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ScienceDirect
International Journal of Project Management 25 (2007) 601–614
INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT
www.elsevier.com/locate/ijproman

Understanding the key risks in construction projects in China

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Abstract

The aim of this paper is to understand the key risks in construction projects in China and to develop strategies to manage them. Risks were prioritized according to their significance of influences on typical project objectives in terms of cost, time, quality, safety and environmental sustainability, and then scrutinized from a joint perspective of project stakeholders and life cycle. Postal questionnaire surveys were used to collect data, based on which a total of 25 key risks were ascertained. These risks were compared with the findings of a parallel survey in the Australian construction industry context to highlight the unique risks associated with construction projects in China. Strategies to manage the risks were sought from the perspectives of project stakeholders and life cycle and in light of the Chinese construction culture. It is concluded that clients, designers and government bodies should take the responsibility to manage their relevant risks and work cooperatively from the feasibility phase onwards to address potential risks in time; contractors and subcontractors with robust construction and management knowledge should be employed to minimize construction risks and carry out safe, efficient and quality construction activities.

Keywords: Risk management; Stakeholders; Life cycle; Construction project management; China

1. Introduction

Construction projects are one-off endeavours with many unique features such as long period, complicated processes, abominable environment, financial intensity and dynamic organization structures [1,2] and such organizational and technological complexity generates enormous risks. The diverse interests of project stakeholders on a construction project further exacerbate the changeability and complexity of the risks [3]. While risks cannot be eliminated, successful projects are those where risks are effectively managed, of which early and effective identification and assessment of risks is essential [2]. Starting with a focus on what is to be achieved in a construction project (i.e., project objectives), risk management process builds to an understanding of what might put goals in jeopardy and what should be done to ensure success.

The rapid growth of the Chinese economy calls for massive development of infrastructures and assets [4–6]. While this brings opportunities to project stakeholders, employing effective risk management techniques to cope with risks associated with variable construction activities is of importance to implement the projects aligning with project objectives including time, cost, quality, safety and environmental sustainability. This paper firstly presents a critical literature review of risks associated with construction projects and then identifies the key risks influencing the achievement of project objectives in the Chinese construction industry with the aid of questionnaire surveys. The paper further moves on to discuss these risks from project life cycle and stakeholders perspectives and present the identified risks using a two dimensional graphical presentation.

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0263-7863/$30.00
doi:10.1016/j.ijproman.2007.03.001

Finally, the paper develops a range of strategies adopted by project stakeholders and in different project phases. The research findings will contribute to both the practice and research in risk management for the Chinese construction industry and also provide valuable information for those international companies who intend to provide construction project management service to China.

2. Related previous research

2.1. Fundamentals of risk management

Risk is perceived as 'the potential for unwanted or negative consequences of an event or activity' [7], a combination of hazard and exposure [8]. Recent research tends to emphasize the two-edged nature of risks, such as 'a threat and a challenge' [1], 'the chance of something happening that will have an impact on objectives; may have a positive or negative impact' [9], 'combination of the probability or frequency of occurrence of a defined threat or opportunity and the magnitude of the consequences of the occurrence' [10]. This paper examines mainly the negative impacts of risks inherent in construction projects through a combined consideration of the likelihood of occurrence and the magnitude of consequence.

Risk management is 'a system which aims to identify and quantify all risks to which the business or project is exposed so that a conscious decision can be taken on how to manage the risks' [1]. PMBOK [11] included risk management as one of the nine focuses in project management and described it as 'the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project'. Recently, AS/NZS 4360 [9] defined risk management as 'the culture, processes and structures that are directed towards realizing potential opportunities whilst managing adverse effects' [9]. In line with these definitions, risk management in the construction project management context is a systematic way of identifying, analysing and dealing with risks associated with a project in an aim to achieve the project objectives. Owing to its increasing importance, risk management has been recognized as a necessity in today's construction industry, and a set of techniques and strategies have been developed to control the influences brought by potential risks [2,12,13]. A systematic process of risk management are normally divided into (1) risk identification and classification, (2) risk analysis, and (3) risk response, where risk response has been further divided into four actions, i.e. retention, reduction, transfer and avoidance [1,9,14].

Risk identification is the first step of risk management process, in which potential risks associated with a construction project are identified. As an integrative part of risk identification, risk classification attempts to structure the diverse risks affecting a construction project. Many approaches have been suggested in the literature for classifying risks. Perry and Hayes [15] 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, Flanagan and Norman [1] suggested three ways of classifying risk: by identifying the consequence, type and impact of risk. Chapman [16] 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. [17] 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 serve the purpose of the research. In this paper, risks were grouped with reference to Perry and Hayes' method in order to study risks from the project stakeholder perspective.

As an intermediate process between risk identification and risk response, risk analysis incorporates uncertainty in a qualitative and quantitative manner to evaluate the potential impact of risks [18]. Once the risks of a project have been identified and analysed, appropriate risk response strategies must be adopted to cope with the risks in the project implementation. The treatment measures on each risk are based on the nature and impact of the risk. The main aim is to remove as much as possible the potential negative impact and to increase the level of control of the risks. However, the process of risk management does not aim to eliminate all risks but to identify appropriate strategies to assist project stakeholders to manage them [15].

Extensive research has been undertaken in the field of risk management for construction projects. Major outcomes of these attempts are the identification of the project objectives related risks and the project phase related risks. While these recognized risks are pertaining to different construction projects in the context of different countries, they are all of great importance in guiding the risk management research and practice for the Chinese construction industry.

2.2. Risk versus project objectives

A direct relationship between effective risk management and project success is acknowledged since risks are assessed by their potential impact on the project objectives [19]. Hence, employing 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 or two aspects of project strategies with respect to cost [20,21], time [22,23], quality [24,25], safety [26–29] and environmental sustainability [30,31]. Zou et al. [3] conducted a comprehensive review of the current literature as summarised below:

- Project cost overrun risks include: inaccurate cost budget; price escalation of material and material-availability uncertainties; labour-market and labour cost increase; supplier or subcontractors' default; unpredictable weather; fluctuation in currency and interest rates; excessive interface on project management; political instability, corruption and unfamiliarity with local regulations.
- Project time delay risks include: poor project scope definition; project complexity; inadequate planning; inappropriate project schedule; design variations; inaccurate engineering estimate; inaccuracy of material estimate; material and equipment shortage; long lead-time items; shortage of skilled labour; poor labour productivity; unpredictable weather conditions.
- Project quality risks include: iterative cycles resulting from unanticipated errors and changes; 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, poor workmanship, use of sub-standard materials, not following specifications or standards, inappropriate construction processes.
- Project safety risks include: lack of safety regulations and legislation; poor safety awareness of top management and project managers; reluctance to input resources to safety; lack of training; poor accident record keeping and reporting system; reckless operation; disorganized labour; poor site conditions, layout and space; severe weather conditions.
- Project environmental sustainability risks include: direct environment risks such as dust, harmful gases, noises, solid and liquid wastes; and indirect environmental risks which are influenced by a project but are not necessarily a direct result of the project, such as the exposure of contaminated materials during the excavation of soil for footing.

