Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 8 (20): 3738-3742, 2008
ISSN 1812-5654

Approach to Analyze Risk Factors for Construction Projects Utilizing Fuzzy Logic

[1]Amiruddin Ismail, [2]Abbas M. Abd and [1]Zamri Bin Chik
[1]Department of Civil and Structural Engineering, University Kebangsaan Malaysia, Malaysia
[2]Department of Civil Engineering, Diyala University, Iraq

Abstract: To effectively manage the risks in construction projects, it is necessary for organizations to identify important risk and to provide a tool to measure their effects. This study is a part of a research aimed to provide a methodology for identifying and ranking risk sources and factors in construction projects as approach to create an integrated construction project management system. A common problem in project risk management processes is the need to determine the relative significance of different sources of risk in order to guide subsequent risk management effort and ensure it remains cost effective. A common approach is to rank risks in terms of probability and severity to identify sources of risk that will receive the most attention. In this study, the methodology used was the collection of data in the shape of previous researches and works, interviews with experts and questionnaire survey, followed by data analysis and interpretation using fuzzy logic. The main factors of risk around the integrated project management system was studied and determined in term of effect, probability of occurrence to weight each factor.

Key words: Construction project, risks assessment, utilizing fuzzy logic

INTRODUCTION

The construction industry, perhaps more than others, has been plagues by risk and this has not always been dealt with adequately, often resulting in poor performance with increasing costs and time delays. With the need for improved performance in the construction industry and increasing contractual obligations, the requirement of an effective risk management approach has never been more necessary (Carr *et al*., 2001).

Manage the project successfully requires the application of a series of programs and tools. Quality, project management concept, cost analysis and risk management are all regarded as essential for every major project. Risk management processes, tools, documentation and communication are less standardized than any other dimension of project management. This document aims to provide a methodology for the risk management process in construction projects.

Risk identification, analysis and assessment are used to manage a consequence and the effect of risk factors depending on risk sources. Every project especially in construction is dynamic, risky and challenging. Risk and uncertainty are obviously occurred by internal or/and external factors that are inherent in nature of construction industry. To control and minimize a risk, it needs to know how to manage properly whether the risk should be transferred to others or shared fairly to the competent parties to assess risks.

Rarely project team do quantify uncertainty and systematically assess these involved risks. Furthermore, even if they assess, they will less frequently evaluate the consequences (potential impacts) associated with these risks. One reason might be lack of a rational straightforward way to combine all the facets of risk systematically into a prioritized and manageable scheme (Al-Bahar *et al*., 1993). Risk management is an important part of the decision making process. Due to the fact that risk can affect schedule, performance, quality and budget of a construction project, risk can not be truly eliminated but it can be minimized, transferred or shared from one party to another.

To fully understand risk, one must understand that risk factors vary greatly in level of importance as well as in their contribution to overall risk exposure. Certain risk factors have the potential to cause a business interruption or failure themselves, while other risk factors must work in combination with factors of equal or greater importance to cause such consequences. This paper is first to identify project based risks that are likely to impact on the project, second to rank the identified risks according to its impact on the project and finally study the interaction effect between these factors each to the other.

Corresponding Author: Abbas M. Abd, Department of Civil and structural Engineering, Universiti Kebangsaan Malaysia, Malaysia Tel: 0060176346943

MATERIALS AND METHODS

Risk identification: This study was conducted at UKM University-Malaysia during 2007 as a part of Ph.D requirements. It was started with risk identification, the objectives of risk identification are to identify and categorize risks that could affect the project and document these risks. The outcome of risk identification is a list of risks. What is done with the list of risks depends on the nature of the risks and the project. The major steps involved in risk management of a project are risk identification, risk assessment and the processes of prioritization and response to the risks (Thomas *et al*., 2006). Identification process is of considerable importance because the process of risk analysis and response management may only be performed on identified potential risks. Schatteman mentioned that the risk identification process involves identification of the major potential sources of risk associated with the project objectives. Over 81% of the project accidents related to the uncertainties in human error, planning, design and material and loads during the construction have occurred before the completion of construction. Therefore, more research is necessary to find the causes and solutions for the risks during construction phases (Choa *et al*., 2008). Risk identification process must involve an investigation into all possible potential sources of project risks and their potential consequences and documenting their characteristics. The objective of this step is to identify all potential risks and clarify how they affect the overall time duration, quality and cost of the project. After all the risks have been identified and linked together, 10 risk sources are chosen and ranked as most critical risk variables.

