A Risk Management Approach to Address Construction Delays from Client Aspect

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ABSTRACT

Delay risk factors associated with clients have a major impact on the successful delivery of a construction project. Research studies conducted so far have unsuccessful in delivery an effective methodology that helps in analysing and managing the client risk factors at the early design stages in a construction project. To that context, the study aims to provide a new methodology for a client risk management model (CRMM). The study includes the development of a framework by integrating the findings from the literature review and a construction industry survey. A client risk analysis system is developed by integrating the analytical hierarchy process and Monte Carlo simulation underpinned within @Risk program. A case study is used to demonstrate the methodology and found that it is capable to manage the risks with a suitable risk mitigation strategy and supports the proactive actions at the design stage of a construction project from client aspect.

INTRODUCTION

The construction industry in the Kingdom of Saudi Arabia (KSA) is one of the largest and fastest growing industries and significantly contributing to the GDP of the Kingdom's economy. The construction sector of KSA reported 11.6% growth in 2011 compared to 7.8% in 2010 (Bank Audi, 2012) and this figure is expected to rise at the end of 2013 (Arab News, 2012). The companies around the world including KSA are facing delays due to various factors that have deep impact on the construction projects and eventually result in cost and time overrun. According to Al-Kharashi and Skitmore (2009), 59% water and sewage projects in the Eastern Province of KSA were delayed due to a number of factors. Likewise, Assaf and Al-Hejji (2006) reported that 70% of all public sector construction projects fail to complete on time. Several studies have been conducted in the past to investigate and address the causes and impact of delay in the industry. Hence, this study focuses on identifying and addressing delay issues and help clients to reduce the impact of client risk factors that causes project delay using a risk management approach.

LITERATURE REVIEW

In order to address the problem of delays, a number of researchers (Smith *et al.*, 2009; Chapman, 2011) have conducted studies that take risk management techniques into account. These studies have identified a range of risk management tools and techniques that can be applied to a construction project, but have emphasized only a few techniques, including interviews, checklists, surveys, brainstorming, PERT, probability-impact analysis and the Delphi method. Hull (1990) introduced different models, based on Monte Carlo simulation (MSC) and PERT, to assess proposal risk from cost and duration points of view. Hastak and Shaked (2000) deploy the analytical hierarchy process (AHP) within a framework for assessing international construction projects, with risk modelled as P-I (probability-impact analysis). Although the model provides an assessment of project risk levels, the assessment methodology is rather simplistic and problematic to use a predetermined scale. A decision support system (DSS) proposed by Dey (2001), is based on AHP and decision trees. Moreover, Dikmen and Birgonul (2006) use AHP within a multi-criteria decision-making (MCDM) framework for risk and opportunity assessment of international construction projects. The model cannot be used to quantify or assess project risk; it only compares the risk of one project with other projects, and provides a relative risk score.

AHP and utility theory are used by Hsueh *et al.* (2007) to develop a multi-criteria risk assessment model for construction joint ventures. It merely proposes that decision-makers are able to make judgments: the higher the expected utility value, the lower the overall project risk. Finally, Zayed *et al.* (2008) use AHP to assign weights to risks before calculating the project risk level, which is defined as the sum of the weighted risk effects of the risk factors. However, the method of generating the project risk level, which neglects the interdependencies between risks, and the way of eliciting risk effect based on expert opinion, raises some concern.

In a recent study, Jaskowski and Biruk (2011) mentioned that the durations of project tasks are directly and separately influenced by various risk factors. However, Jaskowski and Biruk (2011) took guidelines from Dawood’s research (1998) to quantitatively analyse the delay factors in their model, using the effect of each delay factor separately to forecast the duration of tasks and the entire construction project. Hence, it can be concluded that construction risk modelling is a developing and ongoing process. No satisfactory methodology or tool for assessing construction risk factors from a client aspect in a construction project has been developed or proposed to date. The majority of existing risk assessment methods focus on risk ratings, and there is a lack of a comprehensive framework that would assess the different impacts of client risk factors at all stages in term of their delay on a construction project. Therefore, the focus of the study is to analyse and quantify impact risk factors from a client aspect.