2.3. Risk versus project stages

The life cycle of a construction project is normally divided into a few stages, including conceptual (feasibility), design, construction and operation stages. Uher and Toakley [32] investigated various structural and cultural factors concerned with the implementation of risk management in the conceptual phase (i.e., *feasibility stage*) 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 [16] translated the risks described within the Central Computer and Telecommunications Agency Publication "Management of Project Risk" into the *design risks* which included but 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 [33] 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.

It is clear that although attempts have been made to study risk management in a particular project phase, there is a lack of comprehensive observation of risk management for the whole project life cycle. More effective management of risks would be possible if these risks were identified and considered in a more complete and systematic way in a project life cycle [12].

2.4. Risk management research in the Chinese construction industry

To the best of the authors' knowledge, little effort in both research and practice was committed to systematically identify and manage risks in the Chinese construction industry and hence the construction activities in China are exposed to many risks which may be partly neglected, if not all, and without proper management [34].

This conclusion does not refute many researchers' contribution in a particular aspect of risk management for Chinese construction activities, such as joint ventures and build-operate-transfer (BOT) projects. For example, Shen et al. [17] conducted surveys to examine risks associated with Sino-foreign construction joint ventures, analysed the highly ranked and typical risks and proposed practical risk management strategies to manage these risks. From the perspective of Chinese contractors, Fang et al. [35] investigated risks encountered by the local contractors while contracting for projects in the Chinese construction market. Shen et al. and Fang et al.'s research both used risk importance index to evaluate the risk importance based on surveys. Wang et al. [5] carried out research to evaluate and manage foreign exchange and revenue risks in China's BOT projects based on the findings of an international survey on risk management of BOT projects in developing countries. These studies provided valuable information for both Chinese and overseas industry practitioners to gain a better understanding of the Chinese construction market. However, risks associated with construction activities have not been systematically studied and managing strategies have not been systematically established in the Chinese construction industry yet.

The overseas research and experience can contribute to the risk management for construction projects in China. However, due to unique economic, environmental, cultural

and political background in China and lack of advanced technology and management in the Chinese construction industry, there is a need to conduct research of risk management with emphasis on the Chinese construction projects and its culture, which is the main aim of this paper.

3. Research methodology

This paper aims to study risks associated with construction projects in the Chinese construction industry. The research methodology selected comprised a comprehensive literature review, a postal questionnaire to the Chinese construction industry practitioners, a statistical analysis of the survey data and a systematic exploration of identified risks from the perspectives of stakeholders and life cycle. In addition, a comparative study for the risks in Chinese construction industry to those in Australian construction industry was also conducted.

The questionnaire consisted of two sections. Section I solicited general information about the respondents. Section II carried a total of 85 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 magnitude of consequence on each project objective (time, cost, quality, safety and environmental sustainability) that would result in as "high, medium or low". These risks were sourced from a wide range of literature including journal papers and books worldwide as well as those specifically focused on the Chinese industry [1,5,13,16–18,23,28,34–36]. A consultation was conducted with industry experts in China to verify the risk list. Furthermore, prior to a full scale survey, pilot surveys was carried out with a few industry experts to test and verify the survey. The survey questionnaire was refined based on the pilot survey feedbacks. It is believed that the 85 risks listed in the survey is very comprehensive to represent almost all risks that might occur in construction projects in China and elsewhere. The 85 risks were categorized into seven groups, with eight risks related to clients, eight related to designers, 39 related to contractors, four related to subcontractors/suppliers, five related to government bodies, five related to superintendents, 16 related to external issues (i.e. economic circumstance, physical working and social environments). The questionnaires were distributed to 177 construction practitioners in China. 86 responses were received but 3 of them were identified as invalid due to vastly incomplete answers. This represents a valid response rate of 46%, which is acceptable according to Moser and Kalton's assertion [37].

3.1. Sample composition

The respondents were practitioners in the Chinese construction industry. They had an average of 15 years' work experience in the construction sector. They had professional qualifications and 76.5% of them received tertiary education. The construction projects that they have been committed to include infrastructures, housing, public assets and commercial buildings. More details of the respondent profiles are presented in Table 1. The respondents' long work experience, solid tertiary educational background and multifaceted involvement in diverse construction projects infer that the respondents have adequate knowledge of construction project management and the associated risks.

3.2. Data analysis method

The survey feedback includes two groups of data, the likelihood of occurrence of each risk and its magnitude of consequence on project objectives in terms of cost, time, quality, environment and safety. The three-point scales for the likelihood α (highly likely, likely, less likely) and the consequence β (high magnitude, medium magnitude, low magnitude) need to be converted into numerical scales. The matrix presented in Table 2 shows the converted numerical values and the calculation of the risk significance index which will be explained in details later. Note that depending on the design of the questionnaire, different values can be assigned to α and β. For example, if a three-point rating scale is chosen, according to Shen et al. [17] and Zou et al. [3], "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, which were also 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 Eq. (1), which is presented in detail by Zou et al. [3].

$$r_{ij}^{k} = \alpha_{ij}\beta_{ij}^{k} \tag{1}$$

Where r_{ij}^{k} = significance score assessed by respondent j for the impact of risk i on project objective k; i = ordinal num-

Table 1
Profiles of the survey respondents

Respondent profiles	Categorization and percentages	
Educational background	College (23.5%)	Bachelor's degree (67.9%)
	Master's degree (7.4%)	Doctoral degree (1.2%)
Number of years of work experience	Less than 5 years (2.5%)	5–10 years (17.3%)
	10–15 years (43.2%)	More than 15 years (37%)
Types of construction projects currently involved in	Infrastructure (43.2%)	Housing (77.8%)
	Public assets and commercial buildings (71.6%)	