Risk analysis: Typically, a project's qualitative risk assessment will recognize some risks whose occurrence is likely or whose consequences are serious that further quantitative analysis is warranted. A key purpose of quantitative risk analysis is to combine the effects of the various identified and assessed risk events into an overall project risk estimate. Risk analysis involves the qualitative and quantitative assessment of the identified risk factors. Project management has to estimate the probability of occurrence of the risk factors as well as their potential impact, The risk impact on any of the project parameters is always modeled on a likelihood distribution function that represents the risk value and the likelihood of its occurrence. (Motawa *et al*., 2006). The risk management database can then be updated with the new information. It is commonly submitted in the risk management literature that part of the project risk management process requires the analysis of identified risks in terms of their potential consequences and probability of occurrence. The risk analysis is the vital link between systematic identification of risk and rational management of the significant ones. It forms the foundations for decision making between different management strategies.

Table 1: Internal and external risk sources

No.	Risk source
Internal risk source	
1	Risk related to system and documentation
2	Risk related to system management
3	Risk related to resources management
4	Risk related to realization requirements
5	Risk related to remedial requirements
External risk source	
6	Technical risks
7	Market risks
8	Financial risks
9	Political risks
10	Contractual risks

Determining the risk factors: There are several approaches to identify the risks in construction projects. Baccarini and Archer describe a methodology to risk ranking depend on prioritize risk in projects and linking the targets with the likelihood vs. consequence (Baccarini *et al*., 2001).

Important 23 risks determined by Andi *et al*. (2006) for building and infrastructure projects, it is found that the risks considered as important in building projects are also important in infrastructure projects. The risk factors can grouped to five categories; project related, government related, client related, design related, contractor related, consultant related and market related risks (Shen *et al*., 2006). In this study we will deal with 10 risk sources depending on the above literature review. The risks categorized relative to there source into two main groups:

- **Internal risk source (system related):** This group refer to all factors which concern with construction management related risk, quality management related risk and environmental management related risk.
- **External risk source (project related):** this group of risk source refers to all risk related to project processes.

Each of these groups include number of risks according to the project life cycle; Planning, Project initiation, Design, Construction, Testing, Close-Out and Operations and Maintenance (Table 1).

RESULTS AND DISCUSSION

Risk ranking methodology: After the potential risks have been identified and analyzed, it should be ranked based on their impact to project. Data will be processed in order

to quantify the effect of the major risks to the project. There are two methods in eliciting the data: Objective and subjective method. The Objective method is preferred because of its consistency and accuracy in identifying the risks but we need to retrieve data from databases or to generate data through random experiment.

These data might not available in adequate amount due to lack of historical data and particular method of each project. The parties in project are generally reluctant to document or record data as they come from field during construction or as project proceeds. Even if they do so, the data is incomplete. Therefore this information is not sufficient to be used by objective method. The data elicitation will be done by subjective method based on probability data from the decision makers who give their present state of knowledge and past experience. The data will be put as the input variables, which can be expressed as probability distribution, but it is difficult to be measured.

In this research, methodology of three elements was used to determine the risk impact on project cost, quality and time. Five levels nil, low, medium, high and extreme was used to measure the risks level, second element is the probability of risk occurrence, it is also measured by scale of five levels by the same way (Fig. 1).

The third element is the severity of risk impact which is measured as a percent. Numerical calculations consider the ranking set for both risk level and severity of risk level model for time, cost and quality For qualitative assessment, the following ranking is applied for each risk level and probability:

N = Nil effect or Nil = 1, L = Low = 2, M = Medium = 3, H = High = 4, E = Extreme = 5

The occurrences of different level for the two parameters will generate a (5 by 5) matrix. It is the multiplication result of the two parameters' rank, as shown in Fig. 2.

Using of fuzzy logic: In order to overcome this problem, fuzzy numbers have been used to represent the fuzziness of evaluating values in fuzzy risk analysis problems. In recent years, many methods have been presented for ranking fuzzy numbers. Most methods for ranking fuzzy numbers based on the shape and the deviations of fuzzy numbers. Zeng presents a risk assessment methodology to cope with risks in complicated construction situations. He apply of fuzzy reasoning techniques to provide an effective tool to handle the uncertainties and subjectivities arising in the construction process (Zeng *et al*., 2007).

