

社会基盤整備事業のリスクマネジメント研究の概括と展望
Review of Risk Management for an Infrastructure Construction Project*

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1. Introduction

Infrastructure construction projects typically are large, uncertain, and complex. Since many parties are involved and huge investment is also required, these characteristics of infrastructure construction project lead to increase in either the number of risk factors or the degree of risks in terms of frequency and level of impact. In the case of Thailand, for example, risks occurring in an infrastructure construction project financed by an international lender are related to unclear bid documents, inexperienced of an executing agency in procurement process, financial problems of contractor, etc.¹⁾

This paper aims to provide the comprehensive reviews of risk management literatures mainly for an infrastructure construction project and to identify the area on which the future research should put more attention.

Firstly, the concept of risk management is summarized. Then, the past researches related to risk management in construction were examined to reveal the possible research area in future.

2. Risk Management Reviews

Possible risks that are involved in construction environment include external risk such as economic risk, political risk, legal risk, weather risk, public risk, etc. and internal risk such as financial risk, contractual risk, construction design risk, technical risk, personal risk etc. The typical losses of these risks are generally relevant to project delay, project cost overrun, poor quality, loss of revenue, physical damage to project, physical harm to personnel, loss of reputation and business and so on²⁾.

Thus, there is a considerable need to incorporate the risk management concepts into infrastructure construction practice in order to mitigate or eliminate risk consequence and enhance the performance of project.

This paper examines the risk management in the project management context. Initially, the clarification of terms of uncertainty, risk and opportunity, definition of risk in various fields and characteristics and measurement of risk are described. The risk identification, risk analysis

and risk response in the risk management process are then explained, respectively.

(1) Uncertainty, Risk and Opportunity

Numerous uncertain variables and risks are inherent in all construction projects. Two variables i.e., probability of occurrence of an event and outcome including consequence (favorable or unfavorable) and its probability are key for distinguishing between uncertainty and risk. First, the probability of occurrence of an event is considered as the variable used to distinguish between risk and uncertainty. The uncertainty varies between certain, the case in which the probability of occurrence is 100%, and totally uncertain, the case in which the probability of occurrence is 0%. From this viewpoint, the uncertainty exists when probability of occurrence of the event is not known³⁾. Second, the uncertainty and risk is distinguished by considering the knowledge of probability of outcome. In this distinction, risk exists when there is a range of possible outcome and the probability of outcome is known, whereas uncertainty exists when the probability of each outcome is not known⁴⁾. Third, uncertainty is realized when both the probability of occurrence of event and the consequence and probability of outcome are not known. In summary, the uncertainty exists when either probability of occurrence of event or outcome is not known and both are not known. The risk exists when the probability of occurrence of event and outcome are quantifiable. In decision theory, situations are distinguished by two broad types: (1) risky situation, which is the situation when the probability distribution functions of parameters are known, and (2) uncertain situation, which is the situation when the probability distribution functions are not known. Considering the terms opportunity, the opportunity is realized when there is possibility that the outcome of event may turn to be favorable. This illustrates the distinction among uncertainty, risk and opportunity.

Several researchers have variously defined the term 'risk.' Some definitions focus on both down-side (loss) and up-side (gain) of risk, but some only concentrate on the down-side of risk. Definitions that emphasize only down-side may fail to recognize the existence of opportunity. Risk can be defined differently depending on fields. In insurance field, term risk can be defined as follows: the chance of loss, possibility of loss, uncertainty, dispersion of actual from expected results, and probability of any outcome different from the one expected. In the context of project management, project risk is defined as the chance of certain occurrences adversely affecting project objectives^{5), 6)}.

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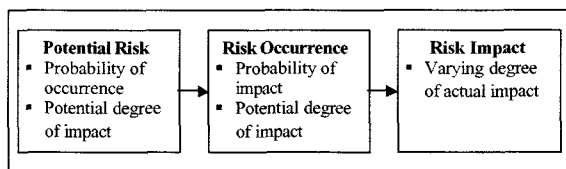


Figure-1 Phase of risk

Risk is characterized in three components i.e. (1) *the risk event*: what might happen to the detriment or in favor of the project; (2) *the probability of occurrence*: the chance of the event occurring; and (3) *the potential loss/gain*: consequence of the event happening that can be specified as loss or gain. From the above characteristics, risk may be measured by multiplying probability of occurrence with its impact⁽⁶⁾⁻⁸⁾. Some attention should be put, however, in calculating expected risk since probability multiplied by impact of risk since measuring and ranking risks according to this calculated figure is sometimes misleading⁹⁾.

Every risk evolves through three main phases: the potential risk, the actual occurrence, and the impact as shown in Figure 1²⁾. Risk should be perceived and treated early since risk will be probably developed to the last phase of its potential loss or harm. Based on Figure 1, the management of risk is not only proactive but it can be the reactive approach to manage risk when it is already occurred.