Table 2
Matrix for the calculation of the risk significance score

α	β		
	High magnitude of consequence (1.0)	Medium magnitude of consequence (0.5)	Low magnitude of consequence (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

ber 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, $j \in (1,n)$; $n =$ total number of valid feedbacks to risk i; $\alpha_{ij} =$ likelihood occurrence of risk i, assessed by respondent j; $\beta_{ij}^k =$ 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 Eq. (2). This average score is called the risk significance index score and can be used to rank among all risks on a particular project objective.

$$R_i^k = \frac{\sum_{j=1}^{n} r_{ij}^k}{n} = \frac{1}{n}\sum_{j=1}^{n} \alpha_{ij}\beta_{ij}^k \quad (2)$$

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

Risks are ranked in accordance with their significance index (R_i^k) in association with each project objective, and this is done in turn on cost, time, quality, safety and environmental sustainability respectively. The rationale of such method is expounded by Zou et al. [3]. However, it should be noted that the method for calculating the risk significance index score may overlook those risks (such as tsunami and terrorism) with a less likelihood of occurrence but a high level of consequence on project objectives, which should be taken into account in risk management practice but was not the focus of this research.

4. Survey results and analysis

All risks observed in the questionnaire can happen to any construction project. The purpose of this investigation is not only to generate a list of risks but also to identify the key risks that can significantly influence the delivery of construction projects. As the risks explored in the survey included a large number of factors, choosing the top 10 ranked ones (out of 85 risk factors) are assumed as an appropriate way to represent the key risks, which is also in line with other similar research [28,38]. The result of the ranking is presented in Table 3.

Table 3
Key risks as per their significance on individual project objective

Key risks	Significance index scores
Cost related risks	
Variations by the client	0.57
Price inflation of construction materials	0.56
Design variations	0.47
Tight project schedule	0.46
Project funding problems	0.44
Contractors' difficulty in reimbursement	0.42
Incomplete or inaccurate cost estimate	0.41
Contractors' poor management ability	0.40
Inadequate site information (soil test and survey report)	0.37
Inadequate program scheduling	0.36
Bureaucracy of government	0.36
Excessive procedures of government approvals	0.36
Time related risks	
Project funding problems	0.58
Variations by the client	0.58
Inadequate program scheduling	0.53
Contractor's difficulty in reimbursement	0.51
Design Variations	0.48
Tight project schedule	0.46
Contractors' poor management ability	0.44
Excessive procedures of government approvals	0.44
Price inflation of construction materials	0.43
Suppliers' incompetency to delivery materials on time	0.39
Quality related risks	
Tight project schedule	0.44
Contractors' poor management ability	0.43
Unavailability of sufficient amount of skilled labour	0.41
Unavailability of sufficient professionals and managers	0.41
Poor competency of labour	0.40
Contractors' difficulty in reimbursement	0.38
Variations by the client	0.37
Project funding problems	0.36
Low management competency of subcontractors	0.35
Design Variations	0.34
Inadequate site information (soil test and survey report)	0.34
Environment related risks	
Serious noise pollution caused by construction	0.40
Water pollution caused by construction	0.32
Tight project schedule	0.32
Project funding problems	0.27
Variations by the client	0.27
Serious air pollution due to construction activities	0.25
Contractors' poor management ability	0.24
Contractors' difficulty in reimbursement	0.24
Prosecution due to unlawful disposal of construction waste	0.24
Bureaucracy of government	0.23
Safety related risks	
Employees did not buy safety insurance	0.46
Tight project schedule	0.45
Project funding problems	0.38
Inadequate safety measures or unsafe operations	0.38
Contractors' poor management ability	0.38
Did not buy insurance for major equipment	0.36
Unavailability of sufficient professionals and managers	0.33
Contractors' difficulty in reimbursement	0.33
Lack of readily available utilities on site	0.31
Poor competency of labour	0.30

It is evident that many risks in Table 3 are repeated among the five categories. For example, ''tight project schedule'', ''contractors' difficulty in reimbursement'', etc. can influence all project objectives; ''variation by client'' can influence objectives in terms of cost, time, quality and environment sustainability. With the repeated ones filtered, a total of 25 factors are highlighted as key risks to impact the project delivery. These risks together with their recognized impacts on project objectives are given in Table 4.

The statistical results shown in Table 4 disclose two facts concerned with the relationship between the category of key risks and the project objectives. Firstly, a majority of the 25 risks are related to contractors, compared with less risks related to designers, clients and government agencies and much less risks related to subcontractors/suppliers and external issues. This is, to some extent, because a large proportion of risk factors investigated in the questionnaire were originated from contractors. Given that updated project procurement methods generally encourage contractors' early involvement in the pre-tendering stage in addition to their traditional task areas, a more persuasive argument to account for this fact is that contractors play an increasingly important role in the project development. Moreover, a large proportion of contractors in the Chinese construction industry traced themselves back to labour contractors and hence generally lack advanced managerial and technological skills and perceptions of environmental protection. Therefore, risks related to contractors were recognized extensively in this survey.

The second fact presents an evident relationship between the category of risks and their impact on project objectives. The distribution of the ticks in Table 4 shows that risks related to clients and contractors can influence all five project objectives while risks related to designers, subcontractors/suppliers, government bodes, and external issues can influence part of the project objectives. To uncover the important roles of different project stakeholders on the successful delivery of construction projects, an in-depth elaboration of such a relationship is presented below.

