Identifying Key Risks in Construction Projects: Life Cycle and Stakeholder Perspectives

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Abstract

Managing risks in construction projects has been recognised as a very important management process in order to achieve the project objectives in terms of time, cost, quality, safety and environmental sustainability. However, until now most research has focused on some aspects of construction risk management rather than using a systematic and holistic approach to identify risks and analyse the likelihood of occurrence and impacts of these risks. This paper aims to identify and analyse the risks associated with the development of construction projects from project stakeholder and life cycle perspectives. Postal questionnaire surveys were used to collect data. Based on a comprehensive assessment of the likelihood of occurrence and their impacts on the project objectives, this paper identifies twenty major risk factors. This research found that these risks are mainly related to (in ranking) contractors, clients and designers, with few related to government bodies, subcontractors/suppliers and external issues. Among them, "tight project schedule" is recognised to influence all project objectives maximally, whereas "design variations", "excessive approval procedures in administrative government departments", "high performance/quality expectation", "unsuitable construction program planning", as well as "variations of construction program" are deemed to impact at least four aspects of project objectives. This research also found that these risks spread through the whole project life cycle and many risks occur at more than one phase, with the construction stage as the most risky phase, followed by the feasibility stage. It is concluded that clients, designers and government bodies must work cooperatively from the feasibility phase onwards to address potential risks in time, and contractors and subcontractors with robust construction and management knowledge must be employed early to make sound preparation for carrying out safe, efficient and quality construction activities.

Keywords: risk, risk management, construction projects, life cycle, stakeholders perspectives

Introduction

Risk management may be described as "a systematic way of looking at areas of risk and consciously determining how each should be treated. It is a management tool that aims at identifying sources of risk and uncertainty, determining their impact, and developing appropriate management responses" (Uher, 2003). A systematic process of risk management has been divided into risk classification, risk identification, risk analysis and risk response, where risk response has been further divided into four actions, i.e. retention, reduction, transfer and avoidance (Berkeley *et al.*, 1991; Flanagan and Norman, 1993). An effective risk management method can help to understand not only what kinds of risks are faced, but also how to manage these risks in different phases of a project. Owing to its increasing importance, risk management has been recognized as a necessity in most industries today, and a set of techniques have been developed to control the influences brought by potential risks (Schuyler, 2001; Baker and Reid, 2005).

Compared with many other industries, the construction industry is subject to more risks due to the unique features of construction activities, such as long period, complicated processes, abominable environment, financial intensity and dynamic organization structures (Flanagan and Norman, 1993; Akintoye and MacLeod, 1997; Smith, 2003). Hence, taking effective risk management techniques to manage risks associated with variable construction activities has never been more important for the successful delivery of a project.

Previous research has mainly focused on examining the impacts of risks on one aspect of project strategies with respect to cost (Chen *et al.*, 2000), time (Shen, 1997) and safety (Tam *et al.*, 2004). Some researchers investigated risk management for construction projects in the context of a particular project phase, such as conceptual/feasibility phase (Uher and Toakley, 1999), design phase (Chapman, 2001), construction phase (Abdou, 1996), rather than from the perspective of a project life cycle. Moreover, little research has probed risks from the perspectives of project stakeholders. As part of a much larger project aiming to articulate and manage key risks associated with construction projects, this paper presents the results of a questionnaire survey and seeks to identify the potential key risks from the perspectives of stakeholders and project life cycle.

Related Past Research and Risk Classification

Substantive research has been done in the field of risk management for construction projects, a significant outcome of which is the identification of many risks that may influence the construction project delivery. Chen *et al.* (2004) proposed 15 risks concerned with project cost and divided them into three groups: resources factors, management factors and parent factors. Through a case study on the West Rail Project of Hong Kong, Chen found that "price escalation of material" pertaining to resource factors, "inaccurate cost budget" and "supplier or subcontractors' default" pertaining to management factors, and "excessive interface on project management" pertaining to parent factors are the most significant risks in this particular project. Summarizing other researchers' work, Shen (1997) identified eight major risks accounting for project delay and ranked them based on a questionnaire survey with industry practitioners. Shen also proposed risk management actions to cope with these risks and validated their effectiveness through individual interview surveys. Tam *et al.* (2004) conducted a survey to examine the elements of poor construction safety management in China and as a result, identified the main factors affecting safety performance including "poor safety awareness of top management", "lack of training", "poor safety awareness of project managers", "reluctance to input resources to safety" and "reckless operation".