(2) Risk Management Process

There are two basic approaches to manage risks: informal and formal approaches⁴⁾. The informal risk management approach views risks in a subjective manner. For example, to subjectively determine the contingency either in percentage or lump sum is considered a risk management technique of informal approach. Using solely the rule of thumb and intuition to deal with risk may not be sufficient. Thus, the risk management process is introduced to assist a decision maker to better deal with the risk. It does not totally replace the informal approaches. Nevertheless, risk management attempt to facilitate and utilize the decision maker's intuition and experience in a more systematic and effective way as its processes are systematic, rational, logical, preventive and priority based on significant risk^{4), 7)}.

Generally, the risk management is described as a systematic approach to deal with risk. The risk management process should establish an appropriate context; set goals and objectives; identify and analyze risks; and review risk responses. In project context, the project risk management is the art and science of identifying, assessing and responding to project risk throughout the life cycle of a project and in the best interests of its objectives⁶⁾.

The risk management process has been discussed by previous researchers in different contexts such as in general context^{10), 11)}, project context^{6), 12), 13)} and construction context^{4), 7), 14)}. The standard model of risk management process can be summarized into three main processes i.e. risk identification, risk analysis and risk

response. The descriptions of these three main processes are discussed in the following sections, respectively.

a) Risk identification process

Risk identification is the process of systematically and continuously identifying, categorizing, and assessing the initial significance of risks associated with a construction project⁷⁾. The sources and type of risks are identified. Risk identification is ideally carried out during the appraisal of the project, although it can be carried out at any stage of the project⁴⁾. Risk identification should be performed on a regular basis throughout the project¹²⁾. The inputs of risk identification process include the project objective, risk management scope and plan and historical data related to project. The project related document, project participants and events occurring in the scope of project are some sources of information used to identify risk¹³⁾. It is desirable to identify risk based on the determined objectives, which are generally related to time, cost and quality aspects.

There are several tools i.e. questionnaire, risk checklist, expert system and techniques i.e. interviews, orientation, analysis of documents, inspection, and observation, which are used for identifying risk¹⁰⁾.

The desirable output of risk identification is the identified risks involved with the project or determined objectives. These identified risks may be classified based on the sources of risks as following classification: dynamic or static, pure or speculative, and fundamental or particular¹⁰⁾. The information related to identified risk can be recorded in forms of risk category summary sheet⁷⁾ or risk log (risk register)⁴⁾ or risk standard data card¹⁵⁾. By using these tools risk information are kept in the form of database.

b) Risk analysis process

Risk analysis process is the vital link between systematic identification of risks and rational management of the significant risks. The risk analysis process aims to evaluate the consequences associated with risks and to assess the impact of risk by using risk analysis and measurement techniques¹⁴⁾.

The main input to risk analysis process is the identified risks from risk identification process. The probability and impact of identified risks are two key variables in assessing the risk. In assessment of risk, there are two general types: qualitative and quantitative risk assessment^{4), 14)}. A typical qualitative risk assessment usually includes the following issues:

- a brief description of the risk;
- the stages of the project when it may occur;
- the elements of the project that could be affected;
- the factors that influence it to occur;
- the relationship with other risks;
- the likelihood of it occurring; and
- how it could affect the project.

The direct judgment, ranking options, comparing options and descriptive analysis are also considered as the qualitative risk measurement¹⁴⁾.

For quantitative risk assessment, probability analysis sensitivity analysis scenario analysis, simulation analysis, correlation analysis, portfolio theory, delphi method,

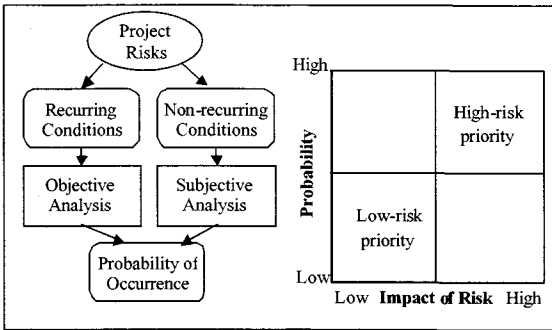


Figure-2 Probability and impact risk diagram

influence diagrams, decision trees, are lists of available techniques^{4), 14)}.

The ultimate deliverables of risk analysis process are probability of occurrence and impact level of risks. Figure 2 presents the conceptual flow diagram to quantify the probability of risk and mapping of quantified probability and impact of risk.

Based on diagram in Figure 2, the proper way to quantify probability of risk (objective or subjective) depends on the recurring condition of project risks. For the impact of risk, possible consequences of risk are defined and quantified in terms of⁴⁾:

- increased cost: i.e. additional cost above the estimate of the final cost of the project;
- increased time: i.e. additional time beyond the completion date of the project through delays in construction;
- reduced quality and performance: i.e. the extent to which the project would fail to meet the user performance based on quality, standards and specification.

c) Risk response process

Risk response process aims to provide the efficient response to the identified and analyzed risks. In risk response process, the decision maker considers how the risk should be managed, for examples, by transferring it to another party or retaining it¹⁴⁾.