- Three risk factors related to clients were identified with significant influence on all project objectives except that ''variations by clients'' was not recognized to have significant impact on project safety. A further examination of the significantly index scores of the three

Table 4
Key risks influencing project objectives and the acronyms

Category of risks	The 25 key risks identified	Acronyms	With significant impact on				
			Cost	Time	Quality	Safety	Environment
Risks related to clients	Tight project schedule	TPS	√	√	√	√	√
	Project funding problems	PFP	√	√	√	√	√
	Variations by the client	VC	√	√	√		√
Risks related to designers	Design variations	DV	√	√	√		
	Inadequate program scheduling	IPS	√	√			
	Inadequate site information (soil test and survey report)	ISI	√		√		
	Incomplete or inaccurate cost estimate	ICE	√				
Risks related to contractors	Contractors' poor management ability	CPMA	√	√	√	√	√
	Contractors' difficulty in reimbursement	CDR	√	√	√	√	√
	Poor competency of labourer	PCL			√	√	
	Unavailability of sufficient professionals and managers	UPM			√	√	
	Without buying insurance for major equipment	WIME				√	
	Without buying safety insurance for employees	WSIE				√	
	Inadequate safety measures or unsafe operations	ISM				√	
	Lack of readily available utilities on site	LAU				√	
	Unavailability of sufficient amount of skilled labourer	USL			√		
	Prosecution due to unlawful disposal of construction waste	PUDW					√
	Serious air pollution due to construction activities	SAP					√
	Serious noise pollution caused by construction	SNP					√
	Water pollution caused by construction	WP					√
Risks related to subcontractors/ suppliers	Low management competency of subcontractors	LMCS			√		
	Suppliers' incompetency to deliver materials on time	SIDM		√			
Risks related to government agencies	Bureaucracy of government	BG	√				√
	Excessive procedures of government approvals	EPGA	√	√			
External issues	Price inflation of construction materials	PICM	√	√			

risks in Table 3 shows that most of them belong to the foremost five risks in each category. This indicated that clients can influence the project objectives maximally.

- Four risk factors concerned with designers were ascertained with significant influences on the traditional project objectives in terms of time, cost and quality. Hence, designers can play an important role in the management of project time, cost and quality.
- Similarly to clients, contractors were acknowledged to have extensive influences on all project objectives. However, the uneven distribution of the ticks indicates that the contractors' major influences focus on project quality, safety and environmental sustainability.
- Two risk factors related to subcontractors/suppliers were highlighted. The suppliers' incompetency to deliver materials on time and the subcontractors' low management competency may retard the project progress and wreck the project quality respectively.
- The bureaucracy and excessive procedures of approvals in the Chinese government agencies were recognized. The results show that the governmental agencies' major influences are concerned with project cost, time and environmental sustainability.
- "Price inflation of construction material" is a global risk and it is not directly related to a project stakeholder. However, the project team, including the clients, designers, contractors, subcontractors and suppliers, should all contribute to the management of this issue.

5. Comparison with the results of a parallel survey in Australia

Zou et al. [3] conducted a parallel survey (using the same survey questionnaire) to explore Australian industry practitioners' perception with respect to risks associated with construction projects in Australia. The translation of the survey questionnaire from Chinese into English was carefully performed and checked by the authors to ensure the consistence between the two versions. As a result, they identified 20 key risks. To ease the comparison, the results of the two surveys conducted are summarized in Table 5.

Table 5 shows that a large proportion of the identified risks associated with construction projects in China and Australia are equivalent. For example, all the risks related to designers, governmental agencies and external issues and part of the risks related to clients, contractors and subcontractors/suppliers are the same. These generic risks are worthy of attention in both countries. On the other hand, the comparison shows that more risks related to contractors were identified in China, indicating that the construction activities carried out by Chinese contractors may expose more problems. The comparison also presents the following unique risks associated with the Chinese construction projects.

- Project funding problems – regardless of the clients' different financial ability, this issue infers the Chinese clients' poor management of funding in the development of construction projects, as discussed later in the following section.
- Contractors' poor management ability – This factor indicates the reality of Chinese contractors' ability to manage construction projects. In Australia, to gain contracting licenses contractors need to pass a certain level of pre-qualification in which the management ability is one of the essential criteria. In comparison, most Chinese contractors originated from labour contractors and generally lack competent management skills and professional knowledge in construction management. The tertiary education on construction management was only established in the recent decade.
- Contractors' difficulty in reimbursement – despite remarkable progress in developing policies to regulate the owners' payment, Chinese contractors still face difficulty in reimbursement. In Australia, this risk is not recognized as the policies with respect to the owners' payment and strategies to manage disputes are well implemented.
- Poor competency of labourers – the construction labourers are almost dimissory farmers and unemployed workers. The labourers in Australia need to receive training and obtain certifications before commencing construction work. This suggests that Chinese labourers should gain some continual professional development training to improve their competency.
- Not buying insurance for major equipments and employees – insurance for major equipments is recommended and safety insurance for employees is mandatary in Australia. Similar insurance policies apply to construction projects in China. However, they were not well implemented due to the low level of awareness of the insurance and/or its importance among Chinese contractors.
- Inadequate safety measures or unsafe operations – safety issues on construction sites are respected by policies and industry practitioners in Australia while they are likely to be neglected in China under the desire for quick success and instant benefit. This remains as a major issue in China [39].
- Lack of readily available utilities on site – this factor reflects the poor planning and management of project resources on construction sites in China.
- Prosecution due to unlawful disposal of construction waste and serious air and water pollution due to construction activities – this reflects the Chinese contractors' poor perception of construction waste and pollution management and lack of skills in minimizing construction pollution. In contrast, only noise pollution was recognized by the Australian practitioners.
- Suppliers' incompetency to deliver materials on time – this discloses one of the critical issues leading to time overrun of construction projects in China. In comparison

Table 5
Comparison of key risks identified in two parallel surveys in China and Australia

Category of risks	Key risks associated with construction projects	
	Key risks identified in the Australian survey	Key risks identified in the Chinese survey
Risks related to clients	Tight project schedule	Tight project schedule
	High performance/quality expectation	Project funding problems
	Variations by the client	Variations by the client
	Incomplete approval and other documents	
Risks related to designers	Design variations	Design variations
	Inadequate program scheduling	Inadequate program scheduling
	Inadequate site information (soil test and survey report)	Inadequate site information (soil test and survey report)
	Incomplete or inaccurate cost estimate	Incomplete or inaccurate cost estimate
Risks related to contractors	Unsuitable construction program planning	Contractors' poor management ability
	Variation of construction programs	Contractors' difficulty in reimbursement
	Lack of coordination between project participants	Poor competency of labourer
	Unavailability of sufficient professionals and managers	Unavailability of sufficient professionals and managers
	Unavailability of sufficient amount of skilled labourer	Without buying insurance for major equipment
	General safety accident occurrence	Without buying safety insurance for employees
	Occurrence of dispute	Inadequate safety measures or unsafe operations
	Serious noise pollution caused by construction	Lack of readily available utilities on site
		Unavailability of sufficient amount of skilled labourer
		Prosecution due to unlawful disposal of construction waste
		Serious air pollution due to construction activities
		Serious noise pollution caused by construction
		Water pollution caused by construction
Risks related to subcontractors/ suppliers	Low management competency of subcontractors	Low management competency of subcontractors
		Suppliers' incompetency to deliver materials on time
Risks related to government agencies	Excessive procedures of government approvals	Excessive procedures of government approvals
	Bureaucracy of government	Bureaucracy of government
External issues	Price inflation of construction materials	Price inflation of construction materials

to the relatively informative material market in Australia, the Chinese market lacks demand-and-supply information of construction materials, which hence cannot support suppliers' work.