While the above research studied the diverse risks influencing the project objectives in terms of cost, time and safety, other research examined the risks or risk management in different phases of a project. Uher and Toakley (1999) investigated various structural and cultural factors concerned with the implementation of risk management in the conceptual phase of a project life cycle and found that while most industry practitioners were familiar with risk management, its application in the conceptual phase was relatively low; qualitative rather than quantitative analysis methods were generally used; widespread adoption of risk management was impeded by a low knowledge and skill base, resulting from a lack of commitment to training and professional development. Chapman (2001) translated the risks described within the Central Computer and Telecommunications Agency Publication "Management of Project Risk" into the design risks which included but were not limited to "difficulty in capturing and specifying the user requirements", "difficulty of estimating the time and resources required to complete the design", "difficulty of measuring progress during the development of the design". Chapman also stated that the design team's in-depth knowledge of the sources of risk can greatly influence the identification of risks in the design phase of a project. Abdou (1996) classified construction risks into three groups, i.e. construction finance, construction time and construction design, and addressed these risks in detail in light of the different contractual relationships existing among the functional entities involved in the design, development and construction of a project.

Risk classification is a significant step in the risk management process, as it attempts to structure the diverse risks affecting a construction project. In order to manage risks effectively, many approaches have been suggested in the literature for classifying risks. Perry and Hayes (1985) presented a list of factors extracted from several sources which were divided in terms of risks retainable by contractors, consultants and clients. Combining the holistic approach of general systems theory with the discipline of a work breakdown structure as a framework, Chapman (2001) grouped risks into four subsets: environment, industry, client and project. Of the 58 identified risks associated with Sino-Foreign construction joint ventures, Shen (2001) categorized them into six groups in accordance with the nature of the risks, i.e. financial, legal, management, market, policy and political, as well as technical risks. In a word, many ways can be used to classify the risks associated with construction projects and the rationale for choosing a method must service the purpose of the research. In this paper, the research team aims to seek to study the risks from the perspective of project stakeholders and life cycle, and hence classifies the risks in accordance with their origins concerned with stakeholders.

Research Methodology

The research methodology selected for this risk management project comprised a comprehensive literature review, a postal questionnaire to the construction industry practitioners and a statistical analysis of the survey data.

The questionnaire consisted of two sections. Section 1 solicited general information about the respondents. Section 2 carried a total of 88 risks associated with construction projects and asked respondents to review and indicate the likelihood of occurrence of these risks as highly likely, likely or less likely and the level of impact on each project objective that would result in as high, medium or low. These risks were mainly sourced from Ahmed *et al.* (1999), Chapman (2001) and Wang and Liu (2004) and to the best of the authors' knowledge, were put into nine categories, with 8 risks related to clients, 8 related to designers, 40 related to contractors, 6 related to subcontractors/suppliers, 5 related to government bodies, 5 related to superintendents, 16 related to external issues (i.e. economic circumstance, physical working environment and social environment).

The research team conducted the survey from June to August 2005. Prior to disseminating the questionnaire, a pilot study was conducted with one academic and one project manager to test whether the questions are intelligible, easy to answer, unambiguous, etc. Valuable feedbacks were obtained to improve the quality of the questionnaire. After a small refinement, the questionnaires were distributed to 60 construction practitioners in Australia. All respondents were contacted beforehand to make sure that they were familiar with construction projects and were willing to join this survey. After six-week waiting period, 22 feedbacks were received in which 2 feedbacks were identified as invalid due to incomplete or invariable answers. This represents a valid response rate of 33%, which is acceptable according to Moser and Kalton's assertion (1971).

Sample composition

The respondents were all industry practitioners, including public and private developers, project managers, main contractors and subcontractors, senior consultants and engineers, and top management personnel (i.e. managing director and senior associate). They had an average of 22 years' work experience in the construction sector, more details of the distribution (in percentage) shown in Figure 1. It is evident that 90% of respondents have worked more than 10 years in the industry. Furthermore, all respondents have received tertiary education. The senior positions, long work experience and tertiary educational background infer that the respondents have adequate knowledge of construction projects and the associated risks.

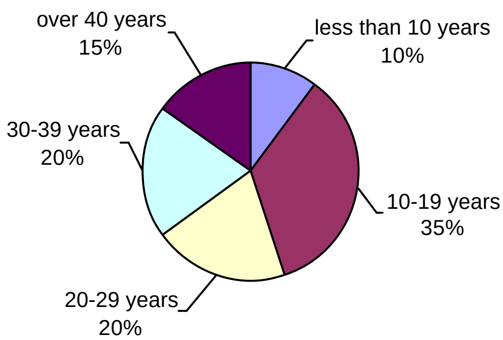

Figure 1 Distribution of Respondents by Years of Work Experience in Construction Industry

It should be noted that the sample size is relatively small in this survey. This may be due to two reasons. Firstly, the questionnaire aimed to explore 88 risk factors related to construction projects, which is time-consuming and may retard respondents from participation. Secondly, the questionnaire content is broad and may not be within the knowledge context of some industry practitioners. The small sample may weaken the effectiveness of the questionnaire survey. However, the handpicked sample pool of industry practitioners and their profound knowledge and ample experience can compensate the aforementioned weakness.

