Sustainable Solutions in Structural Engineering and Construction
Edited by Chantawarangul, K., Suanpaga, W., Yazdani, S., Vimonsatit, V., and Singh, A.

ISBN: 978-0-9960437-0-0

A NEW METHODOLOGY FOR ADDRESSING CLIENT RISKS IN CONSTRUCTION PROJECTS

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Delay-risk factors associated with clients in a construction project have a major impact on a successful delivery on time and within budgeted cost. Risk management studies so far have not effectively managed project risk factors in a way that can assist clients in creating strategies to reduce impacts and risk. To address these issues, the study aims to provide a new methodology for analyzing and managing the risks by building a conceptual model. The study includes the development of a framework, named the client risk management model (CRMM), by integrating the findings from a literature review and a construction industry survey. A client risk analysis system was developed by integrating the analytical hierarchy process and a Monte Carlo simulation within an @Risk program. A case study demonstrated the methodology to analyze and quantify the impact of risk factors, and to create a suitable risk mitigation strategy at the design stage of a construction project. The system was found to be useful for quantifying the impact of client risks and the support in taking proactive decisions.

Keywords: Risk analysis, Construction delay, Design stage, Risk management model, Analytical hierarchy process, Risk mitigation.

1 INTRODUCTION

The construction industry in the Kingdom of Saudi Arabia (KSA) is one of its largest and fastest-growing industries, significantly contributing to KSA's GDP. KSA's construction sector reported 11.6% growth in 2011, compared to 7.8% in 2010 (Bank Audi 2012). Construction projects around the world are facing delays due to various factors that eventually result in cost and time overrun. Assaf and Al-Hejji (2006) reported that 70% of all public sector construction projects fail to be completed on time. Several studies have been conducted to investigate and address the causes and impact of industry delays. Hence, this study focuses on identifying and addressing delay issues and helping clients to reduce the impact of risk factors that cause project delay, by using a risk management approach.

2 LITERATURE REVIEW

In order to address the problem of project 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 the Monte Carlo simulation (MSC) and PERT, to assess proposal risk from cost and duration points of view. 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 risks because it only compares the risk of one project with other projects, providing a relative risk score rather than quantifying impact.

Zayed et al. (2008) use AHP to assign weights to risks before calculating the project risk level, 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, raise some concerns. 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 terms 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.

3 METHODOLOGY

The study is based on the both qualitative and quantitative approach. Findings from the literature and the industry surveyed a small case study and adopted balanced theoretical methods and data collection techniques. A postal questionnaire survey followed by interviews and in-depth analysis was used to conceptualise the framework of CRMM at the early design stage (see Figure 1). The next section explains the information flow diagram for the system.

3.1 Information Flow Diagram

The specification of the framework is presented in the form of an 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 when quantifying the impact of client risk factors, in terms of project completion duration with certain probability using AHP technique (see Figure 2).

3.2 Risk Identification

Under this client risk management system, a questionnaire and interviews were conducted to identify and rank the possible clients' risk factors influencing the design stage of the construction projects. Risk assessment forms were used to rank the client risk factors, then were input into the client risk analysis system (CRAS).

3.3 Risk Analysis

This section describes the development of the CRAS. It is designed for quantitative risk analysis, taking into account the known risk factors in a construction project. It has three parts: input, process and output. Figure 3 shows the key components of the CRAS. A list of client risk factors, a comparison matrix table, and the minimum/ maximum possible durations of the project are the key inputs of the model. Eq. (1)