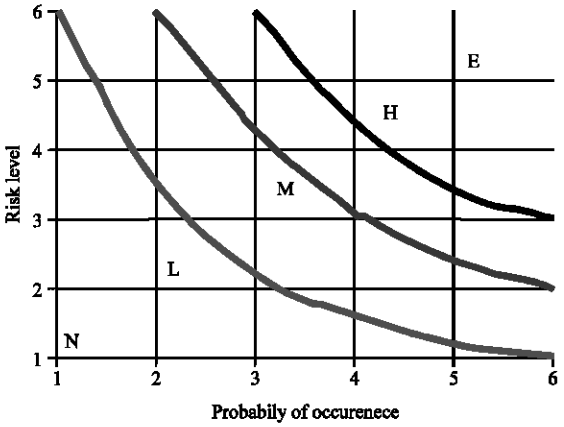

Fig. 1: Risk rating-probability relation

		Risk probability				
		N(1)	L(2)	M(3)	H(4)	E(5)
Risk severity	E(5)	E_N	E_L	E_M	E_H	E_E
		(5)	(10)	(15)	(20)	(25)
	H(4)	H_N	H_L	H_M	H_H	H_E
		(4)	(8)	(12)	(16)	(20)
	M(3)	M_N	M_L	M_M	M_H	M_E
		(3)	(6)	(9)	(12)	(15)
	L(2)	L_N	L_L	L_M	L_H	L_E
		(2)	(4)	(6)	(8)	(10)
	N(1)	N_N	N_L	N_M	N_H	N_E
		(1)	(2)	(3)	(4)	(5)

Fig. 2: Risk level and impact severity ranking

In this research, we propose the approach for ranking fuzzy numbers based on the shapes and the deviations of fuzzy numbers. Based on the proposed fuzzy ranking method, we present a method for dealing with fuzzy risk analysis problems. The proposed method allows the evaluating values to be represented by triangular fuzzy numbers for dealing with risk level, severity and probability of occurrence analysis problems. So each model listed above is according to function of the form:

$$f(m, x) \rightarrow [0,1]$$

where, m is the maximum value of the rating scale (25 in our case), x is the membership function for each parameter (i.e. N = {(0,1), (2.5,0.67), (5,0.33), (7.5,0), (10,0), (12.5,0), (15,0), (17.5,0), (20,0), (22.5,0), (25,0)} and so on for other cases). The fuzzy set for the risk level-severity relation will be in the form as below:

$$f(x): x \rightarrow [0,1]$$

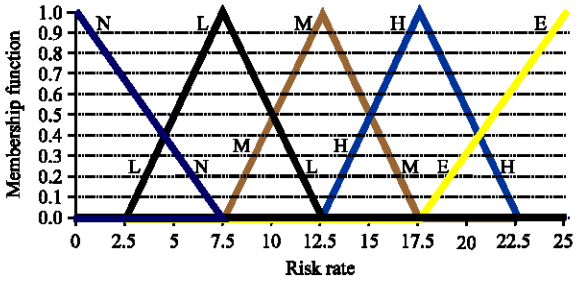

Fig. 3: Relationship of risk level-severity

N = (1, 0.67, 0.33, 0, 0, 0, 0, 0, 0, 0, 0)
L = (0, 0, 0.5, 1, 0.5, 0, 0, 0, 0, 0, 0)
M = (0, 0, 0, 0, 0.5, 1, 0.5, 0, 0, 0, 0)
H = (0, 0, 0, 0, 0, 0, 0.5, 1, 0.5, 0, 0)
E = (0, 0, 0, 0, 0, 0, 0, 0, 0.33, 0.67, 1)

The fuzzy sets represent the relationship of risk level-severity determined by graph the data above into fuzzy triangular shape as shown in Fig. 3.