Data analysis method

The survey feedback includes two groups of data, the likelihood of occurrence of each risk and its level of impact on project objectives in terms of cost, time, quality, environment and safety. The risk significant index developed by Shen *et al.* (2001) was used in this research. With respect to the impact on a particular project objective, the significance score for each risk assessed by each respondent can be calculated through Equation (1).

$$r_{ij}^{k} = a_{ij} b_{ij}^{k} \qquad (1)$$

Where r_{ij}^{k} = significance score assessed by respondent j for the impact of risk i on project objective k; i = ordinal number of risk, $i \in (1, 88)$; k = ordinal number of project objective, $k \in (1, 5)$; j = ordinal number of valid feedback to risk i, $j \in (1, n)$; n = total number of valid feedbacks to risk i; a_{ij} = likelihood occurrence of risk i, assessed by respondent j; b_{ij}^{k} = level of impact of risk i on project objective k, assessed by respondent j.

The average score for each risk considering its significance on a project objective can be calculated through Equation (2). This average score is called the risk significance index score and will be used to rank among all risks on a particular project objective.

$$R_i^k = \frac{\sum_{j=1}^{n} r_{ij}^k}{n} = \frac{1}{n}\sum_{j=1}^{n} a_{ij} b_{ij}^k \qquad (2)$$

where R_i^k = significance index score for risk i on project objective k.

The three-point scales for a (highly likely, likely and less likely) and b (high level of impact, medium level of impact and low level of impact) need to be converted into numerical scales. According to Shen *et al*. (2001) and Wang and Liu (2004), "high" or "highly" takes a value of 1, "medium" takes a value of 0.5, and "less" or "low" takes a value of 0.1. The matrix presented in Table 1 shows the calculation of the risk significance index.

Table 1 Matrix for the calculation of the risk significance index

ß / a	High level of impact (1.0)	Medium level of impact (0.5)	Low level of impact (0.1)
Highly likely (1.0)	1.00	0.50	0.10
Likely (0.5)	0.50	0.25	0.05
Less likely (0.1)	0.10	0.05	0.01

The index scores will be used to rank risk factors in the following section. Please note that the method for calculating the significance index score may overlook those risks with a less likelihood of occurrence but a high level of impact on project objectives, which should be taken into account in the risk management practice and however was not the focus of this research.

Survey Results

All risks observed in the questionnaire can happen to any construction projects. The main purpose of this investigation is not to identify a list of risks but to ascertain the key risks that can significantly influence the delivery of construction projects. Hence, only the top ten ranked ones are chosen as key risks in line with other similar research (McIntosh and McCable, 2003; Tam *et al.*, 2004).

Disregarding the risk category, all risks are ranked in accordance with the index scores measuring their significance on the project cost, time, quality, environment and safety. In doing so, two straightforward methods are applicable: (1) ranking as per each risk's accumulative significance score on all five project objectives and (2) ranking as per each risk's significance score on individual project objective. For the former method, risks with significant impact on a particular project objective are likely to be neglected as the significance is usually offset by their lower level of impact on other project objectives. In comparison, the latter method can not only identify key risks affecting each project objective, but also contain a more complete list of risks if the method of selecting the top 10 ranked risks is employed. The result of the ranking is presented in Table 2.

Table 2 Top 10 ranked risks as per their significance in relation to project objectives

Top 10 ranked risks	Significance Index scores
Cost related risks:	
Tight project schedule	0.67
Design variations	0.49
Variations by the client	0.46
Unsuitable construction program planning	0.42
Occurrence of dispute	0.42
Price inflation of construction materials	0.41
Excessive approval procedures in administrative government departments	0.40
Incomplete approval and other documents	0.39
Incomplete or inaccurate cost estimate	0.38
Inadequate program scheduling	0.38
Time related risks:	
Tight project schedule	0.57
Design variations	0.48
Excessive approval procedures in administrative government departments	0.48
Variations by the client	0.47
Incomplete approval and other documents	0.45
Unsuitable construction program planning	0.45
Inadequate program scheduling	0.42
Bureaucracy of government	0.39
High performance or quality expectations	0.38
Variations of construction programs	0.38
Quality related risks:	
Tight project schedule	0.56
Inadequate program scheduling	0.41
Unsuitable construction program planning	0.38
Incomplete or inaccurate cost estimate	0.38
Low management competency of subcontractors	0.36
High performance or quality expectations	0.35
Variations of construction programs	0.35
Unavailability of sufficient amount of skilled labour	0.31
Design variations	0.30
Lack of coordination between project participants	0.29
Environment related risks:	
Tight project schedule	0.39
Variations of construction programs	0.28
Unavailability of sufficient professionals and managers	0.27
Excessive approval procedures in administrative government departments	0.27
Variations by the client	0.25
Inadequate or insufficient site information (soil test and survey report)	0.25
Low management competency of subcontractors	0.24
High performance or quality expectations	0.24
Inadequate program scheduling	0.23
Serious noise pollution caused by construction	0.23
Safety related risks:	
Tight project schedule	0.45
Low management competency of subcontractors	0.37
Unsuitable construction program planning	0.33
Variations of construction programs	0.30
General safety accident occurrence	0.30
High performance or quality expectations	0.27
Design variations	0.26
Lack of coordination between project participants	0.26
Excessive approval procedures in administrative government departments	0.25
Unavailability of sufficient amount of skilled labour	0.24
Unavailability of sufficient professionals and managers	0.24

