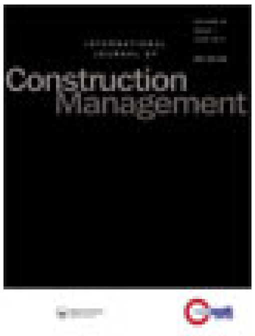

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MANAGING RISKS IN CONSTRUCTION PROJECTS: LIFE CYCLE AND STAKEHOLDER PERSPECTIVES

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Abstract

As an integral part of risk management process, effective risk transfer should be based on a collective understanding of risks in terms of their impacts, responsible project stakeholders as well as likely stages of occurrence in a project life cycle. Until now, most research has focused on examining risks from the perspective of their impacts on individual project objectives. This paper aims to, from project stakeholder and life cycle perspectives, provide an alternative way to scrutinize the risks associated with construction projects. In light of the AS/NZS4360 Australian/New Zealand Standard of Risk Management and ISO31000 Risk Management (Draft), a methodological framework is developed to provide step-by-step details in identifying and analysing the key risks and allocating them to the responsible stakeholders at particular project phases using two-dimensional graphical presentations. An empirical case study is undertaken to demonstrate the application of this risk management framework. The main contribution of the paper includes the proposition, development and test of a conceptual methodological framework as an alternative way to analyse and manage key risks involved in construction project procurement. In addition, with the aid of the proposed framework, 20 key risks are identified and strategies are formulated to manage the risks from the joint perspectives of project stakeholders and life cycle.

Keywords

Risk management, life cycle, stakeholder, construction projects, Australia

INTRODUCTION

Construction projects are subject to many 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, Zou and Zhang 2008). Due to its ability to help clients significantly transfer risks, the traditional project delivery method (design, bid and build) is still popular in many countries including Australia, particularly in the public sector. However, risk transfer does not always mean the reduction of risks if they are not well understood, assessed, transferred and managed. More often than not, the diverse interests of project stakeholders exacerbate the changeability and complexity of risks and make the optimal risk allocation and management very difficult, if not impossible.

A direct relationship between effective risk management and project success was acknowledged by Akintoye and MacLeod (1997). Efforts have been made to explore the impacts of risks on typical objectives of construction projects and probe appropriate risk solutions (Kaming *et al*., 1997; Shen, 1997; Mulholland and Christian, 1999; Chen *et al*., 2004; Tam *et al*., 2004, Smith *et al*., 2006 and PMI 2008), which significantly lifts the profile of research and practice in construction project risk management. However, most risks are dynamic in nature, resonating with the interests of project stakeholders and occurring at various phases of a project life cycle.

Not only should an effective risk management approach understand what kinds of risks the stakeholders may face, but also articulate how to manage these risks at different phases of a project and possibly turn these risks into opportunities. Furthermore, risks always come with a cost and therefore it is important to identify the sources of risks and the stakeholders who are in the best positions to bear and manage the risks. This paper aims to develop a conceptual methodological framework, from the perspectives of project stakeholders and life cycle, to examine risks related to construction projects under the traditional project delivery method.

Based on a critical review of literature, a conceptual methodological framework is developed to provide a holistic method of identifying and ranking possible risks as per their impacts on project objectives, and analysing the key risks from the perspectives of project stakeholders and life cycle. The paper then moves on to present the results of an empirical study which aims to verify the proposed conceptual framework. Thereinto, key risks factors were highlighted and strategies of managing these key risks were proposed from the perspectives of project stakeholders and project life cycle.

PAST RESEARCH ON CONSTRUCTION PROJECT RISK MANAGEMENT

The Australian Standard (also New Zealand Standard) for Risk Management AS/NZS4360 (2004) defines risk management as "the culture, processes and structures that are directed towards realizing potential opportunities whilst managing adverse effects". Owing to the dynamic nature of organizational, environmental and business environment, risk management has been highly recognized 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).

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. Flanagan and Norman (1993) suggested three ways of classifying risk: by identifying the consequence, type and impact of risk. 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 *et al*. (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.

Risks related to project objectives

Cost, time and quality have been traditionally regarded as the objectives in management of construction projects. In today's construction, safety has been never more important and therefore is now seen as another important objective to achieve the goal of "injury and incident free" during any stage of a construction project. More recently, the environmental sustainability of construction activities has gained increasing attention as construction projects, more or less, have impacts on the natural and built environment. Researchers have identified the possible risks with adverse impacts on these project objectives, which give knowledge to project stakeholders and allow them to choose best practices during the design and implementation of construction projects. The following literature presents possible risks related to each typical project objective.

