International Journal of Project Management 25 (2007) 601–614

INTERNATIONAL JOURNAL OF

MANAGEMENT

PROJECT

[www.elsevier.com/locate/ijproman](http://www.elsevier.com/locate/ijproman)

Understanding the key risks in construction projects in China

Patrick X.W. Zou a,\*, Guomin Zhang b,1, Jiayuan Wang c

a *Faculty of the Built Environment, University of New South Wales, Sydney 2052, NSW, Australia*

b *School of Architectural, Civil and Mechanical Engineering, Victoria University, Melbourne 8001, Australia*

c *College of Civil Engineering, Shenzhen University, Shenzhen, PR China*

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 envi- ronmental 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 par- allel 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 con- struction 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.

 2007 Elsevier Ltd and IPMA. All rights reserved.

*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

\* Corresponding author. Tel.: +61 2 9385 5236; fax: +61 2 9385 4507.

*E-mail addresses:* p.zou@unsw.edu.au (P.X.W. Zou), kevin.zhang@ vu.edu.au (G. Zhang), wangjy@szu.edu.cn (J. Wang).

1 Formerly research associate at Faculty of the Built Environment, The University of New South Wales.

be achieved in a construction project (i.e., project objec- tives), 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 mas- sive development of infrastructures and assets [4–6]. While this brings opportunities to project stakeholders, employ- ing eﬀective risk management techniques to cope with risks associated with variable construction activities is of impor- tance to implement the projects aligning with project objec- tives 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.

0263-7863/$30.00 2007 Elsevier Ltd and IPMA. All rights reserved. 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 construc- tion project management service to China.

1. Related previous research
	1. *Fundamentals of risk management*

Risk is perceived as ‘the potential for unwanted or neg- ative consequences of an event or activity’ [7], a combina- tion 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 mag- nitude 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 manage- ment and described it as ‘the processes concerned with con- ducting 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 man- agement 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 pro- ject 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 strate- gies 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 identiﬁca- tion 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 avoid- ance [1,9,14].

Risk identiﬁcation is the ﬁrst step of risk management process, in which potential risks associated with a construc- tion 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 classi- fying 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 con- struction 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 polit- ical, as well as technical risks. In a word, many ways can be used to classify the risks associated with construction pro- jects 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 poten- tial 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 out- comes 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 con- struction 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.

* 1. *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 sustain- ability [30,31]. Zou et al. [3] conducted a comprehensive review of the current literature as summarised below:

Project cost overrun risks include: inaccurate cost bud- get; 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 def- inition; project complexity; inadequate planning; impro- priate 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 manage- ment 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.

* 1. *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 Toak- ley [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 con- ceptual phase was relatively low; qualitative rather than quantitative analysis methods were generally used; wide- spread adoption of risk management was impeded by a low knowledge and skill base, resulting from a lack of com- mitment to training and professional development. Chap- man [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 inﬂu- ence the identiﬁcation of risks in the *design phase* of a pro- ject. 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, devel- opment 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 pro- ject life cycle [12].

* 1. *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’ con- tribution 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 asso- ciated with Sino-foreign construction joint ventures, ana- lysed 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 con- tractors while contracting for projects in the Chinese con- struction 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 over- seas industry practitioners to gain a better understanding of the Chinese construction market. However, risks asso- ciated with construction activities have not been systemat- ically 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 man- agement with emphasis on the Chinese construction pro- jects and its culture, which is the main aim of this paper.

1. Research methodology

This paper aims to study risks associated with construc- tion projects in the Chinese construction industry. The research methodology selected comprised a comprehensive literature review, a postal questionnaire to the Chinese con- struction 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 con- struction industry to those in Australian construction industry was also conducted.

The questionnaire consisted of two sections. Section I solicited general information about the respondents. Sec- tion II carried a total of 85 risks associated with construc- tion 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 envi- ronmental 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 Chi- nese 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 repre- sent almost all risks that might occur in construction pro- jects 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

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].

* 1. *Sample composition*

The respondents were practitioners in the Chinese con- struction industry. They had an average of 15 years’ work experience in the construction sector. They had profes- sional 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 pro- jects infer that the respondents have adequate knowledge of construction project management and the associated risks.