Totally, 51 risks were deemed to be able to influence the project objectives, with 10 factors related to each project objective except that 11 factors were related to safety. The last two factors under the safety category, i.e. “unavailability of sufficient amount of skilled labour” and “unavailability of sufficient professionals and managers”, have an equal significance index score of 0.24. It is evident that many of the 51 risks are repeated among the five categories. For example, "tight project schedule" can influence all five project objectives; "design variations" can influence project objectives in terms of cost, time, quality and safety. With the repeated ones filtered, a total of 20 factors are highlighted as key risks to influence the achievement of the project objectives. These risks together with their abbreviations are given in Table 3.

Table 3 The key risks that influence project objectives and their abbreviations

20 Key Risks	Abbreviations
Tight project schedule	TPS
Design variations	DV
Excessive approval procedures in administrative government departments	EAP
High performance/quality expectations	HPQE
Inadequate program scheduling	IPS
Unsuitable construction program planning	UCPP
Variations of construction programs	VCP
Low management competency of subcontractors	LMCS
Variations by the client	VC
Incomplete approval and other documents	IAD
Incomplete or inaccurate cost estimate	ICE
Lack of coordination between project participants	LCP
Unavailability of sufficient professionals and managers	UPM
Unavailability of sufficient amount of skilled labour	USL
Bureaucracy of government	BG
General safety accident occurrence	GSAO
Inadequate or insufficient site information (soil test and survey report)	ISI
Occurrence of dispute	OD
Price inflation of construction materials	PICM
Serious noise pollution caused by construction	SNP

Graphical presentation of the key risks

Further exploration of these key risks can not only help to understand how many project objectives each risk can influence but also help to compare the magnitude of the significance of different risks on a particular project objective. In doing so, an alteration of Table 2 is presented in Figure 2. Although in the prior paragraph a few examples have been given with respect to the multi-facet impacts of risks on project objectives, a more elaborate description of this observation is reflected in Figure 2. "Tight project schedule" can influence all five project objectives; "design variations", "excessive approval procedures in administrative government departments', "high performance/quality expectation", "inadequate program scheduling", "unsuitable construction program planning" and "variations of construction programs" can affect four project objectives; "low management competency of subcontractors" and "variations by the client" can impact three project objectives; "incomplete approval and other documents", "incomplete or inaccurate cost estimate", "lack of coordination between project participants", "unavailability of sufficient professionals and managers" and "unavailability of sufficient amount of skilled labour can influence two project objectives; while the rest six risks can impact one project objective.

With respect to the magnitude of risk significance, an average significance index score of 0.25 (medium likelihood of occurrence 0.5 × medium level of impact 0.5) can be regarded as high (AS/NZS4360, 2004). As such, it is found that generally, most index scores are located between 0.25 and 0.75 with only 6 scores distributed with in the circle of 0.25, indicating that the identification of the 20 key risks is valid. On the other hand, with respect to the magnitude of significance on project cost, time and quality respectively, "tight project schedule" is found to have extremely high level of significance on all the three aspects (not less than 0.56), and the rest 9 cost, time and quality related risks are found to have high level of significance (not less than 0.29). In comparison, while most environment and safety related risks have high level of significance on project environment and safety, four environment related risks and two safety related risks are found to have a significance index score of less than 0.25. The six risks include "low management competency of subcontractors" (0.24), "high performance or quality expectations" (0.24), "unavailability of sufficient amount of skilled labour" (0.24), "unavailability of sufficient professionals and managers"(0.24), "inadequate program scheduling" (0.23) and "serious noise pollution caused by construction" (0.23). Except the last risk, the former five risks are all identified to have a high level of significance on at least one project objective, as shown in Figure 2. Hence, these five risks should be regarded as key risks. Meanwhile, although "serious noise pollution caused by construction" is perceived to influence environment with a low index score, the research team still regarded it important and kept it in the key risk list after further consultation with two industry practitioners and two academics in the built environment field.