METHODOLOGY

The study is based on the both qualitative and quantitative approach. The findings from the literature and industry survey through a small case study by adopting the balanced theoretical methods and data collection techniques. It was decided to adopt mixed methods that suit best in achieving the objectives of the study. A postal questionnaire survey followed by interviews and in depth analysis was used to conceptualise the framework of CRMM at the early design stage only but it can be enlarged in other states such as tender, construction and operation stages. The next section discusses the specification of the framework.

Framework specification. The findings of the literature suggest that different researchers hypothesise different risk factors when analysing and managing client risk factors. Hence, an industry survey was conducted to identify the potential client risk factors that influence construction projects in the KSA. The developed framework, using findings from the literature review and construction industry survey shows that the client's risk factors are grouped into four stages: the design stage, tender stage, construction stage and operation stage but this study focus on the design stage only (see Figure 1). The next section explains the information flow diagram for the system.

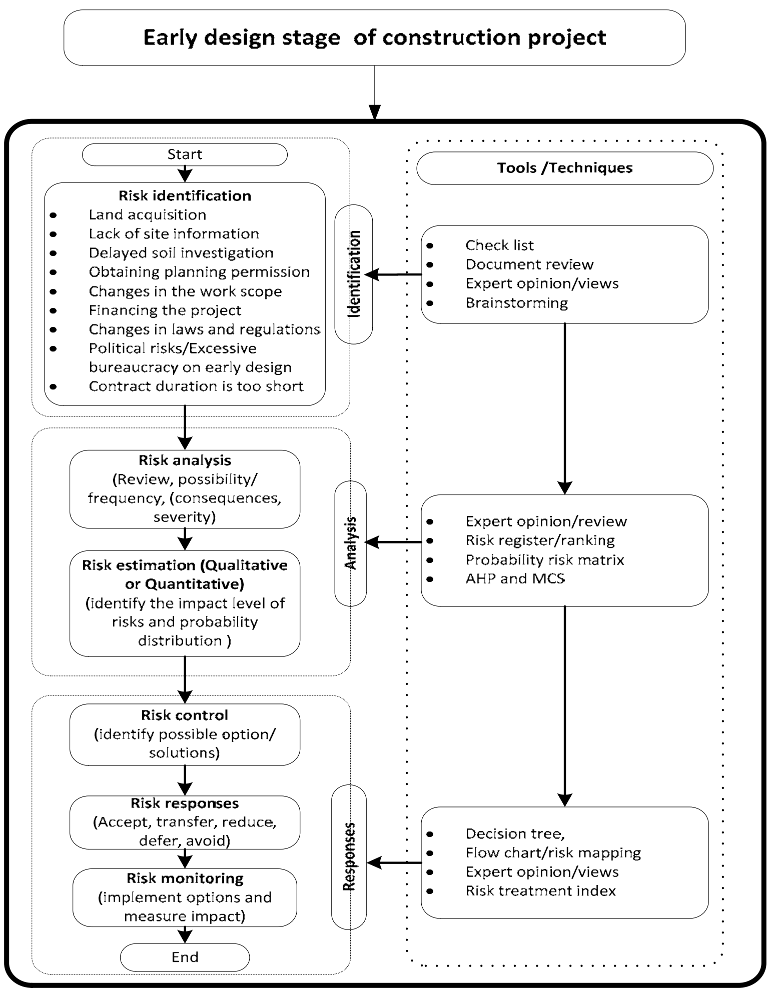

Figure 1. Framework of CRMM at the design stage of a construction project

Information Flow Diagram. The specification of the framework is presented in the form of information flow diagram. The information flow diagram of the CRMM is shown in Figure 1. The diagram contains a total of nine steps that need to be followed during the quantification process considering the impact of client's risk factors in terms of expected project completion time using AHP methodology (see Figure 2).