Project cost – Chen *et al*. (2004) proposed 15 risks concerned with project cost and categorized them into three groups: resources, management and parent factors. Based on 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 technical and human resources factors are the most significant risks in that particular project. Risk factors associated with "political instability and corruption", "fluctuation in currency", "interest rates", "labour-market and material-availability uncertainties" were considered the main causes of additional costs in privatized infrastructure projects in developing countries (Rosenbaum 1997). Kaming *et al*. (1997) found that "unpredictable weather", "inflationary material cost", "inaccurate quantity take-off", "complexity of project location and type", "labour cost increase" and "local regulations" were the main contributors to cost overrun in the procurement of high-rise building projects in Indonesia.

Project time – Shen (1997) identified and ranked 8 major risks accounting for project delay, proposed risk management actions to cope with these risks and validated their effectiveness through individual interviews. Kaming *et al*. (1997) identified that "unpredictable weather conditions", "inaccuracy of material estimate", "material and equipment shortage", "skilled labour shortage", "inadequate planning", "poor labour productivity", "design variations" etc. were the main reasons resulting in delay in high-rise building projects in Indonesia. Mulholland and Christian (1999) presented 80 factors affecting construction project schedule, with 16 pertaining to engineering design (for e.g. engineering estimate, project scope definition etc), 15 pertaining to procurement (for e.g. long lead-time items, equipment and bulk material etc), 31 pertaining to on-site construction (for e.g. labour resource planning, design changes during construction etc) and 17 pertaining to project management (for e.g. project schedule, project complexity etc).

Project quality – Lee *et al*. (2005) pointed out that iterative cycles resulting from unanticipated errors and changes were the main sources of risks on project quality in concurrent design and construction despite its good name for streamlining projects in terms of time. They established a framework for quality and change management to identify the negative iterative cycles and address the detrimental impacts. Tilley *et al*. (2000) investigated issues affecting design and documentation quality and identified a number of factors, for e.g. "problems due to inappropriate design", "lack of appropriate design check", "time availability problems", "non-availability of experienced design personnel", "reduced tender times", "reduction in design fees" etc. These design and documentation issues further resulted in low efficacy of construction process and poor quality of construction products.

Construction safety – Tam *et al*. (2004) examined the elements of poor *construction safety* management in China and 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". Kartam *et al*. (2000) observed the safety regulations and policies by government, insurance companies and construction firms in Kuwait and acknowledged that "disorganized labour", "poor accident record keeping and reporting system", "lack of safety regulations and legislation", and "severe weather conditions during summer" etc were the main contributors to safety problems. Based on an investigation of 100 construction accidents, Haslam *et al*. (2005) found five factors related to workplace that might result in safety problems i.e. "site conditions", "site layout/ space", "working environment", "work scheduling" and "housekeeping". Zou and Zhang

(2008) compared the perceptions of safety risks between the construction professionals in China and Australia.

Environmental impact – As per the sources of pollutions in construction projects in urban China, Chen *et al*. (2000) proposed that the major types of environmental risks include “dust”, “harmful gases”, “noises”, “solid and liquid wastes” etc. and also developed a qualitative approach to assess and control these risks. Dione *et al*. (2005) regarded the list of risks presented by Chen *et al*. (2000) as direct environmental risks and further proposed a concept of indirect environmental risks. They defined indirect environmental risks as risks that may be influenced by the project but are not necessarily a direct result of the project. A typical example is the excavation of soil for footing resulting in the release or exposure of previously contaminated materials. They further proposed a flowchart to manage the direct and indirect environmental risks and encouraged implementing in a project at an early stage.

Risks related to project life cycle

While the above research studied the diverse risks related to project objectives, other research examined risks at different phases of a project life cycle. Uher and Toakley (1999) investigated various structural and cultural factors concerned with the implementation of risk management in the conceptual phase (i.e., *feasibility stage*) 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 poor 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 risks can significantly 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 at length in light of the different contractual relationships existing among the functional entities involved in the design, development and construction of a project.