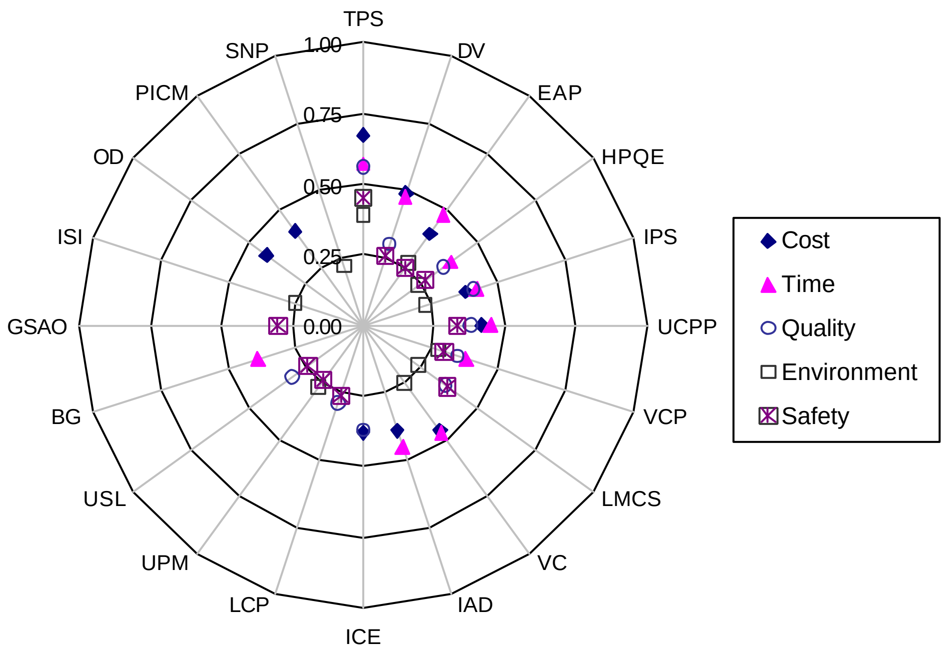

Figure 2 Key risks versus significances of influence on project objectives

Discussions of the Survey Results

As disclosed in the prior literature study, no research has so far been identified to systematically investigate the risks associated with construction projects from the perspectives of stakeholders and project life cycle. In this section, the key risks identified will be examined from the two perspectives.

Key risks versus stakeholders

The foregoing analysis ascertained 20 key risks related to clients, designers, contractors, subcontractors, government bodies and external environment. The stakeholders' role and responsibility on the management of these risks are elaborated below.

Risks related to clients

Four key risks are related to clients. "Tight project schedule" was ranked as the most significant risk among all discussed factors, which infers that formulating an appropriate schedule in the conceptual/feasibility phase is never more constructive to the project delivery. The clients should prepare a practical schedule allowing sufficient but not redundant time to accommodate all design and construction activities. As time and cost are always closely correlated, a lengthy schedule will undoubtedly wreck the project cost benefit. “Variations by the client” can directly result in changes in the planning, design and construction. Variations possibly result from two reasons, the change of mind by the clients or the misunderstanding /misinterpretation of the clients’ needs in the project brief. For the former cause, the clients will bear the responsibility; for the latter one, a knowledgeable initial project team should be established as early as possible to define the project scope and functions precisely. “High performance/quality expectations” is beared in most clients’ mind, which however may mean the sacrifice of project cost, time and even safety. The outcome of the project may also outreach the market or the clients’ needs. Hence, clients should define the performance/quality of the proposed projects based on rational research of their own and/or the market needs. “Incomplete approval and other documents” usually occurs due to management weakness of the project routines or the bureaucracy of government. Clients need to establish a competent team to obtain the approval from government agencies and prepare project documents effectively and efficiently.

Risks related to designers

Also, four key risks related to designers were uncovered. “Design variations” were popularly arisen in the design phase of a project and may result from issues such as “variations by the client” and defective designs. To avoid defective design, the design team need not only to fully understand what the clients want as defined in the project brief, but also to establish an efficient communication scheme among the designers. “Inadequate program scheduling” often appears in projects with a tight schedule when some programs need to be reduced to meet the project timeline. Moreover, uncertainty surrounds most facets of construction projects, which makes it impossible to accurately predict the time required for various programs. Choosing experienced designers can help to minimize the difference between the proposed and practical program schedules. “Incomplete or inaccurate cost estimate” is directly related to the designers/consultants’ knowledge and attitude towards work. As previously mentioned, many unforeseen factors encompass construction activities, which often deviates the estimated cost from the real cost. Choosing responsible and experienced designers and if possible getting the contractors/subcontractors involved early can help to illuminate the black box and minimize the inaccuracy. “Inadequate or insufficient site information (soil test and survey report)” can affect the progress of excavation, foundation and footing construction. Prior to any design scheme, bore hole, soil test and survey with the government agencies and nearby buildings should be conducted to ascertain the site conditions and reduce unexpected risks.