6. Managing the key risks

The foregoing analysis of key risks highlighted the importance of project stakeholders' roles in the management of project cost, time, quality, safety and environmental sustainability in the Chinese construction industry. These risks may arise at different phases of a project life cycle, and some of them are possibly concerned with more than one phase. An illustration of the multifaceted connections of the key risks, stakeholders and project life cycle is presented in Fig. 1 with reference to the risk management framework developed by Zou et al. [3].

In order to manage these risks effectively, strategies should be sought from the perspectives of project stakeholders and life cycle. In this section we formulate recommendations for managing the key risks in construction projects in China. These recommendations are primarily built on the research findings and the authors' own experience in the field. The key risks associated with construction projects are registered and the risk management strategies are adopted to manage these key risks to reach the project objectives successfully. The incorporated risk management strategies from the perspective of project stakeholders and life cycle are discussed as follows.

6.1. Strategies from the perspective of stakeholders

The key risks related to project stakeholders are discussed to identify appropriate strategies that the stakeholders should take to manage their relevant risks, as elaborated below.

6.2. Risks related to clients

"Tight project schedule" was perceived to extensively influence all project objectives, which infers that formulating an appropriate schedule at the conceptual/feasibility

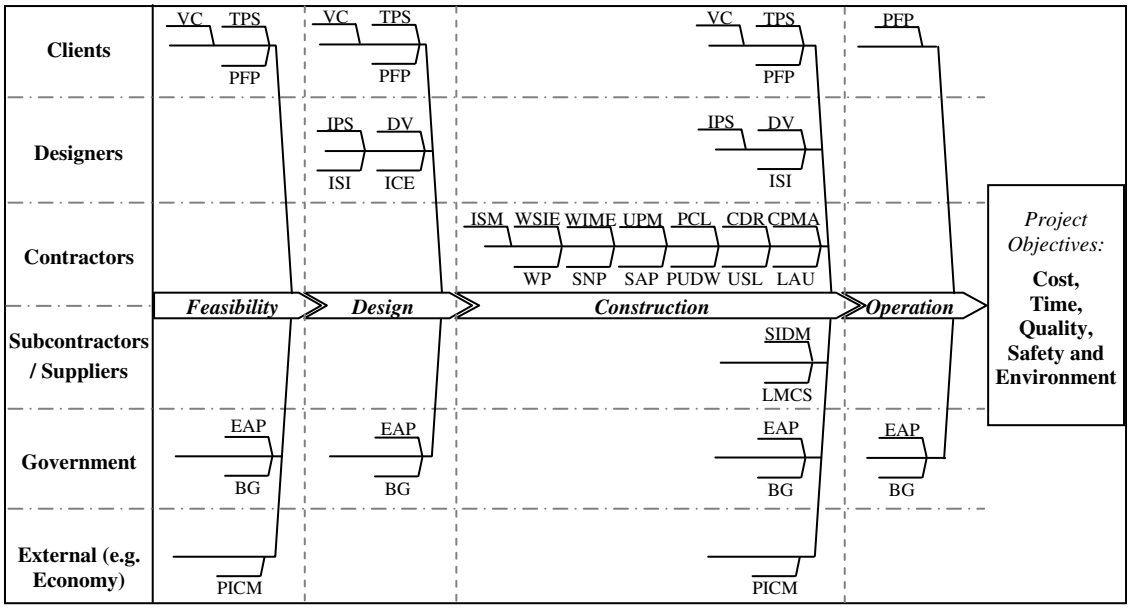

Fig. 1. Connections of key risks, stakeholders and project life cycle. Note: please refer to the appendix for a list of acronyms in alphabetical order with definitions.

phase is never more constructive to project delivery. Time is money. Under the force of this proverb, many Chinese clients are likely to expect to complete a project as quickly as possible without considering the order of nature and construction activities. As a lengthy schedule undoubtedly wrecks project cost benefit, clients should prepare a practical schedule allowing sufficient but not redundant time to accommodate all design and construction tasks.

The all-around influence of "project funding problems" was acknowledged. In the Chinese construction industry, it is quite normal that clients/developers do not have sufficient financial capacity on their own to develop projects at the start. One of the major funding sources is through pre-selling the property (say in residential and commercial projects). If the market demands are not forecasted accurately, lack of funding will turn to a reality. In the feasibility and design phases, clients should prepare a project forecast and strategic plan as practically as possible and designers should develop the design within the clients' financial capability. In the construction phase, clients should develop a clear and appropriate plan, envisage a contingency fund, secure standby cash flow in advance and control schedule and cost. The last choice is entering into a fixed rate loan contract with lending banks if nothing else helps.

"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 clients or the misunderstanding/misinterpretation of the clients' needs in the project brief. For the former cause, the clients should bear the responsibility; for the latter, a knowledgeable initial project team should be established as early as possible to define the project scope and functions precisely.

6.3. Risks related to designers

"Design variations" arise in the design phase of a project, which may result from issues such as "variations by the client" and defective designs. The responsibility for variations resulting from the clients' change of mind should be taken by the clients. To minimize defective designs, the design team need to fully understand what the client wants, arrange comprehensive site investigation to obtain reliable design data, and establish an efficient communication scheme among the designers. Design and build (D&B) procurement and early involvement of specialist contractors can be adopted to enable the development of design in harmony with site conditions and constructability thus minimizing design/drawing defects.

"Inadequate program scheduling" often appears in projects with a tight schedule where some programs need to be reduced to meet the timeline. Furthermore, uncertainty surrounds most facets of construction projects, which makes it impossible to accurately predict the time required for various programs. Choosing experienced designers and early involvement of specialist contractors can help to minimize the difference between the proposed and practical program schedules.