The next step is the risk factors which under the 10 risk source will categorized into five levels as explained above according to the impact of the risk on the project cost, quality and schedule. A weight will assign to each factor. In this research, the questionnaire will be used to collect the information and experiences from the experts, project manager and staff. The analysis of data will be done using the following statistical formula (1 to 3) to obtain the rank of risk sources, the rank of risk factor within its source and the weighted rank of risk factor:

$$RsR(a) = \frac{\sum_1^n RfS(a) \times 100\%}{\sum_1^n RsS} \quad (1)$$

$$RfR(aa) = \frac{RfS(aa) \times 100\%}{\sum_1^n RfS(a)} \quad (2)$$

$$\overline{RfR}(aa) = RsR(a) \times RfR(aa) \times 100\% \quad (3)$$

Where:

RsR(a) = The rank of risk source (a)
RsS = The score of risk source
RfS(a) = The score of risk factors within the risk source (a)
RfS(aa) = The score of risk factor (aa)
RfR(aa) = The rank of risk factor (aa)
$\overline{RfR}$ = Weighted rank for risk factor (aa)

The Eq. 1-3 will apply for risk effect, risk probability and risk severity. The final risk rank will be:

Final Risk Rank = Risk effect×Risk severity×Risk probability (4)

For Eq. 4, final risk ranking FRR will be calculated depending on data that will collected via questionnaire utilizing fuzzy logic and ranking formulas to enable the project organization to setup strategies and alternatives to manage the risks within the project life cycle. Alternatives will develop for each risk item using value-engineering concepts. The above methodologies will result firstly in developing an administrative system to manage the project risks according to the results obtained and collected. Then the expert system will develop as a tool for assessment and manage the risk within the project.

There are two basic approaches to manage a risk: risk control and risk transfer. Risk control is the way to measure by avoiding or reducing the probability of losses occurring. This is used when the risk can not be transferred. For whatever reason we need to avoid, reduce, or retain them. The risk transfer is the way to handle the risks by transfer or shifting them from one party to another such as from client to contractor or to insurance company. However, in some conditions, risk transfer or shifting may effect reversely to them as well in long term. The second result will be developing of computer-aided tools to construct an expert system for the project risk management system under the studied conditions.

CONCLUSION

To identifying project-based risks, bottom up approach namely risk Level-Severity-Probability was utilized to determine the critical risk source and factors. Classifying method has been applied to make a decision among group of experts to rank those risks in term of effect on project cost, quality and time. Fuzzy logic used to quantify the qualitative assessment for the risk level, severity and probability relationships. However, this method can be apply for the given risk management process and into variety project cases. In addition, it can reduce confrontation and conflict as well, in case utilizing it properly. Moreover the result of this process will show the priority for the critical risk to enables project team to smartly create risk management strategies and problem solutions in each phases of project life cycle depending on the risk rank.

REFERENCES

Al-Bahar, J.F and K.C. Crandall, 1990. Systematic risk management approach for construction projects. J. Const. Eng. Manage., 116: 533-546.

Andi, Santi and Adi darmawan, 2006. Identifying and managing important risks in building and infrastructure projects: Contractors perspective. International Civil Engineering Conference Towards Sustainable Civil Engineering Practice. August 25-26, 2006, Surabaya, Indonesia, pp: 301-308.

Baccarini, D. and R. Archer, 2001. The risk ranking of projects: A methodology. Int. J. Project Manage., 19: 139-145.

Carr, V. and J.H.M. Tah, 2001. A fuzzy approach to construction project risk assessment and analysis: Construction project management system. J. Adv. Eng. Software, 32: 847-857.

Choa, T. and T.S. Kim, 2008. Probabilistic risk assessment for the construction phases of a bridge construction based on finite element analysis. Finite Elements Anal. Design, 44: 383-400.

Motawa, I.A., C.J. Anumba and A. El-Hamalawi, 2006. A fuzzy system for evaluating the risk of change in construction projects. Adv. Eng. Software, 37: 583-591.

Shen, L., A. Platten and X. P. Deng, 2006. Role of public private partnerships to manage risks in public sector projects in Hong Kong. Int. J. Project Manage., 24: 587-594.

Thomas, A.V., S.N. Kalidindi and L.S. Ganesh, 2006. Modelling and assessment of critical risks in BOT road projects. Construction Manage. Econ., 24: 407-424.

Zeng, J., M. An and N.J. Smith, 2007. Application of a fuzzy based decision making methodology to construction project risk assessment. Int. J. Project Manage., 25: 589-600.