Risks related to contractors

Seven key risks related to contractors were highlighted. “Unsuitable construction program planning” may result from inadequate program scheduling, innovative design or contractors’ lack of knowledge in planning construction programs, so can “variations of construction programs”. To reduce the negative influence of the two risks, an informative program scheduling should be worked out in the design phase, and the constructability of innovative design should be examined. More importantly, the abilities to manage construction programs and implement innovative design should be used as key criteria in appointing contractors. “Lack of coordination between project participants” may lead to chaos in the management of construction team and programs. A general contractor or project manager who is skilful in team and program coordination should be engaged. On the other hand, strengthening the participant’s perception of cooperation and communication is also of importance for improving construction quality and efficiency. “Unavailability of sufficient professionals and managers” and “unavailability of sufficient amount of skilled labour” may result in delays in the construction phase. The contractors should be mapping the construction progress all the time and coordinating different project stakeholders in order to secure sufficient professionals, managers and skilled labours ready to work. “Occurrence of dispute” exists in most construction projects, on account of the discrepancy and variations in the design and construction. Encountering any design variations or difficulty in construction, contactors should always discuss with the team and negotiate with the project manager (particularly the representative of clients) about potential changes in the documentation and record the resulted delay of progress in construction log. “Serious noise pollution caused by construction” is a serious issue in Australia as it may lead to the neighbour’s complaints and then result in government interference. Contractors should arrange a suitable time for the construction work with serious noise and if necessary, make sound insulation on site. “General safety accident occurrence” is usually due to lack of project management, negligence of construction safety policy and confliction of unparallel construction programs. Once happening, it will bring on personnel change and further impede the construction progress. Therefore, contractors should establish a systematic construction program scheduling and provide safety training to on-site staff to improve their awareness of safety.

Risks related to subcontractors

“Low management competency of subcontractors” is the only recognised key risk related to subcontractors. Unlike a general contractor who continuously manages a construction site for a long period, subcontractors normally allocate their manpower and other resources to different projects in order to achieve maximum profit of their own business. Without competent management skills, subcontractors cannot successfully manage their resources to meet the needs from several concurrent construction sites. Accordingly, in additional to specialist abilities, the management competency should be regarded as one of the key criteria for appointing subcontractors.

Risks related to government bodies

“Excessive approval procedures in administrative government departments” and “bureaucracy of government” are not seldom complained by clients and contractors. These risks are normally out of the control of the project stakeholders. To attract investment within their administrative territory, the government agencies should always make great efforts to create a friendly environment in which the approval procedures are reduced or at least the approval time is shortened, and the bureaucracy is minimized. From the project team perspective, they should always adopt the strategies of maintaining close relationship with local government officers and communicating with them as much as possible and at the same time recording everything in black and white, as suggested by He (1995).

Risk related to external issues

In addition to the above 19 key risks related to project stakeholders, one risk, “price inflation of construction materials”, is identified to be related to external environment. The price of construction materials is always changing in response to the inflation and the relation between supply and demand in the construction material market. As this risk is usually unavoidable, clients should choose an appropriate type of contract such as lump-sum to transfer the risk to other parties; while contractor should always avoid using fixed price contracts to bear the risk. One fair way to deal with the potential price fluctuation is to add the contingency premium.

Key risks versus project life cycle

More effective management of risks would be possible if these risks are managed from the perspective of a project life cycle. Accordingly, the foregoing 20 key risks are allocated into different project phases as per their possible time of occurrence. Many risks may arise in more than one phase of a construction project and hence they need to be considered in more than one phase. For example, “tight project schedule” results from clients’ expectation of carrying out the construction project against time as outlined in the feasibility report. Meanwhile, it also happens in the design phase where the designers are urged to work out the drawing and prepare the documentation quickly and in the construction phase where contractors have to reduce program schedules to catch up with the progress. Such an unrealistic schedule can heavily influence the achievement of project objectives in terms of cost, quality, environment and safety. Once accidents happen or conflictions between construction programs arise, the project schedule can be even further delayed.

As much research suggested, addressing project risks earlier rather than later in the project life cycle can minimize the negative consequence brought by the risks (Ward and Chapman, 1995; Smith, 2003). Identifying the possible occurrence of risks in each stage and making appropriate actions to cope with them are significant. On the other hand, as these risks are all project stakeholders orientated, how to effectively get different participants to manage them in the context of a project life cycle is decisive to the project success. In doing so, a consolidation of key risks, stakeholders and the project life cycle is presented in a fish-bone diagram, as shown in Figure 3.