"Inadequate site information (soil test and survey report)" leads to uninformative designs and further affects the progress of excavation, foundation and footing construction. Prior to any design scheme, under the regulation of site investigations stipulated by the Ministry of Construction, PR China [40], 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.

"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, the fluctuation of market prices and rigid cost estimation methods adopted by quantity surveyors, 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 improve accuracy.

6.4. Risks related to contractors

"Contractors' poor management ability" was recognized to influence all project objectives. A majority of Chinese contractors originated from labour and specialist contractors and generally lack managerial skills to contract large projects, if not all types. Hence, the ability to manage the development of construction programs should be regarded as one of the key criteria in appointing contractors. More importantly, from the viewpoint of contractors, they should always do their best to improve their management skills through formulating viable construction programs based on team work, defining clear authority and responsibility, developing clear contractual terms with subcontractors, carrying out routine site meetings to identify problems and seek solutions, strengthening the participant's perception of cooperation and communication.

"Contractors' difficulty in reimbursement" is a crux in the Chinese construction industry. Its causes may involve "project funding problem", clients' adversarial stance, and occurrence of disputes. To solve the problem, contractors should assess the clients' financial capacity and obtain relevant statements that guarantee the progress payments. As far as their own responsibilities are concerned, contractors should effectuate construction tasks strictly in accordance with the contracts. Encountering design variations or difficulty in construction, contractors should always discuss with the team, 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, to avoid discrepancy with the clients in the future reimbursement. In addition, contractors should also endeavour to establish a good relationship with clients to minimize adverseness and uncooperative activities. If it does happen, contractors should take legal weapon to vindicate their rights.

"Poor competency of labour" was recognized to influence project quality and safety. Subletting labour works to subcontractors is common in China. While it may reduce the overheads, contractors may lose control over the competency of the labour. Another deep-rooted reason is that due to the lack of work force to meet the needs of massive urban development in China, a majority of construction labour are dimissory farmers and unemployed workers who start to work on construction sites without receiving professional training. To change this reality, construction labourers should be trained temporarily prior to commencing their work. In the long run they should receive formal professional education and obtain qualifications to work in construction projects.

"Unavailability of sufficient professionals and managers", "unavailability of sufficient amount of skilled labourers" and "lack of readily available utilities on sites" may result in quality and safety problems in the construction phase. The massive development in China leads to high demands of skilful management personnel and labourers, which however cannot be satisfied as the project management/chartered builder systems were only established in recent years in China. It is unexpected that these risks were not recognized to influence project time objective significantly. This infers a fact that incompetent staff and labourers are generally employed and inappropriate utilities are extensively used on construction sites, which may enable contractors to catch up with the project progress but at the same time result in project quality and safety at a venture. Accordingly, contractors need to develop a robust construction plan incorporating rational distribution of staff and utilities. Moreover, they should map the construction progress all the time to secure sufficient professionals, managers and skilled labourers ready to work and utilities ready to use.

"Not buying insurance for major equipment" and "not buying safety insurance for employees" was perceived as significant contributors to unsafe construction environment in China. Purchasing insurance for major equipment is not mandatory. Under an optimistic mentality, most contractors do not intend to buy such insurance. Comparatively, buying safety insurance for employees is a must in China, as defined by the Law of the People's Republic of China on Work Safety [41], which however is not implemented out and due to the poor overseeing scheme and incomplete insurance scheme in China [42]. To facilitate the implementation of a construction insurance scheme, the Chinese government needs to expedite construction legislation incorporating safety insurance as a necessity, increase the industry practitioners' awareness, and establish a construction insurance agent system.

The significant impact of "inadequate safety measures or unsafe operations" on construction safety was acknowledged. It reflects a lack of perception and/or commitment on construction safety among contractors and labourers. Contractors should examine and implement safety regulations stringently and effectively, make every effort to ensure that safe working conditions are not jeopardized by poor site coordination or regardless of safe operation guidelines. Contractors also need to train all employees with safety knowledge and skills so that they can perform in the light of safety regulations.

The survey also raised another four critical issues related to construction waste and pollution, i.e. "prosecution due

to unlawful disposal of construction waste", "serious air pollution due to construction activities", "serious noise pollution caused by construction" and "water pollution caused by construction". In China, these issues resulted from contractors and other construction practitioners' poor awareness of the environmental impacts of construction activities. Legislations for the administration of irresponsible construction performances should be established urgently. The Construction and Environmental Protection Agencies of local Government in China should appoint inspectors to oversee the construction process and effectuate the relevant environmental protection legislations. Furthermore, specifications concerned with the minimization of construction pollution should be formulated and imparted to contractors. For example, with respect to noise pollution, contractors should arrange a suitable time for those construction tasks with serious noise and if necessary, make noise reduction arrangements on site.

6.5. 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 effectively manage their resources to meet the needs from several concurrent construction sites, which will cause time delay on their job on particular sites. As a chain reaction, such delay will influence other subcontractors' activities and further delay the overall performance of the project. Accordingly, management competency should be regarded as one of the key criteria for appointing subcontractors. In addition, concerted efforts of subcontractors in a construction team are important to bridge the gap of low management competency and achieve win–win results. The subcontractors should obtain some professional training and constantly reflect on their work to improve their management skills and competence.

"Suppliers' incompetency to deliver materials on time" was acknowledged. Likewise, the selection of suppliers should be based on a sound investigation of their credit standing and capability to fulfil the contract of supplying materials, in which a long-term cooperative relationship should be highly respected. From the designers and contractors' perspectives, the selection of building materials should align with the market conditions and supply cycles. In particularly, the geographic location of materials should be considered to avoid long lead time and long distance transportation.

6.6. Risks related to government agencies

"Excessive approval procedures in administrative government departments" and "bureaucracy of government" are often complained about by clients and contractors in China. Due to culture issues, some officers in the Chinese government departments do not have a right attitude towards their services to the public. The authority for approvals is assumed as a personal privilege in pursuit of personal benefits (e.g. corruptions). These risks are normally out of the control of the project stakeholders. The government plays an important role in alleviating political risks and creating a favourable environment for project development. To attract investment within their administrative territory, the government agencies should make every effort 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 relationships with local government officers and communicating with them as much as possible and at the same time documenting everything.