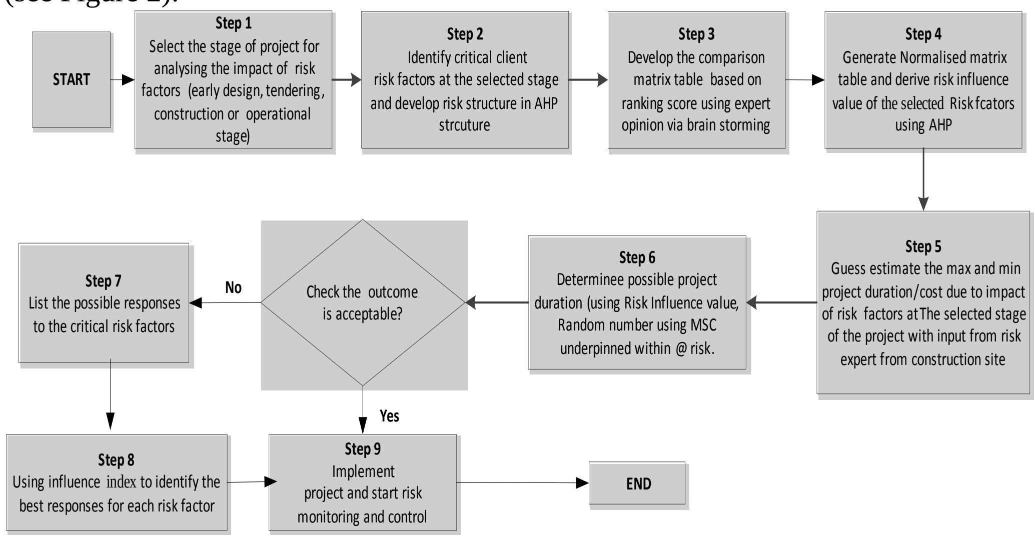

Figure 2. Information flow diagram

Risk Identification. In this process of client risk management system, questionnaire and interviews were conducted to gather the global overviews of risk factors influencing in the construction projects. The risk assessment forms are used to disseminate and rank the client risk factors at design stage. The identified critical risk factors in this process are used as input in the risk analysis process.

Risk Analysis. This section describes the development of the CRAS (see Figure 3). It is designed for the quantitative risk analysis, considering the known risk factors in a construction project. It is conceptualised under three parts: input, process and output, which are used in the early design, stage of a construction project. The figure 2 shows the key components of the CRAS.

Inputs. A list of client risk factors, comparison matrix table and the maximum/ minimum possible durations of the project are the key inputs of the model.

Inputs		
Client's risk factors at the selected stage of project	Risk ranking score in the Comparison matrix table	Min and max project duration

Process			
Producing Normalized matrix table	Applying AHP on client Risk factors	Random number generation for each RF	Running MCS using risk software

Output		
Quantification of delay duration	Confidence level of the project duration	Sensitivity report of the risk factors

Figure 3. CRAS model

The client risk factors which are critical at the selected stage of the construction project are identified by analysing the survey data, and discussion with the professionals of risk experts at the brainstorming stage as discussed in risk identification section above. A comparison matrix table is developed using the ranking score of the critical client risk factors through the brainstorming meeting with the risk experts using risk assessment form. The maximum possible project duration when all risk factors of design stages have influence to the construction project and the minimum project duration the risk factors at design stage have no influence to the project are estimated with the help of the risk experts. The known inputs are processed to get the expected outputs using the client risk analysis system. The next section discusses the process of the system.

