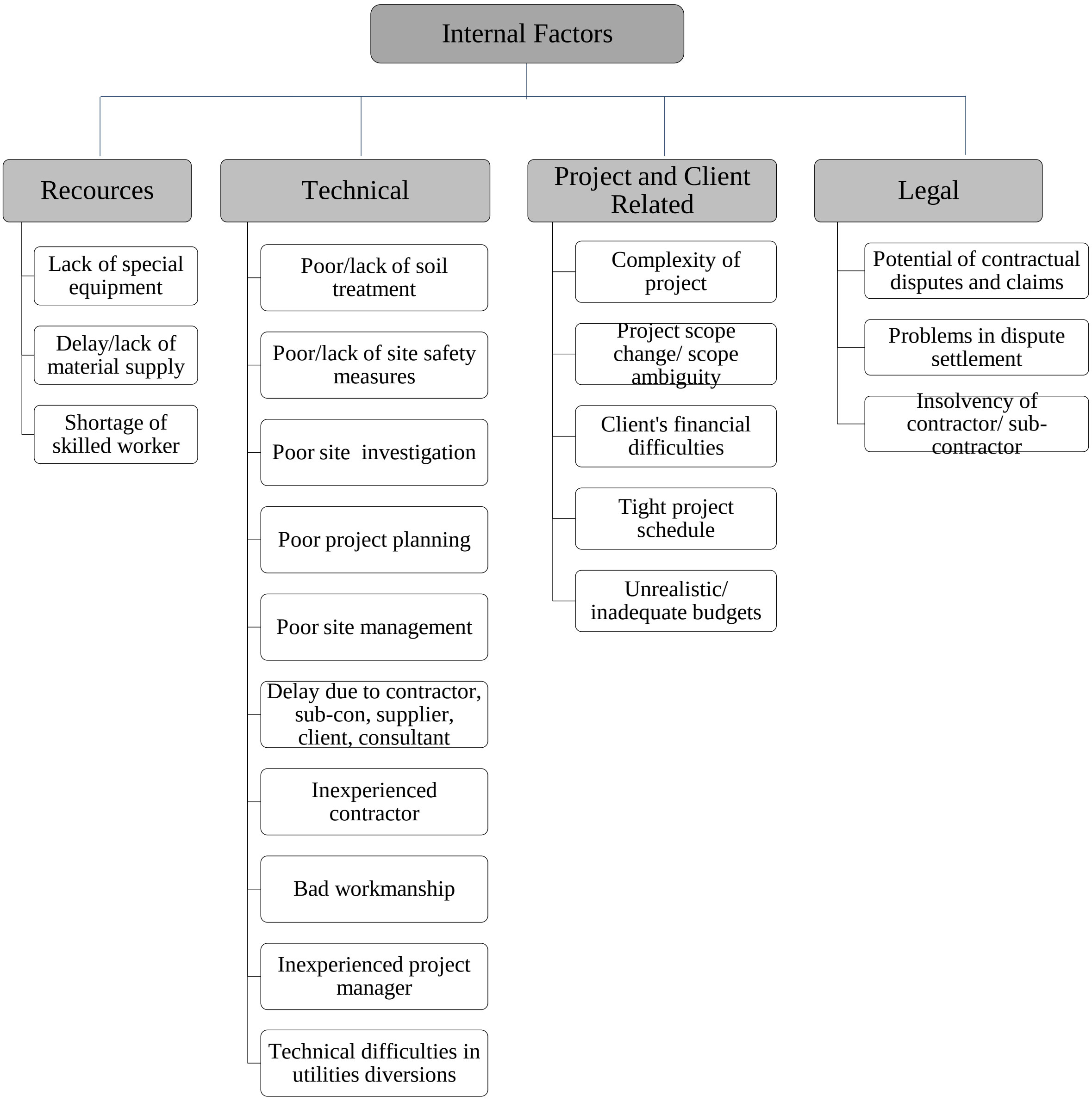

Figure 1. Internal risks hierarchy.

4. Research methodology

The research strategy used in this research is the quantitative research. The research method of this research was questionnaire survey. This is because the time is a limiting factor in this research. We need to complete this research within a year, thus making the survey method the most favorable. In this study, postal questionnaire technique was used as it is more convenient and economic.

4.1. Population and sample size

In this research, the population was civil engineers in the contractor organisations. There are some criteria for the targeted experts. Those criteria are: (1) the participants had to have civil engineering background; (2) have at least 15 years of working experience in the construction industry; and (3) have been involved in at least 1 local infrastructure projects in soft soil. Construction organisations were found through the Construction Industry Development Board (CIDB) website. The targeted experts were further identified from the respective companies' websites or through phone call to the human resource department. A total of 55 plus questionnaires were sent out and 13 valid responses were received.