Response is an action or activity that is implemented to deal with a specific risk or combination of risks. Risk responses can be categorized into four different forms: acceptance, reduction, avoidance and transfer^{10), 14)}. It is also useful to consider the timing of the response rather than being concerned too much about the type of response, which is whether the response is to be implemented before (proactive) or after (reactive) the risk occurrence.

To find efficient responses is the key in the conventional risk management process. Theoretically, the efficient response provides a minimum level of risk for a given level of impact and a minimum level of impact for a given level of risk as shown in the risk efficiency boundary in Figure 3¹³⁾.

When a specific risk occurred, the possible responses are listed up and evaluated to find the efficient response. This efficient response is the final output of the risk response process. Additionally, other desirable output can be a risk management plan.

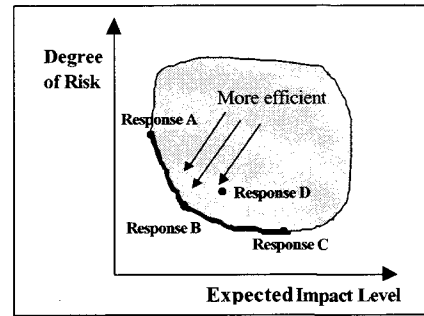


Figure-3 Risk efficient concept

3. Past Risk Management Research

This part discusses the intensive level of the past risk management researches in construction in order to reveal the possible study areas for future risk research in construction. The past risk management researches summary in this paper refers to the list of researches referred in a past study, which reviewed risk management researches in construction from 1960-1997¹⁶⁾. However, the arrangement of review results of the summary in this paper and that past study¹⁶⁾ is different. Additionally, the reviews of risk management researches from 1997-2001 are also included in this paper's summary. This paper summarizes the past risk management researches by considering the risk management researches in the areas of risk category, risk management process development, subjective issues in risk management and project type that risk management process was applied associated with each process in risk management: risk identification, risk analysis and risk response. A tentative summary of intensive level of past risk management researches in construction is shown in Table 1.

The intensive levels of previous researches, which are evaluated from the number of researches, are represented as high, medium and low, respectively. Researches that studied the economic and financial risk, building, estimating and scheduling related risks, managerial risk, political and legal risks, cultural risk, social risk and health and safety risk are included in the risk category field. Risk management process development field includes the researches that developed and proposed the process in risk management i.e., risk identification, risk analysis and risk response. Researches, which studied subjects related to subjective assessment, risk perception, risk attitude, risk communication and survey of risk management practice, are included in the field of subjective issues in risk management. Researches, which focused on the application of the process in risk management to a specific type of project, are included in the field of type of application project.

Considering researches in risk category field, most of risk researches in construction focused on risk identification and risk analysis to a specific risk i.e. economic and financial risk, bidding, estimating, and scheduling related risks. The developments of risk identification and risk analysis process were intensively researched than the development of risk response process. The intensive level of past researches related to

Table-1 Tentative summary of risk management researches in construction

Area of Risk Management Research	Risk Management Process	Risk Identification	Risk Analysis	Risk Response
Risk Category				
Economic and Financial Risk		Medium	High	Low
Bidding Related Risk		Medium	High	Low
Estimating Related Risk		Low	High	Low
Schedule Related Risks		Low	High	Low
Managerial Risk		Medium	Medium	Low
Political and Legal Risk		Medium	Low	Low
Cultural Related Risks		Medium	Low	Low
Social Risk		Low	Low	Low
Health and Safety Risk		Low	Low	Low
Risk Management Process Development		High	High	Low
Subjective Issues				
Subjective Assessment		Low	Medium	Low
Risk Perception		Low	Low	Low
Risk Attitude		Low	Low	Low
Risk Communication		Low	Low	Low
Survey of Risk Management Practice		Low	Medium	Medium
Type of Application Project				
BOT		Medium	Low	Low
Infrastructure Project		Low	Medium	Low

subjective issues in risk management such as subjective assessment, risk perception, risk attitude and risk communication seem to be tentatively low. The past researches rarely incorporated the subjective related issues such as risk perception, risk attitude and risk communication with the process in risk management. In addition, the application of risk management to infrastructure construction project seems to be less intensive than other types of project scheme such as BOT project.

From the tentative summary of past risk management researches in construction, it reveals the rooms for future research in the areas of social, health and safety risk category, subjective issues in risk management such as risk perception, risk attitude, risk communication, development of risk response process and the application of risk management process to infrastructure construction project.

4. Conclusion

As a way to deal with complex characteristics of the infrastructure construction project itself and risks inherent in the external and internal of project, it is desirable to apply the concept of risk management into the practice throughout life cycle of infrastructure construction project. The paper points out this necessity and summarizes the risk management concept including the clarification of uncertainty, risk and opportunity, definition of risk and overview of risk management process.

A tentative summary of intensive level of past risk management researches is discussed in the final part of paper. This aims to provide overview summary of past risk management researches and to reveal the possible area for future risk management research in construction. The summary shows that health and safety risk, social risk and cultural risk, the issues related to subjective i.e., risk perception, risk attitude and risk communication and development of risk response process, and application of risk management process to an infrastructure construction project were not intensively studied.

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