Process. During the processing stage of the client risk analysis system, the critical client's risk factors, affecting on a construction project are analysed using the comparison matrix table, which is designed based on the AHP method. The ranking scores in terms of impact in project delay of each client risk factor are gathered in the comparison matrix table, and then converted into the normalised matrix table, which helps to identify the influence value of each risk factor. The equation 1, which has been validated by Dawood (1998), is selected in the study to calculate the possible duration of project because the equation helps to quantify the expected project duration, taking into account the impacts of the risk factors affecting on project. Therefore, this method was considered for the calculation of the possible duration of a project in the study.

The maximum and minimum durations of project (guess estimate from experts), influence values/impact of risk factors (identified using AHP method) and the random numbers (probability found through MCS) of each risk factor are a multiple factors, which are integrated in the equation 1 to quantity the best possible duration of the project. The formula of the equation 1 is shown below where *Min Time* = the minimum that can be assigned to project, *Max Time* = the maximum that can be assigned to project, *Random* n = random numbers generated by MCS for the selected type of risk distribution (probability/likelihood), and RF_n = Influence value of risk factor (n) on a project.

$$\text{Possible Duration} = \text{Min Time} + [\text{Max Time} - \text{Min Time}] \times [(RF1 \times Rand1) + (RF2 \times Rand2) + (RF3 \times Rand3) + \ldots\ldots + (RF_n \times Randn)] \qquad \text{Eq. 1}$$

Outputs. After processing the inputs into the CRAS as discussed above, following outputs are generated:

- The possible quantification of the project duration considering the impact of risk factors at the selected stage of the project. This provides information about the maximum, minimum and mean duration of the project at the known level of confidence in graphical and tabular format, considering the impact of all selected risk factors on project the selected stage of the project.
- Sensitivity report of the selected client risk factors at design stage. This provides the tabular and graphical view of the sensitivity of client risk factors, which are more sensitive than others when risk factors are affecting the project duration. Thus suitable risk responses strategy was selected based on the sensitivity report to reduce the impact of risk factors on the construction project. The next section provides the risk response strategy.
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Case Study Demonstration. The proposed client risk management model was applied to run a case study of the construction of King Abdullah University of Science and Technology project in Jeddah city in the KSA. The project duration was estimated 24 months (625 days) based on 6 working days per week and awarded this project to build. Actually, the project was delayed by additional 14 months. The case study was run based on the original project duration and only client's risk factors were included in the study to analyse the impact of these factors on overall project duration. The key inputs of the CRMM are shown in Table 1 below.

Table 1. Expected impact of critical client risk factors on overall project duration

Risk ID	Critical client risk factors at design stage	Influence value (I_b)	Selected distribution types of RF based on expert views	Random= P_b identified by MCS
RF1	Owner's lack of experience in construction	0.1814	Uniform (0,1)	0.50
RF2	Deficiency in drawings	0.1318	Triangle (0, .4,1)	0.46
RF3	Design errors made by designers	0.0575	Uniform (0,1)	0.25
RF4	Mistakes in soil investigation	0.0701	Triangle (0,.2,1)	0.50
RF5	Incompetent design office	0.0425	Uniform (0,1)	0.30
RF6	Inadequate early planning of the project by client	0.0382	Triangle (0,.4,1)	0.50
RF7	Land acquisition	0.0663	Triangle (0, .3,1)	0.43
RF8	Contract duration too short	0.0821	Normal (0,1)	0.35
RF9	Lack of site information	0.0940	Beta (4,2,0,1)	0.50
RF10	Lack of coordination between ministries about readiness of the site	0.2411	Triangle (0,.3,1)	0.43

The case study results showed that the possible project duration might be 613 days when the impact of risk factors associated with client were analysed and considered in the project duration. The impact of risk factors associated with client in this project included all the client risk factors at design stage. The sensitivity report of showed that contract duration too short is the most critical risk factors followed by lack of client experience compared to other risk factor of client (see Figure 4).