4.2. Data analysis

The research analysis of this study was Analytic Hierarchy Process (AHP). AHP is a structured complex decision-making technique and developed by Saaty [15]. It is a method that compares the paired criteria and then derives the ratio scales from there. AHP basically follows five simple steps: construct a hierarchy, pair-wise comparison, consistency assurance, relative-weight computation, and lastly aggregation of relative weights. This was performed by using the Microsoft Excel. Consistency check was calculated in this research with a tolerance of 10% or less which is considered acceptable

5. Results and discussions

5.1. Demographic information of the respondents

All the respondents have more than 15 years working experience and have involved in at least 1 local infrastructure projects in soft soil. The responses were considered acceptable and this was supported by some previous studies. From an example, Khalil and his fellow researchers [16] shortlisted 22 potential respondents and obtained 12 valid responses. Also, according to [17], there is no fixed to the number of respondent for AHP analysis.

5.2. Anaylsis results

Table 2 represents the abbreviations of the 21 internal risks. Based on the analysis results, the consistency ratio was less than 0.10 (10%), within the acceptable limit. Table 3 indicates the local and global weightages among the identified internal risks. Based on Table 3, resource factor (R) is found out to be the most impacting risk factor among others when considering time element which gives a score of 0.39. The resources of a project include the manpower, material, and machineries.

Among the resources risks, the most impacting risk factor is lack of special equipment (R1) with a weightage of 0.4. While, among the technical risks, poor project planning (T4) has the highest weightage on time element. The planning of a project is very important as it ensures the smooth flow of a construction. If the project is not planned properly, one process of delay or problem could postpone the whole construction. This would result in a very serious time delay and late completion of construction project can cause the client to lose money. For the group of project & client related risks, the highest weightage is project scope change/project ambiguity (PC2). A project scope change means that the work under contract changed, this would result in a new project planning and this would require time to complete. For the legal factors, potential of contractual disputes and claims (L1) has the highest weightage. According to [6], the large number of variables and sections in the contracts that make it tough and risky to manage.

Based on Table 3, lack of special equipment (R1) has the highest impact on time element. This followed by potential of contractual claim (L1), shortage of skilled worker (R3), delay/lack of material (R2) and the insolvency of contractor/sub-contractor (L3). From here, we can see that generally resources (R) and legal (L) have the most impact on time element. According to [6], their research also stated that the lack of special equipment would have a large impact on the construction project as it takes time to tale in the special equipment as it may not be easily obtainable. On the other hand, the 5 least significant factors are poor/lack of site safety measures (T2), technical difficulties in utilities diversion (T10), bad workmanship (T8), inexperienced project manager (T9) and poor/lack of soil treatment (T1). All these factors are under the group of technical risks.

Table 2. Internal Factors Abbreviation

	Resources (R)
R1	Lack of special equipment
R2	Delay/lack of material supply
R3	Shortage of skilled worker
	Technical (T)
T1	Poor/lack of soil treatment
T2	Poor/lack of site safety measures
T3	Poor site investigation
T4	Poor project planning
T5	Poor site management
T6	Delay due to contractor, sub-con, supplier, client, contractor
T7	Inexperienced contractor
T8	Bad workmanship
T9	Inexperienced project manager
T10	Technical difficulties in utilities diversions
	Project & Client Related Risks (PC)
PC1	Complexity of project
PC2	Project scope change/scope ambiguity
PC3	Client's financial difficulties
PC4	Tight project schedule
PC5	Unrealistic/inadequate budgets
	Legal (L)
L1	Potential of contractual disputes and claims
L2	Problems in dispute settlement
L3	Insolvency of contractor/sub-contractor

Table 3. Local and Global Weightage for all Comparisons between Internal Factors

Risk Factors			Local Weightage	Global Weightage
Level 1		Level 2		
R	0.39	R1	**0.40**	**0.157**
		R2	0.28	**0.110**
		R3	0.31	**0.122**
T	0.15	T1	0.09	***0.013***
		T2	0.04	***0.006***
		T3	0.10	0.015
		T4	**0.17**	0.025
		T5	0.16	0.024
		T6	0.11	0.017
		T7	0.11	0.017
		T8	0.07	***0.011***
		T9	0.08	***0.012***
		T10	0.06	***0.009***
PC	0.16	PC1	0.17	0.028
		PC2	**0.31**	0.050
		PC3	0.19	0.030
		PC4	0.15	0.023
		PC5	0.19	0.030
L	0.30	L1	**0.43**	**0.128**
		L2	0.26	0.078
		L3	0.32	**0.095**

6. Conclusions

Throughout the research, it was found that resource factor has the highest weightage on time element. The 5 most significant risk factors are lack of special equipment, potential of contractual disputes and claims, shortage of skilled worker, delay/lack of material supply and insolvency of contractor/sub-contractor. Therefore, when a contractor company is contracting an infrastructure project in soft soil, they should be aware of the possible risks that are mentioned in this research and pay more attention on the top 5 listing risk factors and come out with an appropriate response plan so that when risks occur, they will have a countermeasure to deal with the risk. It is believed that this research can bring out awareness to the civil engineering industry as the construction on soft soil may poses different risks compared to other soil type. Engineers that take part in a soft soil construction need to be noted of the possible risks. Other than that, it can serve as a preliminary guideline for construction professionals during the planning, budgeting, and managing stages. This research was focused on the construction stage and did not cover other construction project stages such as designing stage, planning stage, and operational stage. Different risk factors may occur during different stages. Therefore, to fully understand how the risk factor changes throughout the whole project, future research on different project stages is recommended.

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