Previous research has mainly focused on examining the impacts of risks on individual project objectives in terms of cost, time, quality, safety and environmental impact. However, many risks were found in the foregoing literature to exert influence on more than one project objective. For example, weather conditions can influence project cost, time and safety, and project scheduling can affect both project time and safety. Overlooking the multi-facet impacts of some risks will wreck the effectiveness of risk management on construction projects. On the other hand, some researchers investigated risk management for construction projects in the context of a particular project phase rather than from the perspective of a project life cycle. This makes effective risk management hardly achievable as risks need to be identified and analysed in a more systematic way in a project life cycle (Chapman and Ward 2004). More importantly, despite the acknowledgement that most risks are attributable to participants, little research has probed them from the perspective of project stakeholders. Therefore, there is a need to further investigate the multi-faceted impacts of risks in construction projects and manage them from both the project life cycle and stakeholders’ perspectives. Accordingly, risks are classified using two methods in this paper. Firstly, in the questionnaire survey, risks are classified as per their attributions to major project stakeholders such as clients, designers (including architects and consulting engineers), contractors, subcontractors/suppliers, superintendents and government bodies in line with the classification defined by Flanagan and Norman (1993). Secondly, in the risk analysis, the identified key risks are classified with a consideration of their possible phases of occurrence in a project life cycle.

A PROPOSED CONCEPTUAL LIFE CYCLE RISK MANAGEMENT FRAMEWORK

Tackling risks under the traditional project delivery method in construction projects, a conceptual framework is established to identify, analyse and allocate risks to the responsible stakeholders from a life cycle perspective, as shown in Figure 1. Following the principles in the Australian Standard of Risk Management (AS4360, 2004) and the International Standard Organisation ISO31000 Risk Management – Principles and Guidelines on Implementation (Draft) (2008), the framework encapsulates six essential steps for construction professionals to manage the risks in a systematic and holistic manner. It also provides professionals with semi-quantitative risk prioritizing methods and with graphical spider and fishbone forms to map the risk profiles.

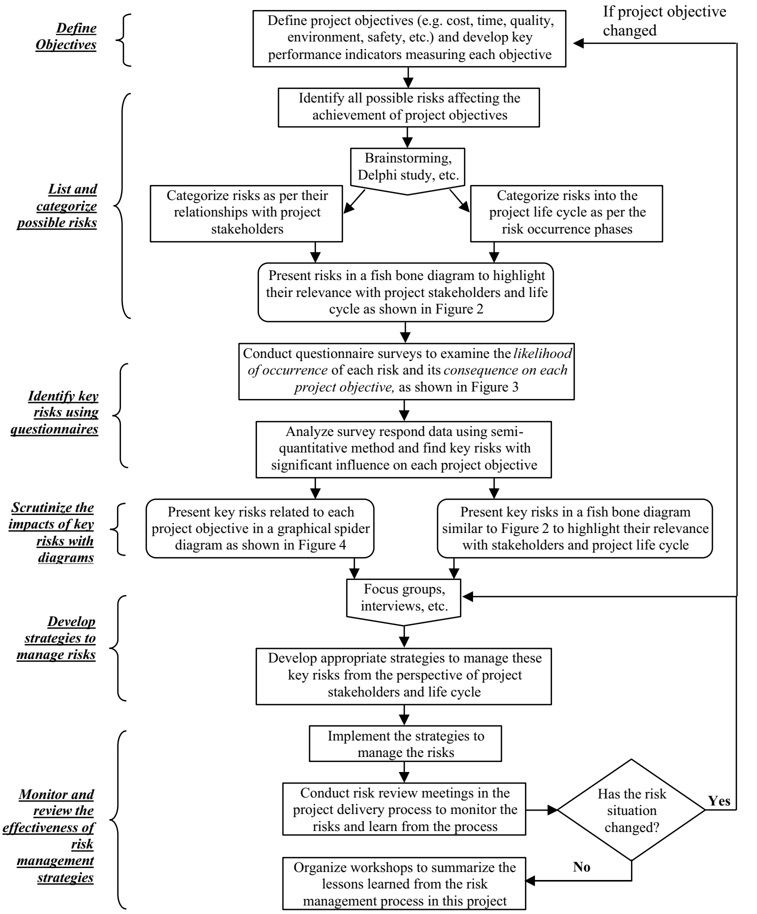

Figure 1 Conceptual life cycle risk management framework for construction projects

1. Define project objectives which may include time, cost, quality, safety and environmental performance sustainability (but could also be other objectives). Also, define the key performance indicators measuring the achievement of each project objective.

2. List all possible risks that may affect achievement of the project objectives and classify these risks for the responsible parties (i.e. the stakeholders) and the phases of the project life cycle that they may arise from or have an impact on. Brainstorming or Delphi techniques may be used in this step. As an outcome, a fishbone diagram as shown in Figure 2 can be formulated to map the location and impact of these risks.