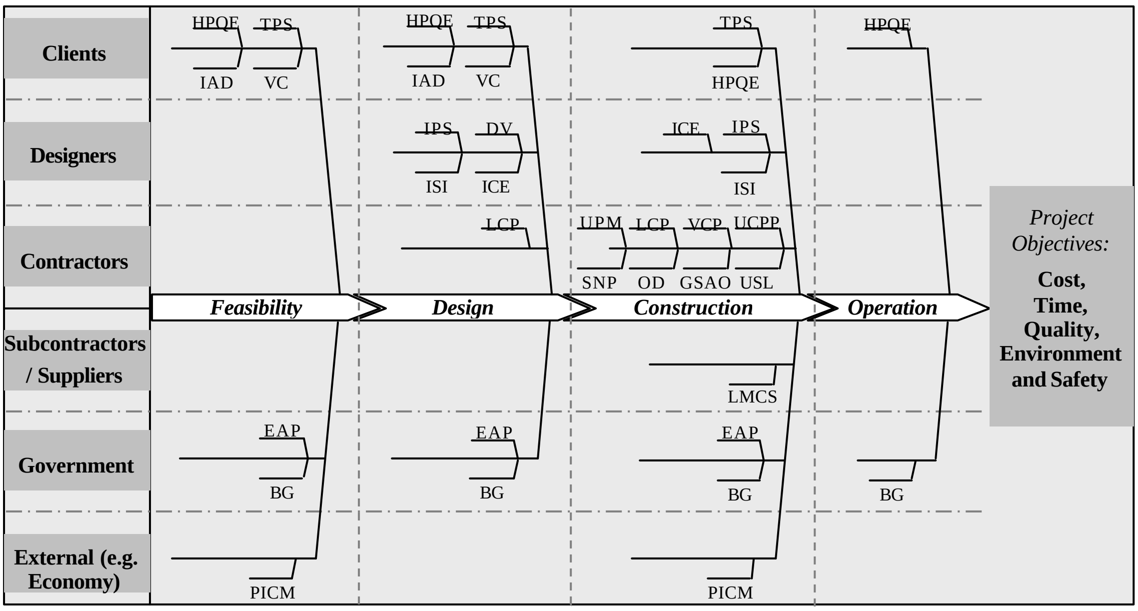

Figure 3 Consolidation of key risks, stakeholders and the project life cycle

These key risks are categorized into the project life cycle, with 7, 11, 17 and 2 risks associated with feasibility, design, construction and operation phases respectively. It is easy to judge that a majority of risks occur in the pre-operation stages, with only two risks pertaining to the project operation. This finding tallies with the nature of construction projects in which a great deal of ambiguity and complexity popularly exists before the physical work of construction is completed. When the project is put into use, most ambiguity and uncertainty has been changed to reality and the possible risks may only come from the satisfaction of the complete facilities and the government sticky regulation in terms of facility management, environment sustainability, etc.

The fish-bone diagram also presents that the risks associated with the feasibility and design stages are mostly related to clients, designers and government bodies. Further investigation of the 12 unrepeated risks related to the preconstruction activities infers that clients, designers and government bodies should work cooperatively from the feasibility phase onwards to address potential risks in time. In particular, the research team provides the following recommendations.

(1) Clients should know what kind of product they want and clearly define it in the brief;
(2) The client, early involved designers and contractors should help clients produce an appropriate project schedule, form reasonable expectation on the product quality, prepare for financial fluctuation such as price inflation of construction material and get documents approved by government agencies in time;
(3) Designers (including consulting engineers) should carry out in-depth investigation of site conditions at first, articulate the clients' needs in a technically competent way within the limitation of the clients' resource and work collaboratively to minimize the design and cost variations;
(4) Government bodies should avoid bureaucracy and create a swift environment to support the project development while the project team should always maintain close relationship with the government officers to shorten the time for approvals.

Although some risks in project feasibility and design stages also extend their occurrence and influence to the post-design stage, most risks associated with the construction are more likely to root in contractors and subcontractors. In this phase, the design is fixed, the project progress no longer depends on creating a realistic schedule but on sticking to it, and budgetary risk is no longer a matter of pricing but that of cost control. To keep the construction work on track, experienced contractors need to be involved in the project as early as possible to make sound preparations for developing valid construction programs. On the other hand, contractors need to establish a highly cooperative construction team in which competent specialist contractors and skilled labours are staffed, and communication, trust, commitment and integration is expected to bridge the physical and knowledge gap between different project participants. With maximum team efforts, construction programs can be well executed, and negative issues associated with construction such as friction, inefficiency, duplication of effort, accident and pollution can be significantly minimized.