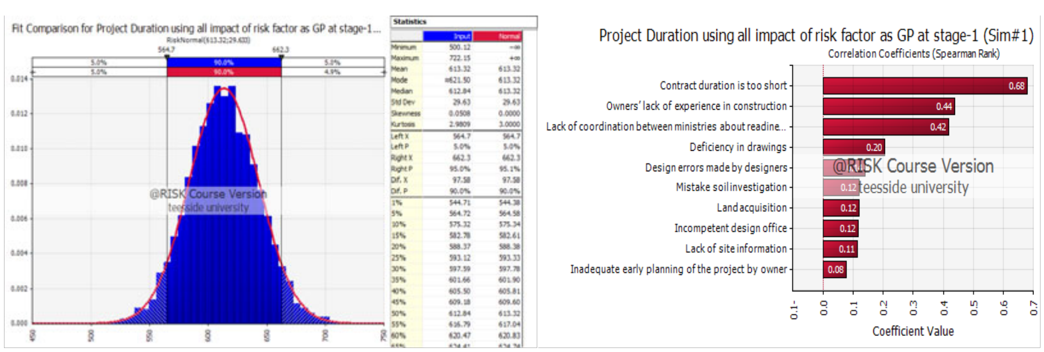

Figure 4. Probability and correlation coefficients graph before risk treatment

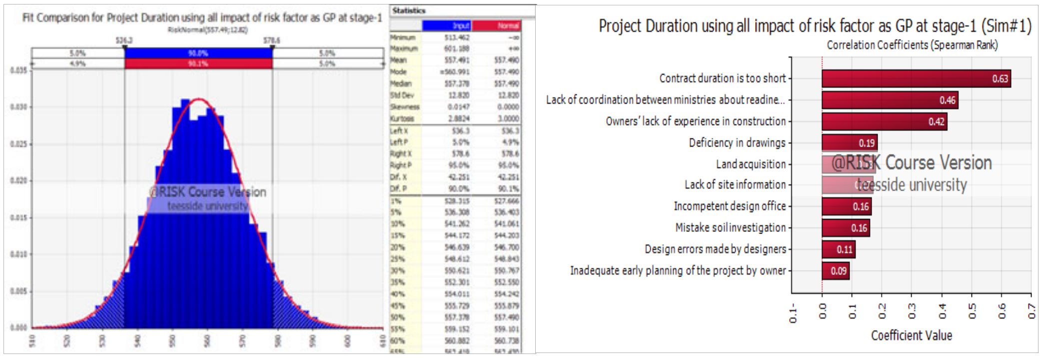

Figure 5. Probability and correlation coefficients graph after applying risk treatment

To reduce the impact of critical risk factors from client aspect were analysed and suitable risk mitigation strategy was applied for risk treatment. After applying risk treatment, the project was simulated using @risk programme and considering the reduced impact values of risk factors. The final result showed that the project duration was reduced from 613 to 557 days (see Figure 5). The case study result confirms that the proposed risk management model is capable of analysing and quantifying the impact of client risk factors on project duration

SUMMARY

The study presents a framework of client risk management model, which assist to client to quantify the impact of client risk factors at design stage of the project. The impacts of the risk factors are analysed and quantified in terms of expected project duration with certain probability using AHP and MCS techniques, which are underpinned within the @Risk program. The outputs of the system are the sensitivity report of the risk factors and the probability graph with confidence levels achieved by the client during the project. The case study reveals that the construction project duration varied from 564 to 662 days with a finishing point probability of 50% when considering risk factors associated with clients at the design stage. After applying the suitable risk response strategy, the case study results indicated that the project might have been completed within 536 to 578 days with a probability of 50% under normal distribution. It is concluded that the model help to clients in analysing and managing the client risk factors at design stage of a construction project. The model is useful for both public and private clients to address the delays and take proactive actions to reduce the impact of delay in a construction project.

FUTURE RESEARCH ACTIVITIES

The next stage of the study will focus on developing the model all stages of a construction project from client aspects and will run more case studies to evaluate the model so that its practical significance will be evaluated.

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