* 1. *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 *a* (highly likely, likely, less likely) and the consequence *b* (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 val- ues can be assigned to *a* and *b*. 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 objec- tive, the signiﬁcance score for each risk assessed by each respondent can be calculated through Eq. (1), which is pre- sented in detail by Zou et al. [3].

related to external issues (i.e. economic circumstance, phys-

*rk* ¼ *aijbk*

ð1Þ

ical working and social environments). The questionnaires *ij ij*

*ij*

¼

were distributed to 177 construction practitioners in China. 86 responses were received but 3 of them were identiﬁed as

Where *rk* signiﬁcance score assessed by respondent *j* for the impact of risk *i* on project objective *k*; *i* = ordinal num-

|  |  |
| --- | --- |
| Table 1Proﬁles of the survey respondents |  |
| Respondent proﬁles | Categorization and percentages |  |
| Educational background | College (23.5%)Master’s degree (7.4%) | Bachelor’s degree (67.9%)Doctoral degree (1.2%) |
| Number of years of work experience | Less than 5 years (2.5%)10–15 years (43.2%) | 5–10 years (17.3%)More than 15 years (37%) |
| Types of construction projects currently involved in | Infrastructure (43.2%)Public assets and commercial buildings (71.6%) | Housing (77.8%) |

Table 2

Matrix for the calculation of the risk signiﬁcance score

*a b*

Table 3

Key risks as per their signiﬁcance on individual project objective

Key risks Signiﬁcance

High magnitude of consequence

Medium magnitude of consequence (0.5)

Low magnitude of consequence (0.1)

*Cost related risks*

index scores

Highly

likely

|  |  |
| --- | --- |
| (1.0) |  |
| Likely | 0.50 | 0.25 | 0.05 |
| (0.5) |  |  |  |
| Less | 0.10 | 0.05 | 0.01 |

likely

(1.0)

1.00 0.50 0.10

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

(0.1)

Inadequate site information (soil test

and survey report)

0.37

ber of risk, *i* 2 (1,*m*); *m* = total number of risks; *k* = ordi- nal number of project objective, *k* 2 (1,5); *j* = ordinal num- ber of valid feedback to risk *i*, *j* 2 (1,*n*); *n* = total number of valid feedbacks to risk *i*; *aij* = likelihood occurrence of risk *i*, assessed by respondent *j*; *bk* level of consequence of risk *i*on project objective *k*, assessed by respondent *j*.

*ij*

¼

The average score for each risk considering its signiﬁ- cance on a project objective can be calculated through Eq. (2). This average score is called the risk signiﬁcance

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

index score and can be used to rank among all risks on a

particular project objective.

Suppliers’ incompetency to delivery materials on time

0.39

P*n k ij*

*r*

*j*¼1

*Rk* ¼ ¼

*i*

*n*

1 X*n*

*a bk*

ð2Þ

*Quality related risks*

Tight project schedule 0.44

Contractors’ poor management ability 0.43

Unavailability of suﬃcient amount of skilled labour 0.41

*j*¼1

*n*

*ij*

*ij*

where *Rk* ¼ signiﬁcance index score for risk *i* on project

*i*

Unavailability of suﬃcient professionals and managers

0.41

objective *k*.

Risks are ranked in accordance with their signiﬁcance index (*Rk* in association with each project objective, and this is done in turn on cost, time, quality, safety and envi- ronmental 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 signiﬁ- cance index score may overlook those risks (such as tsu- nami 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.

*i*

Þ

1. 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 con- struction 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.

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 pro- portion of risk factors investigated in the questionnaire were originated from contractors. Given that updated pro- ject 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 technologi- cal 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 pro- ject objectives while risks related to designers, subcontrac- tors/suppliers, government bodes, and external issues can inﬂuence part of the project objectives. To uncover the important roles of diﬀerent project stakeholders on the suc- cessful delivery of construction projects, an in-depth elabo- ration 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 exami- nation 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 p p p p p

Project funding problems PFP p p p p p

Variations by the client VC p p p p

Risks related to designers Design variations DV p p p

Inadequate program scheduling IPS p p

Inadequate site information (soil test and survey ISI p p

report)