Conclusions

While most research has focused on some aspects of construction risk management, this research endeavoured to identify key risks associated with the achievement of all project objectives in terms of cost, time, quality, environment and safety. On the basis of a survey with industry practitioners owning robust experience and knowledge of construction projects, 20 key risks were highlighted on a comprehensive assessment of their likelihood of occurrence and level of impacts on project objectives. "Tight project schedule" was found to have significant impact on all five aspects while the rest risks can significantly influence at least one aspect of project objectives. An innovative attempt to analyse these key risks from the perspectives of project stakeholders and project life cycle presented the following insights – clients, designers and government bodies should work cooperatively from the feasibility phase onwards to address potential risks effectively and in time; contactors and subcontractors with robust construction and management knowledge must be employed early to make sound preparation for carrying out safe, efficient and quality construction activities.

Acknowledgements

The authors would like to thank Wendy Liu and Angela Low for their assistance in preparing and distributing the survey questionnaires. The authors would also like to thank the practitioners who have kindly responded to our survey questionnaires. In particular, the authors would like to thank the Charted Institute of Building (CIOB) Australia Office and their members, for their support in distributing and responding the survey questionnaires.

References

Abdou, O.A. (1996) Managing Construction Risks, *Journal of Architectural Engineering*, **2(1)**, 3-10.

Ahmed, S.M., Ahmad, R. and Saram, D.D. (1999) Risk Management Trends in the Hong Kong Construction Industry: a Comparison of Contractors and Owners Perceptions, Engineering, *Construction and Architectural Management*, **6(3)**, 225-234.

Akintoye, A.S. and MacLeod, M.J. (1997) Risk Analysis and Management in Construction, *International Journal of Project Management*, **15(1)**, 31-38.

AS/NZS 4360 (1999) *Australian / New Zealand Standard on Risk Management*, Standards Australia and Standards New Zealand.

Baker, W. and Reid, H. (2005) *Identifying and Managing Risk*, Frenchs Forest, N.S.W.: Pearson Education.

Berkeley, D., Humphreys, P.C. and Thomas, R.D. (1991) Project Risk Action Management, *Construction Management and Economics,* **9(1)**, 3-17.

Chapman R.J. (2001) The Controlling Influences on Effective Risk Identification and Assessment for Construction Design Management, *International Journal of Project Management*, **19**, 147-160.

Chen, H., Hao, G., Poon, S.W. and Ng, F.F. (2004) Cost Risk Management in West Rail Project of Hong Kong, *2004 AACE International Transactions*.

Flanagan, R. and Norman, G. (1993) *Risk Management and Construction,* Victoria: Blackwell Science Pty Ltd, Australia.

He, Z. (1995) Risk Management for Overseas Construction Projects, *International Journal of Project Management*, **13(4)**, 231-237.

McIntosh, K. and McCable, B. (2003). Risk and Benefits Associated with International Construction-Consulting Joint Ventures in the English-Speaking Caribbean, *Canadian Journal of Civil Engineering*, **30**, 1143-1152.

Moser, C. A. and Kalton, G. (1971) *Survey Methods in Social Investigation*, UK: Heinemann Educational.

Perry, J.H. and Hayes, R.W. (1985) Risk and Its Management in Construction Projects, *Proceedings of the Institution of Civil Engineering, Part I*, **78**, 499-521.

Schuyler, J. (2001). *Risk and Decision Analysis in Projects (second edition),* Pennsylvania: Project Management Institute, Inc, USA.

Shen, L.Y. (1997). Project Risk Management in Hong Kong, *International Journal of Project Management*, **15(2)**, 101-105.

Shen, L.Y., Wu, G.W.C. and Ng, C.S.K. (2001) Risk Assessment for Construction Joint Ventures in China, *Journal of Construction Engineering and Management*, **127(1)**, 76-81.

Smith, N.J. (2003). *Appraisal, Risk and Uncertainty (Construction Management Series)*, London: Thomas Telford Ltd, UK.

Tam, C.M., Zeng, S.X. and Deng, Z.M. (2004) Identifying Elements of Poor Construction Safety Management in China, *Safety Science*, **42**, 569-586.

Uher, T. (2003) *Programming and Scheduling Techniques*, UNSW Press, Sydney

Uher, T.E. and Toakley, A.R. (1999) Risk Management in the Conceptual Phase of a Project, *International Journal of Project Management*, **17(3)**, 161-169.

Wang, J.Y. and Liu, C.L. (2004) *Risk Management for Construction Projects*, Beijing: China Water Publication.

Ward, S.C. and Chapman, C.B. (1995) Risk-Management Perspective on the Project Lifecycle, *International Journal of Project Management*, **13(3)**, 145-149.