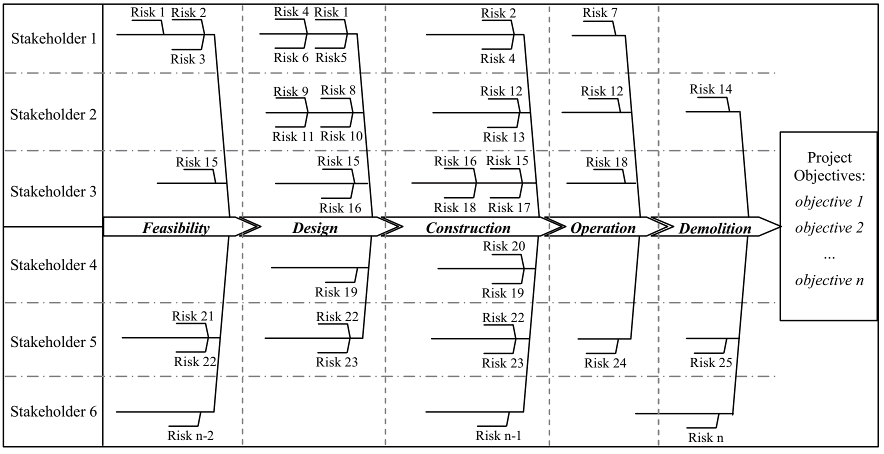

Figure 2 Risk identification in accordance to project stakeholders and life cycle

3. Construct a questionnaire survey using the risks identified in Step 2, with a rating scale of one to five (or one to three depending on the need) of their likelihood and impact, similar to the one shown in Figure 3 (as a sample) and conduct the survey with all concerned project stakeholders. Then, analyse the data collected using the semi-quantitative method discussed in the "Data analysis technique" section.

4. Present the results in a graphical spider diagram which provides a straightforward and easy to understand view of which risk affects which project objective(s) and its magnitude. An example of the diagram is given in the "Empirical case study" section, as shown in Figure 4. A cause-effect fishbone diagram similar to Figure 2 may also be used to present the key risk factors.

5. Organise focus groups to discuss the key risks identified and formulate strategies to manage them. The focus group members should include most if not all stakeholders of the project. During the project development process, conduct review meetings and repeat Steps 4–5 whenever needed. This is because risks are dynamic and may change from one stage to another. Furthermore, project objectives may evolve/ change in different phases of the project life cycle.In such situations, the risks should be re-identified and analysed and strategies be developed to manage these risks accordingly. In other words, it is an iterative process as shown in Figure1.

CONSTRUCTION PROJECT RISKS SURVEY QUESTIONNAIRE

Please choose a number from 1 to 5 to measure the likelihood of occurrence and the consequence of a risk,
Likelihood: 5-almost certain; 4-highly likely; 3-likely; 2-less likely; 1-almost incredible
Consequence: 5-extremely high level; 4-high level; 3-medium level; 2-low level; 1-extremely low level

Risk Factors	Likelihood	Consequence				
		Objective 1	Objective 2	……	Objective m-1	Objective m
	1 (almost incredible) ~ 5 (almost certain)	1 (extremely low level of consequence) ~ 5 (extremely high level of consequence)				
Risks related to stakeholder *a* (e.g. Client)						
Risk a-1						
Risk a-2						
…...						
Risk a-n_1						
Risks related to stakeholder *b* (e.g. Designer)						
Risk b-1						
Risk b-2						
……						
Risk b-n_2						
Risks related to stakeholder *c* (e.g. Contractor)						
Risk c-1						
Risk c-2						
……						
Risk c-n_3						
…...						

Figure 3 Sample survery questionnaire

6. Implement the strategies at the feasibility study, design and construction phases, and monitor and review the risks and their management strategies regularly using workshops. All project stakeholders are encouraged to attend and contribute to these workshops. In particular, topics in these workshops should include but be not limited to: (1) what risks have been dealt with well? (2) how and why were these risks dealt with well? (3) what risks have not been dealt with properly? and (4) how would the risks have been dealt with differently? At the completion of the project, review the entire risk management process at least one time. A report should be compiled for the project in relation to the management of the risks and opportunities, and be used as reference for future projects.

Data analysis techniques

The survey results include two groups of data, the likelihood of occurrence of each risk and its level of consequence on project objectives. The five-point scales for the likelihood (almost certain, highly likely, likely, less likely and almost incredible) and the consequence ß (extremely high level, high level, medium level, low level and extremely low level) as appearing in Figure 3 need to be converted into numerical scales. The matrix presented in Table 1 shows the converted numerical values and the calculation of the risk significance index.