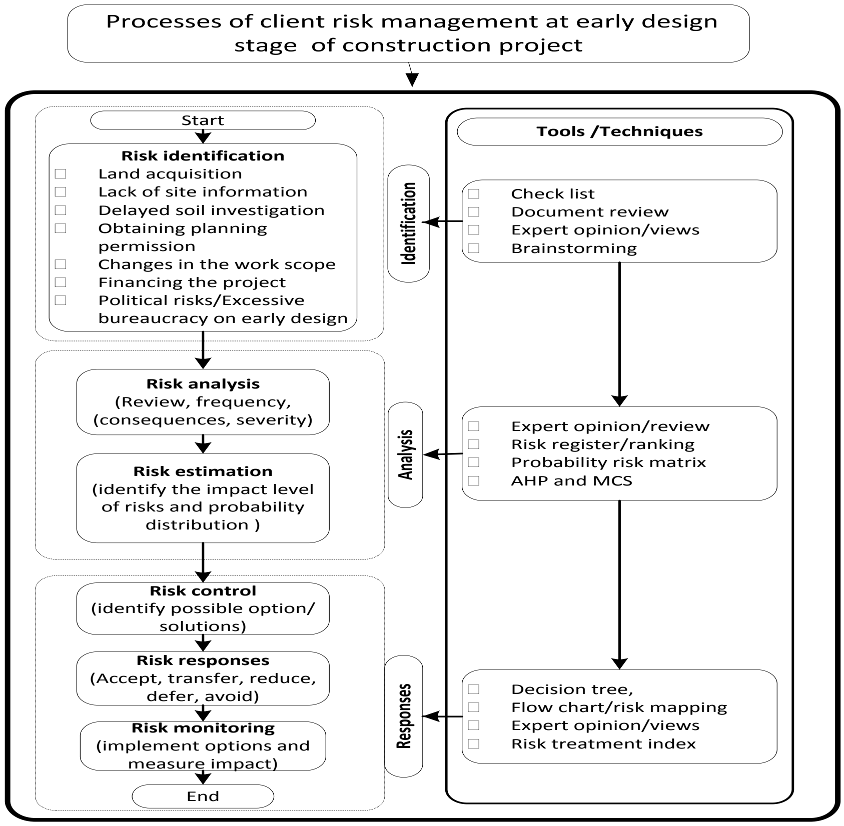

Figure 1. Framework of CRMM at the design stage of a construction project.

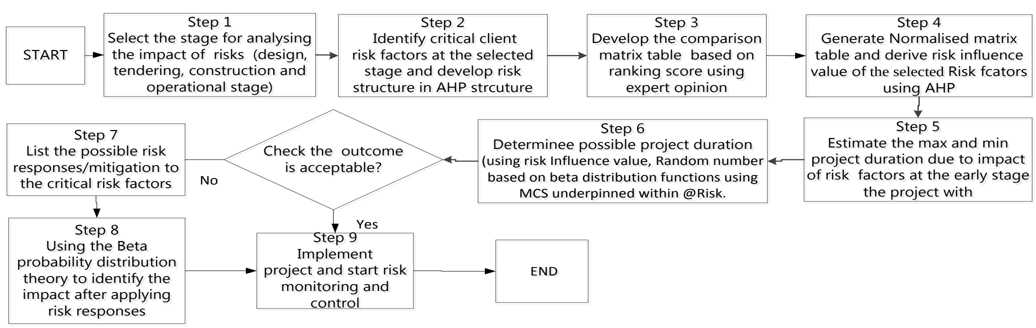

Figure 2. Framework of CRMM at the design stage of a construction project.

was selected in the study to calculate the possible duration of the project because it quantifies the expected project duration, taking into account the impact of the risk factors affecting the project. The maximum and minimum durations of a project (guesstimated by experts) influence the values and/or impact of risk factors (identified using the AHP method). Random numbers (probability found through MCS) of each risk factor are multiple factors. Both are integrated into Eq. 1:

Possible Duration = Min Time + [Max Time – Min Time] x [(RF1 x Rand1) + (RF2 x

$$Rand2) + (RF3\ xRand3) + \ldots\ldots + (RF_n\ x\ Randn)] \quad (1)$$

where *Min Time* = the minimum duration, *Max Time* = the maximum duration, *Random* n = random numbers generated by MCS of risk distribution (probability/likelihood), and RF_n = Influence value of risk factor (n) on a project.

3.3.1 Inputs

Client risk factors that are critical at the early design stage of a project are identified by analyzing the survey data. Discussion with risk experts is discussed in the risk identification section at the brainstorming stage. Estimates of the influences on the project of maximum and minimum durations are carried out with the help of risk experts. The known inputs are processed to get the expected outputs using the client risk analysis system.

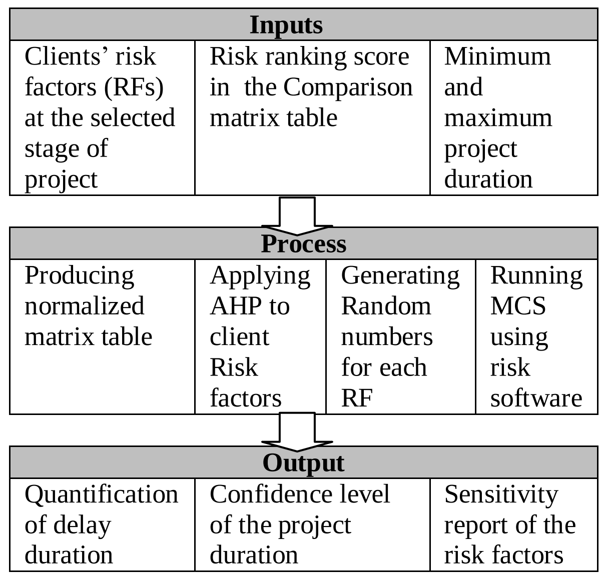

Figure 3. CRAS model.

3.3.2 Process

The critical client's risk factors are analysed using the comparison table, which is designed based on AHP method and equation 1 as shown above.