6.7. Risk related to external business environment

"Price inflation of construction materials" was identified within the external business environment. The price of construction materials is changing along with 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 the contractor should always avoid using fixed price contracts to bear the risk. One fair way to deal with potential price fluctuation is to add a contingency premium. On the other hand, the cost estimation practice in China is generally based on quotation books issued by the government rather than market conditions. Hence, changing the rigid quotation method to the reference of market conditions in preparing the bill of quantities and estimations is essential to minimize the price fluctuation of construction materials.

6.8. Strategies from the perspective of a project life cycle

More effective management of risks would be possible if the risks are managed from the perspective of a project life cycle. Hence, identifying the possible occurrence of risks in each stage and making appropriate arrangements to cope with them are significant. As shown in Fig. 1, the 25 key risks are allocated into different project phases as per their possible time of occurrence. Many risks may occur in more than one phase and hence they need to be considered in more than one time. For example, "project funding problem" may result from inappropriate project forecasting and planning at the feasibility stage, luxury design exceeding the project budget at the design stage, difficulty or variation in project financing in the construction stage, and even failure of raising funding for project maintenance and operation. Also, these risks should be monitored regularly to evaluate their changes.

The key risks are categorized into a project life cycle, with 6, 9, 23 and 3 risks associated with feasibility, design, construction and operation phases respectively. Fig. 1 shows that a majority of risks occur in the pre-operation stages, with only three 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 when the project is in a construction process. After the physical work of construction is completed and put into use, most ambiguity and uncertainty has been changed to reality and the possible risks may only come from the funding for the project operation and difficult government regulations in terms of facility management, environment sustainability, etc. To accommodate these risks appropriately, concerted efforts are needed at different phases of a project life cycle, particularly at the project feasibility, design and construction phases, as presented below.

- Feasibility phase: Most risks at this stage are related to clients and governmental agencies. Clients should know what kind of product they want and need, conduct the project feasibility study as practically as possible, and develop the project brief which can be informative enough to guide the project development. Government agencies should avoid bureaucracy and minimize the procedures for approvals while clients should always maintain a close relationship with government officers to shorten the time for approvals. The potential influence of price fluctuation of construction materials should be contemplated in the project feasibility study.
- Design phase: Designers play the most important role in this phase. They should make every effort to fully understand the client's wants and needs. They should carry out comprehensive investigation of site conditions, articulate the clients' needs in a technically competent way and within the limitation of the clients' resource, work collaboratively to develop sound program schedule and cost planning and minimize defective designs. Clients should minimize changes at their instigation and if variations are unavoidable, they should inform designers of any changes in time. Likewise, government agencies should eliminate bureaucracy and create a swift environment to support project development. Whenever possible, the designers should involve contractors and client in reviewing the design drawings in order to minimise design defects and improve the constructability of the design as well as value for money [43].
- Construction phase: Most risks in the construction phase are likely to rest with 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. First of all, contract terms need to be formulated to pinpoint the roles of all project participants, in which the responsibility of variations and project delay and the method of owners' payment should be defined clearly. To keep the construction work on track, contractors with competent management skills need to be appointed and a highly cooperative construction team need to be established in which experienced specialist contractors and skilled labourers are staffed, and communication, trust, commitment and integration is expected to bridge the physical and knowledge gap between different project participants. Constrictors and subcontractors should develop safe work method statement for every major construction activity. Contractors should at least purchase safety insurance for all employees, if not for major equipment. Last but not least, viable strategies and techniques should be adopted to monitor and minimize the pollution associated with construction activities throughout the development processes.

In a word, diverse risks related to different project stakeholders may occur at different project stages. Improper management of these risks can significantly influence the achievement of project objectives. In the Chinese construction industry, clients, designers, government bodies should take the responsibility to manage their relevant risks and work cooperatively from the feasibility phase onwards to address potential risks in time; contractors and subcontractors with robust construction and management knowledge should be employed to minimize construction risks and carry out safe, efficient and quality construction activities.

7. Conclusions

Managing risks in construction projects has been recognized as a very important process in order to achieve project objectives in terms of time, cost, quality, safety and environmental sustainability. This paper presents the research results obtained through questionnaire surveys conducted in China. A total of 25 key risks were ascertained based on a comprehensive assessment of their likelihood of occurrence and magnitude of consequence on project objectives. These risks were compared with the findings of a parallel survey in Australia to ascertain the generic risks in both countries and highlight the unique risks associated with Chinese construction projects. The unique risks included project funding problem, contractors' poor management ability, difficulty in reimbursement, unwilling ness to buy insurance and lack of awareness of construction safety and pollutions, etc. It is these generic and unique risks that influence the achievement of construction project objectives in China.

Further exploration of the recognized risks found that they are mainly related to contractors, followed by clients, designers, subcontractors/suppliers and governmental agencies, and occurred mainly in the construction phase, followed by feasibility and design phases. To

tackle these risks appropriately, strategies to manage risks were sought from the perspectives of project stakeholders and life cycle under the Chinese industry background and culture. It is concluded that clients, designers and government agencies should work cooperatively from the feasibility phase onwards to manage potential risks effectively and in time; contractors and subcontractors with robust construction and management knowledge and skills must be employed early to minimize construction risks and make sound preparation for carrying out safe, efficient and quality construction activities.

Appendix. A list of acronyms in alphabetical order

Acronyms	Represented risk factors
BG	Bureaucracy of government
CDR	contractors' difficulty in reimbursement
CPMA	contractors' poor management ability
DV	design variations
EPGA	excessive procedures of government approvals
ICE	incomplete or inaccurate cost estimate
IPS	inadequate program scheduling
ISI	inadequate site information (soil test and survey report)
ISM	inadequate safety measures or unsafe operations
LAU	lack of readily available utilities on site
LMCS	low management competency of subcontractors
PCL	poor competency of labourer
PFP	project funding problems
PICM	price inflation of construction materials
PUDW	prosecution due to unlawful disposal of construction waste
SAP	serious air pollution due to construction activities
SIDM	suppliers' incompetency to deliver materials on time
SNP	serious noise pollution caused by construction
TPS	tight project schedule
UPM	unavailability of sufficient professionals and managers
USL	unavailability of sufficient amount of skilled labourer
VC	variations by the client
WIME	without buying insurance for major equipment
WP	water pollution caused by construction
WSIE	without buying safety insurance for employees

References

[1] Flanagan R, Norman G. Risk management and construction. Victoria, Australia: Blackwell Science Pty Ltd; 1993.