Note that depending on the design of the questionnaire, different values can be assigned to α and ß . For example, if a three-point rating scale is chosen, according to Shen *et al.* (2001), Wang and Liu (2004) and Zou *et al.* (2007), "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.

With respect to the impact on a particular project objective, the significance score (i.e. significant index) for each risk assessed by each respondent can be calculated through Equation (1).

Table 1 Matrix for the calculation of the risk significance index

α \ β	Extremely high level of consequence (1.0)	High level of consequence (0.7)	Medium level of consequence (0.5)	Low level of consequence (0.3)	Extremely low level of consequence (0.1)
Almost certain (1.0)	1.00	0.63	0.45	0.27	0.09
Highly likely (0.7)	0.7	0.49	0.35	0.21	0.07
Likely (0.5)	0.50	0.35	0.25	0.15	0.05
Less likely (0.3)	0.30	0.21	0.15	0.09	0.03
Almost incredible (0.1)	0.10	0.07	0.05	0.03	0.01

$$r_{ij}^{k} = \alpha_{ij}\, \beta_{ij}^{k} \qquad (1)$$

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, $i \in (1, m)$; *m* = total number of risks; *k* = ordinal number of project objective, $k \in (1, 5)$; *j* = ordinal number of valid feedback to risk *i*, $j \in (1, n)$; = total number of valid feedbacks to risk *i*; α_{ij} = likelihood occurrence of risk *i* , assessed by respondent *j*; β_{ij}^{k} = level of consequence 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 can be used to rank all risks on a particular project objective.

$$R_{i}^{k} = \frac{\sum_{j=1}^{n} r_{ij}^{k}}{n} = \frac{1}{n} \sum_{j=1}^{n} \alpha_{ij}\beta_{ij}^{k} \qquad (2)$$

where R_{i}^{k} = significance index score for risk *i* on project objective *k*. The average index score for each risk considering its significance at the overall level of all project objectives can be calculated in a similar equation.

All risks are ranked in accordance with their significance index score 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 on all five project objectives and (2) ranking as per each risk's significance on individual project objective. For the former method, risks with significant impact on a particular project objective may be neglected as 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 that derived from each project objective.

It should be noted that the method for calculating the risk significance index score may overlook the extreme risks with a very low level of likelihood of occurrence but a very high level of consequence on project objectives, which should be taken into account in the risk management practice.

AN EMPIRICAL CASE STUDY

To verify the conceptual methodological framework proposed, an empirical study for a systematic exploration of risks associated with construction projects under the traditional project delivery method is conducted.

Data collection methodology

A postal questionnaire was conducted with the construction industry practitioners in Australia. The questionnaire consisted of two sections. Section I solicited general information about the respondents. Section II 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 consequence on each project objective that would result in as high, medium or low. These risks were mainly sourced from Ahmed *et al*. (1999), Mulholland and Christian (1999), Chapman (2001), Wang and Liu (2004) and Loosemore *et al*. (2006) and to the best of the authors' knowledge, were categorized into seven groups, 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, and 16 related to external issues (i.e. economic circumstance, physical work and social environment).

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 feedback was obtained to improve the questionnaire quality. After refinement, the questionnaires were distributed through post to 60 construction practitioners in Sydney, Australia. The sample was carefully chosen from a database owned by the authors' research group. The database includes a list of construction project stakeholders such as government agencies, clients, developers, project managers, senior consulting engineers, contractors and top management personnel (i.e. development manager, managing director and senior associate), who have served in the local industry over 10 years. After a three-week wait and follow-up period, 22 feedbacks were received in which two feedbacks were identified as invalid. This represents a valid response rate of 33%, which is acceptable according to Moser and Kalton's assertion (1971).

Sample composition

The 22 respondents who responded had an average of 22 years' work experience in the construction industry. It is evident that 90% of respondents have worked more than 10 years and 35% of respondents have worked more than 30 years in the construction sector. 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.

Case study results

The collected data was analysed using the methodologies discussed in previous sections. The top ten ranked risks are chosen as key risks in line with other similar research (McIntosh and McCable 2003; Tam *et al*. 2004). The result of the ranking is presented in Table 2. It is evident that many of the risks are repeated among the five categories in line with the project objectives i.e. cost, time, quality, environmental sustainability and safety. For example, "tight project schedule" can influence all five project objectives; "design variations" can influence project objectives in terms of cost, time, quality, environment and safety. With the repeated ones filtered, a total of 20 factors are highlighted as key risks that impact the five project objectives under the traditional project delivery. These risks together with their abbreviations are given in Table 3.