3.3.3 Outputs

The key outputs are the quantification of the risk impact on possible project durations, and the sensitivity report considering the impact of risk factors at a selected stage of the project. This provides a tabular and graphical view of the sensitivity of client risk factors, which are more sensitive than others when risk factors affect the project duration. Thus, a suitable risk-response strategy was selected based on the sensitivity report to reduce the impact of risk factors on the construction project.

4 CASE-STUDY DEMONSTRATION

The proposed model was tested with a construction project in the KSA. The project duration was estimated 24 months (625 days). In actuality, the project was delayed by an additional 14 months, due to exceptional risk. The case study was run based on the original project duration, and only the client's risk factors were included in the study to analyse the impact of these factors on the overall project duration. The key inputs of the CRMM are shown in Table 1:

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

Risk ID	Critical risk factors at design stage t	Influence value (I_b)	Selected risk distribution types	Probability (P_b) with distribution
RF1	Owner's lack of experience	0.1814	Uniform (0,1)	0.50
RF2	Deficiency in drawings	0.1318	Triangle (0, .4,1)	0.46
RF3	Design errors 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 ministries about readiness of site	0.2411	Triangle (0,.3,1)	0.43

The case study results are shown in Figures 4 and 5 below. The possible project duration might be 613 days at 50% probability, when accounting for the impact of client risk factors affecting the early design stages (see Figure 4).

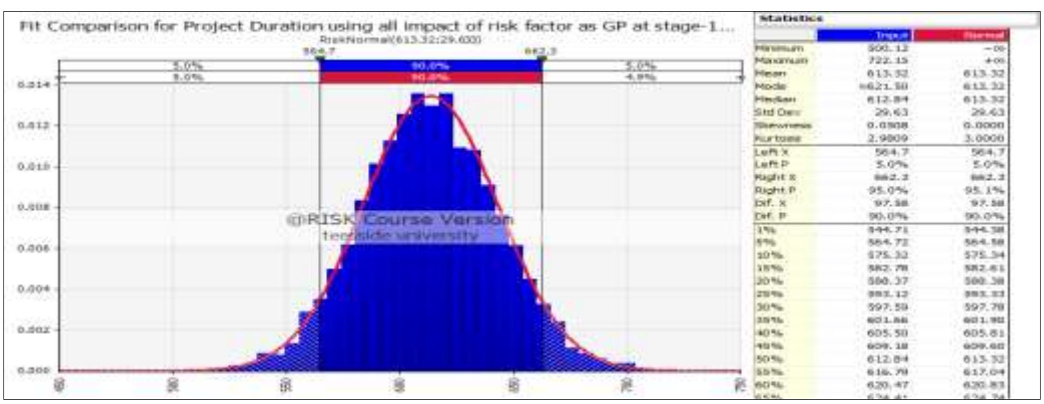

Figure 4. Probability graph before applying risk responses.

After applying the selected risk treatments/responses, the project was simulated again using @risk programme, this time considering the reduced probability of the client risk factors as shown in Table 1. It is found that the mean project duration has been reduced from 613 to 557 days (see Figure 5). The case study result confirmed that the proposed client risk management model is capable of analyzing and quantifying the impact of client risk factors at the design stage of a construction project.

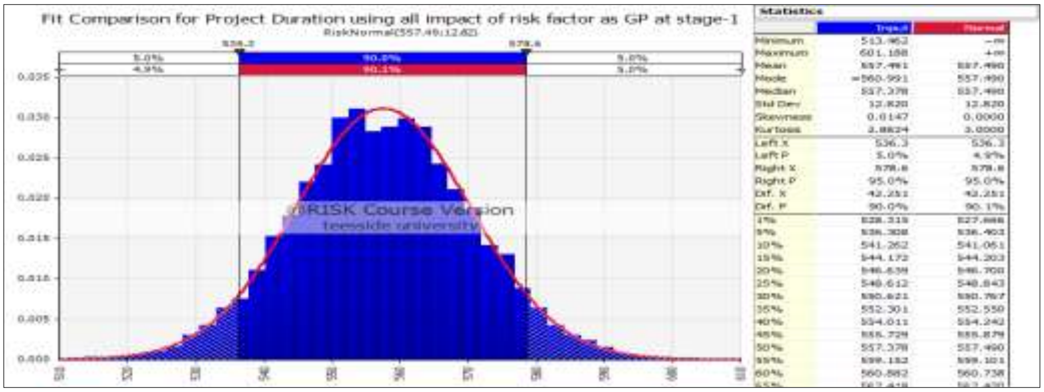

Figure 5. Probability graph after applying risk responses.

5 CONCLUSIONS

The study presented a framework of a client risk management model, helpful to analyse and quantify the impact of client risk factors at the design stage of a project. The impacts of the risk factors were analyzed and quantified in terms of expected project duration using AHP and MCS techniques within the @Risk programme. The model is useful to address delays and take proactive actions to reduce the impact of client risks for both public and private construction projects. The next stage of the study will focus on the development the model in the procurement and construction stages of the project.

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