[2] Smith NJ. Managing risk in construction projects. Oxford: Blackwell; 1999.

[3] Zou PXW, Zhang G, Wang JY. Identifying key risks in construction projects: life cycle and stakeholder perspectives. In: Proc. 12th Pacific rim real estate society conference, Auckland, New Zealand, January 22–25, 2006.

[4] Chen JJ. The impact of Chinese economic reforms upon the construction industry. Building Res Informat 1997;26(4):239–45.

[5] Wang SQ, Tiong RLK, Ting SK, Ashley D. Evaluation and management of foreign exchange and revenue risks in China's BOT projects. Constr Manage Econom 2000;18:197–207.

[6] Zeng SX, Tam CM, Deng ZM, Tam VWY. ISO 14000 and the construction industry: survey in China. J Manage in Eng 2003;19(3):107–15.

[7] Rowe WD. An anatomy of risk. New York: Wiley; 1977.

[8] Chicken JC, Posner T. The philosophy of risk. Thomas Telford; 1998.

[9] AS/NZS 4360. Australian/New Zealand standard on risk management. Standards Australia and Standards, New Zealand, 2004.

[10] Association of Project Management, website: <http://www.apm.org.uk/RtoT.asp>, accessed on 10 December 2005.

[11] PMI. A guide to the project management body of knowledge: PMBOK Guide. 3rd ed. USA: Project Management Institute Inc.; 2004.

[12] Chapman CB, Ward SC. Project risk management: process techniques and insights. 2nd ed. UK: John Wiley & Sons; 2003.

[13] Baker W, Reid H. Identifying and managing risk. Frenchs Forest, NSW: Pearson Education; 2005.

[14] Berkeley D, Humphreys PC, Thomas RD. Project risk action management. Constr Manage Econom 1991;9(1):3–17.

[15] Perry JH, Hayes RW. Risk and its management in construction projects. In: Proc. the institution of civil eng.; 1985. Part I, 78, 499–521.

[16] Chapman RJ. The controlling influences on effective risk identification and assessment for construction design management. Int J. Project Manage 2001;19:147–60.

[17] Shen LY, Wu GWC, Ng CSK. Risk assessment for construction joint ventures in China. J Constr Eng Manage 2001;127(1):76–81.

[18] Wang SQ, Dulaimi MF, Aguria MY. Risk management framework for construction projects in developing countries. Constr Manage Econom 2004;22:237–52.

[19] Baloi D, Price ADF. Modelling global risk factors affecting construction cost performance. Int J Proj Manage 2003;21:261–9.

[20] Kaming PF, Olomolaiye PO, Holt GD, Harris FC. Factors influencing construction time and cost overruns on high rise projects in Indonesia. Constr Manage Econom 1997;15:83–94.

[21] Chen H, Hao G, Poon SW, Ng FF. Cost risk management in west rail project of Hong Kong. In: 2004 AACE Int. Transact; 2004.

[22] Shen LY. Project risk management in Hong Kong. Int J Proj Manage 1997;15(2):101–5.

[23] Mulholland B, Christian J. Risk assessment in construction scheduling. J Constr Eng Manage 1999;125(1):8–15.

[24] Lee S, Peña-Mora F, Park M. Quality and change management model for large scale concurrent design and construction project. J Constr Eng Manage 2005;131(8):890–902.

[25] Tilly PA, McFallen SL, Tucker SN. Design and documentation quality and its impact on the construction process. AISC – IEAust Special Iss Steel Constr 2000;34(4):7–14.

[26] Abdelhamid TS, Everett JG. Identifying root causes of construction accidents. J Constr Eng Manage 2000;126(1):52–60.

[27] Kartam NA, Flood I, Koushki P. Construction safety in Kuwait: issues, procedures, problems and recommendations. Safety Sci 2000;36:163–84.

[28] Tam CM, Zeng SX, Deng ZM. Identifying elements of poor construction safety management in China. Safety Sci 2004;42:569-58.

[29] Haslam RA, Hide SA, Gibb AGF, Gyi DE, Pavitt T, Atkinson S, et al. Contributing factors in construction accidents. Appl Ergonomics 2005;36:401–15.

[30] Chen Z, Li H, Wong CTC. Environmental management of urban construction projects in China. J Constr Eng Manage 2000;126(4): 320–4.
[31] Dione S, Ruwanpura JY, Hettiaratchi JPA. Assessing and managing the potential environmental risks of construction projects. Practice Periodical Struct Desi Constr ASCE 2005;10(4):260–6.
[32] Uher TE, Toakley AR. Risk management in the conceptual phase of a project. Int J Proj Manage 1999;17(3):161–9.
[33] Abdou OA. Managing construction risks. J Archi Eng 1996;2(1):3–10.
[34] Wang JY, Liu CL. Risk management for construction projects. Beijing: China Waterpower Press; 2004.
[35] Fang D, Li M, Fong PS, Shen LY. Risks in Chinese construction market – contractors' perspective. J Constr Eng Manage 2004;130(6): 853–61.
[36] Ahmed SM, Ahmad R, Saram DD. Risk management trends in the Hong Kong construction industry: a comparison of contractors and owners perceptions. Eng Constr Arch Manage 1999;6(3):225–34.
[37] Moser CA, Kalton G. Survey methods in social investigation. UK: Heinemann Educational; 1971.
[38] McIntosh K, McCable B. Risk and benefits associated with international construction -consulting joint ventures in the English-speaking Caribbean. Canadian J Civil Eng 2003;30:1143–52.
[39] Zou PXW, Fang DP, Wang SQ, Loosemore M. An overview of the Chinese construction management practice. J Technol Manage China.
[40] Ministry of Construction, PR China. The policy of site investigation and design of construction projects. Website: <http://www.cin.gov.cn/law/admin/2000102003-00.htm>, accessed on 20 January 2006.
[41] Law of the PR China on Work Safety. Website: <http://www.cin.gov.cn/law/main/2005042003.htm>, accessed on 11 December 2005.
[42] Ling M, Zhang W. Problems of developing insurance of works and its solutions in China. Build Constr; 2005; June (Supplement).
[43] McGeorge D, Palmer A, Zou PXW. Construction management in a market economy. Beijing, China: Chian Architectural Building Press; 2003. 200p.