Using the approach described in previous sections, an alteration of Table 3 is presented in Figure 4. 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 4.

Table 2 Top 10 ranked risks as per their impact on 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

Table 3 Key risks influencing project objectives and the abbreviation

The 20 Key Risks	Abbreviation
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

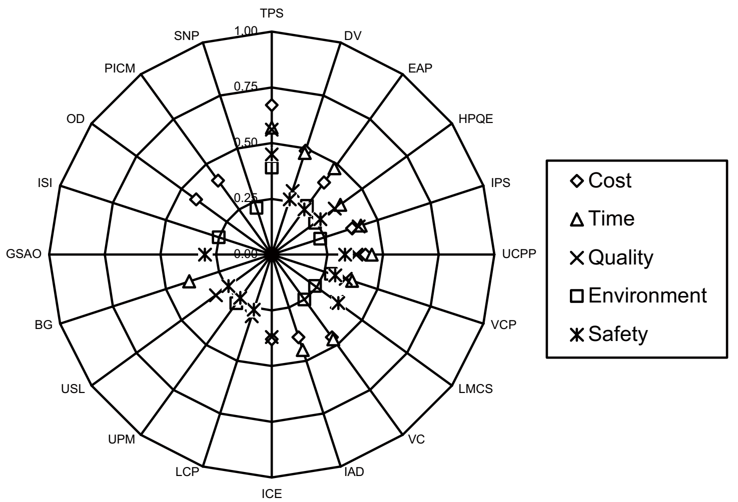

Figure 4 Graphical presentation of key risks in accordance to its impace on project objectives

Strategies to manage the key risks

Strategies to manage the key risks will be developed from two perspectives: stakeholders and life cycle. Due to the limited number of feedbacks received from the questionnaire survey, the following discussion mainly serves to demonstrate the application of the framework through integrated perspectives of the project stakeholders and the project life cycle. However, the findings inferred do propose conceptual solutions to tackle typical risks identified. As a result of the discussion, Figure 5 is put at the end of the section but should be always referred in the discussion of key risks versus stakeholders and project life cycle.

Key risks versus stakeholders

The stakeholders' role and responsibility on the management of the key 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. This is coincident with the feature of the design, bid and build method which is not fast-tracked in nature. This risk infers that formulating an appropriate schedule at the conceptual/feasibility phase is never more constructive to the project delivery. The client 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 related, a lengthy schedule will undoubtedly wreck project cost benefit. "Variations by the client" can directly result in changes in project planning, design and construction. Variations possibly result from two reasons: change of mind by the clients or misunderstanding /misinterpretation of the clients' needs in the project brief. In the former cause, the client will bear the responsibility; for the latter, a knowledgeable initial project team should be established as early as possible to define the project scope and function precisely. "Too high performance/quality expectations" is borne 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, the client should define the performance/quality of the proposed projects based on rational research of their own and/or the market needs. "Incomplete approval documents" usually occurs due to management weakness of the project routines or government bureaucracy. 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" popularly arise in the design or construction phase of a project, which may result from issues such as "variations by the client" and defective designs. To avoid defective design, the design team need not only 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 estimation" is directly related to the 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 inviting specialist contractors involved early on can help illuminate the black box and minimize inaccuracy. "Inadequate or insufficient site information" 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 impacts of the two risks, an informative program scheduling should be established in the design phase, and the constructability of innovative design be examined. More importantly, the ability 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 management chaos in construction team and programs. A general contractor or project manager who is skilful in team and program coordination should be engaged. Moreover, 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 construction. The contractors should map the construction progress continuously and coordinate different stakeholders in order to secure enough professionals, managers and skilled labours ready to work. More often than not, "occurrence of dispute" occurs on account of discrepancy and variations in the design and construction, and contactors should always discuss with the team and negotiate with the client representative about potential changes in the documentation and record the resultant delay of progress in the construction log. "Serious noise pollution caused by construction" is a serious issue as it may lead to neighbours' complaints and result in government interference. Contractors should arrange a suitable time for the construction activities with serious noise and if necessary, set up sound insulation facilities on site. "Occurrence of safety accident" is usually due to lack of project management, negligence of construction safety policy and conflict of unparalleled 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 attention and awareness of safety.

Risks related to subcontractors

"Subcontractors' low management competency" 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 for their 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, management competency should be regarded as an essential criterion for selecting subcontractors.

Risks related to government bodies

Clients and contractors often complain about "excessive approval procedures in administrative government departments" and "bureaucracy of government". These risks are usually out of the control of the project stakeholders. To attract investment within their administrative territory, the government agencies should always make efforts to create a friendly environment in which the chaotic approval procedures are reduced or at least the approval time shortened, and the bureaucracy minimized. From the project team perspective, they should always adopt a strategy of maintaining close relationship with local government officers and communicating with them at length and meanwhile recording everything in black and white, as suggested by He (1995).

Risks related to external environment

"Price inflation of construction materials" is identified as related to external environment. The price of construction materials is always changing in response to inflation and the supply and demand condition in the construction material market. As this risk is usually unavoidable, clients always try to choose lump-sum contracts to transfer the risks to other parties; while contractors 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 or set up clear rise and fall clause in the contract.

Key risks versus project life cycle

The recognized key risks need to be managed in time in a project life cycle. The 20 key risks are allocated into project phases as per their possible time of occurrence. Many risks may occur in more than one project phase and hence they need to be attended to 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 prepare the drawings and 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 significantly retard the achievement of project objectives in terms of cost, quality, environment and safety. Once accidents happen or conflicts between construction programs arise, the project schedule can be even further delayed.

As much research suggests, addressing project risks earlier rather than later in the project life cycle can minimize the negative consequence brought by the risks (Smith 2003; Chapman and Ward 2004). Identifying the possible occurrence of risks at each stage and making appropriate actions to cope with them are significant. Meanwhile, as these risks are all project stakeholders' orientated, proactively getting participants to manage them in the context of a project life cycle is decisive to the project success. In doing so, a way of managing key risks in various project phases by responsible project stakeholders is presented in a fish-bone diagram, as shown in Figure 5.

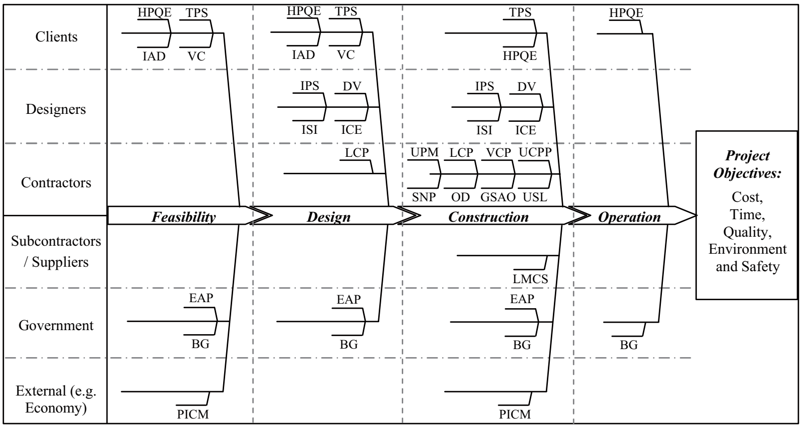

Figure 5 Consolidation of key risks, stakeholders and project life cycle

These key risks are categorized in the project life cycle, with 7, 11, 18 and 2 risks associated with feasibility, design, construction and operation phases respectively. A majority of risks occur in the pre-operation stages, with only two risks pertaining to the project operation. The 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 sticky government regulations in terms of facility management, environment sustainability etc.

The fish-bone diagram also presents that 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 pre-construction activities infers the importance of team work with significant collaboration among clients, designers and government bodies from the feasibility phase onwards to address potential risks in time. In particular, the authors provide the following recommendations.

1. Clients should know what kind of products they want and clearly define their needs in the project brief;

2. The client, early involved designers and specialist contractors should help clients produce an appropriate project schedule, form reasonable expectation of the product quality, prepare for financial fluctuation such as price inflation of construction materials and get documents approved by government agencies on time;

3. The designers (including consulting engineers) should carry out in-depth investigation of site conditions at first, articulate the client's needs in a technically competent way within the limitation of the client's 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 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 in construction are more likely to take root in contractors and subcontractors. In this phase, the design is fixed, the project progress depends on not only a realistic schedule but also 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 engaged to develop 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 project participants. With maximum team effort, 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

Much research effort has been devoted to identifying and examining risks related to construction projects based on their impacts on project cost, time, quality, environmental sustainability and safety. However, risks in construction projects are dynamic in nature, particularly resonating with project stakeholders and occurring at various phases of a project life cycle. To identify and manage them effectively and efficiently, a more systematic way of managing these risks from the perspectives of project stakeholders and life cycle is imperative and constructive. This paper proposed a conceptual framework as an alternative method to identify and manage key risks under the traditional project delivery method. The methodological framework proposed also include a 2-dimentional cause-effect fishbone diagram that provides a straight forward and graphical presentation of all risks and graphical spider diagram to show the significant index of each key risk in relation to individual project objectives. This framework was tested using an empirical case study via surveys. Thereinto, 20 key risks were highlighted on a comprehensive assessment of their likelihood of occurrence and level of consequence on project objectives. “Tight project schedule” was found to have significant impact on all five aspects while the remaining risks can significantly influence at least one aspect of project objectives. Strategies of managing these key risks were proposed from the perspectives of project stakeholders and project life cycle.

The originality and contributions of this paper therefore includes: (1) examining the risks related to construction projects from the joint perspectives of project stakeholders and life cycle; (2) proposing, developing and testing a conceptual methodological framework as an alternative way to study risks related to construction projects and implement the risk management strategies; and (3) developing strategies to manage key risks from the joint perspectives of project stakeholders and life cycle.

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 (2004). Australian / New Zealand Standard on Risk Management, *Standards Australia and Standards New Zealand*, Australia.

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

Chapman R.J. (2001). “The Controlling Influences on Effective Risk Identification and Assessment for Construction Design Management.” *International Journal of Project Management,* 19(3), 147-160.

Chapman, C.B., and Ward, S.C. (2004). Project Risk Management: Process, Techniques and Insights, second edition, UK: John Wiley & Sons, Ltd.

Chen, H., Hao, G., Poon, S.W., and Ng, F.F. (2004). “Cost Risk Management in West Rail Project of Hong Kong.” 2*004 AACE International Transaction*, INT.09.1-09.5.

Chen, Z., Li, H., and Wong, C.T.C. (2000). “Environmental Management of Urban Construction Projects in China.” *Journal of Construction Engineering and Management*, 126(4), 320-324.

Dione, S., Ruwanpura, J.Y., and Hettiaratchi, J.P.A. (2005). “Assessing and Managing the Potential Environmental Risks of Construction Projects.” *Practice Periodical on Structural Design and Construction* ASCE. 10 (4), 260-266.

Flanagan, R., and Norman, G. (1993). Risk management and construction, Victoria: Blackwell Science Pty Ltd, Australia.

Haslam, R.A., Hide, S.A., Gibb, A.G.F., Gyi, D.E., Pavitt, T., Atkinson, S., and Duff, A.R. (2005). “Contributing Factors in Construction Accidents.” *Applied Ergonomics*, 36(4), 401-415.

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

ISO (International Standard Organisation, 2008), International Standard ISO/DIS31000 Risk Management --- Principles and Guidelines on Implementation (Draft), International Standard Organisation.

Kartam, N.A., Flood, I., and Koushki, P. (2000). “Construction Safety in Kuwait: Issues, Procedures, Problems and Recommendations.” *Safety Science,* 36(3), 163-184.

Kaming, P.F., Olomolaiye, P.O., Holt, G.D., and Harris, F.C. (1997). "Factors Influencing Construction Time and Cost Overruns on High Rise Projects in Indonesia." *Construction Management and Economics,* 15(1), 83-94.

Lee, S.; Peña-Mora, F., and Park, M. (2005). "Quality and Change Management Model for Large Scale Concurrent Design and Construction Project." *Journal of Construction Engineering and Management*, 131(8), 890-902.

Loosemore M., Raftery J., Reilly C. and Higgon D. (2006), Risk Management in Projects, Taylors and Francis,

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(6), 1143-1152.

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

Mulholland, B., and Christian, J. (1999). "Risk Assessment in Construction Scheduling." *Journal of Construction Engineering and Management,* 125(1), 8-15.

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.

Project Management Institute (PMI, 2008), "A Guide to the Project Management Body of Knowledge (PMBOK Guide) (draft), 4th edition", Project Management Institute, Newtown Square, Pennsylvania, USA.

Rosenbaum, D.B. (1997). "Risk Questions Hamper Deals." *Engineering News-Record*, 238(8).

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(7), 569-586.

Tilley, P.A., McFallen, S.L., and Tucker, S.N. (2000). "Design and Documentation Quality and Its Impact on the Construction Process." AISC – IEAust Special Issue Steel Construction, 34(4), 7-14.

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 Hydraulic and Hydra-power Publication Press.

Zou P.X.W., Zhang G.M., and Wang J.Y. (2007), Understanding the key risks in construction projects in China" *International Journal of Project Management,* 25(6), 601 -- 614.

Zou P.X.W. and Zhang G.M. (2008) A Comparative study on the perceptions of construction safety risks in China and Australia, to appear in *ASCE Journal of Construction Engineering and Management.*