Incomplete or inaccurate cost estimate ICE p

Risks related to contractors Contractors’ poor management ability CPMA p p p p p

Contractors’ diﬃculty in reimbursement CDR p p p p p

Poor competency of labourer PCL p p

Unavailability of suﬃcient professionals and managers

UPM p p

Without buying insurance for major equipment WIME p

Without buying safety insurance for employees WSIE p

Inadequate safety measures or unsafe operations ISM p

Lack of readily available utilities on site LAU p

Unavailability of suﬃcient amount of skilled labourer

Prosecution due to unlawful disposal of construction

waste

USL p

PUDW p

Risks related to subcontractors/ suppliers

Risks related to government agencies

Serious air pollution due to construction activities SAP p

Serious noise pollution caused by construction SNP p

Water pollution caused by construction WP p

Low management competency of subcontractors LMCS p

Suppliers’ incompetency to deliver materials on time SIDM p

Bureaucracy of government BG p p

Excessive procedures of government approvals EPGA p p

External issues Price inﬂation of construction materials PICM p p

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 ascer- tained with signiﬁcant inﬂuences on the traditional pro- ject 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. How- ever, the uneven distribution of the ticks indicates that the contractors’ major inﬂuences focus on project qual- ity, 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 manage- ment 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 stake- holder. However, the project team, including the clients, designers, contractors, subcontractors and sup- pliers, should all contribute to the management of this issue.

1. 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 compari- son, the results of the two surveys conducted are summa- rized 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 subcon- tractors/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 contrac- tors were identiﬁed in China, indicating that the construc- tion activities carried out by Chinese contractors may expose more problems. The comparison also presents the following unique risks associated with the Chinese con- struction projects.

Project funding problems – regardless of the clients’ dif- ferent ﬁnancial ability, this issue infers the Chinese cli- ents’ poor management of funding in the development of construction projects, as discussed later in the follow- ing section.

Contractors’ poor management ability – This factor indicates the reality of Chinese contractors’ ability to manage construction projects. In Australia, to gain con- tracting 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 Chi- nese 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 diﬃ- culty in reimbursement. In Australia, this risk is not rec- ognized 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 recom- mended and safety insurance for employees is manda- tary 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 poli- cies 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 con- struction activities – this reﬂects the Chinese contrac- tors’ 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 amount of skilled labourer

Unavailability of suﬃcient professionals and managers Without buying insurance for major equipment

Risks related to subcontractors/ suppliers

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

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 Austra- lia, the Chinese market lacks demand-and-supply infor- mation of construction materials, which hence cannot support suppliers’ work.

1. Managing the key risks

The foregoing analysis of key risks highlighted the importance of project stakeholders’ roles in the manage- ment of project cost, time, quality, safety and environ- mental sustainability in the Chinese construction industry. These risks may arise at diﬀerent phases of a project life cycle, and some of them are possibly con- cerned with more than one phase. An illustration of the multifaceted connections of the key risks, stakehold- ers and project life cycle is presented in Fig. 1 with ref- erence 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 stake- holders and life cycle. In this section we formulate rec- ommendations 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 asso- ciated 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 per- spective of project stakeholders and life cycle are dis- cussed as follows.

* 1. *Strategies from the perspective of stakeholders*

The key risks related to project stakeholders are dis- cussed to identify appropriate strategies that the stakehold- ers should take to manage their relevant risks, as elaborated below.

* 1. *Risks related to clients*

‘‘Tight project schedule’’ was perceived to extensively inﬂuence all project objectives, which infers that formulat- ing an appropriate schedule at the conceptual/feasibility

PFP

EAP

BG

PICM

PICM

**External (e.g. Economy)**

EAP

BG

EAP

BG

EAP

BG

**Government**

**Subcontractors**

**/ Suppliers**

***Operation***

ISM WSIE WIME UPM PCL CDR CPMA

WP SNP SAP PUDW USL LAU

***Construction***

SIDM

LMCS

***Design***

***Feasibility***

**Contractors**

*Project Objectives:*

**Cost, Time, Quality, Safety and Environment**

IPS DV

ISI

IPS DV

ISI ICE

**Designers**

VC TPS

PFP

VC TPS

PFP

VC TPS

PFP

**Clients**

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 practi- cal 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 suﬃ- cient 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 accu- rately, lack of funding will turn to a reality. In the feasibil- ity 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 possi- bly 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 knowledge- able initial project team should be established as early as possible to deﬁne the project scope and functions precisely.

* 1. *Risks related to designers*

‘‘Design variations’’ arise in the design phase of a pro- ject, 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) pro- curement and early involvement of specialist contractors can be adopted to enable the development of design in har- mony with site conditions and constructability thus mini- mizing design/drawing defects.

‘‘Inadequate program scheduling’’ often appears in pro- jects 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 min- imize 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 con- struction. Prior to any design scheme, under the regulation of site investigations stipulated by the Ministry of Con- struction, 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 atti- tude towards work. As previously mentioned, many unforeseen factors encompass construction activities, the ﬂuctuation of market prices and rigid cost estimation meth- ods adopted by quantity surveyors, which often deviates the estimated cost from the real cost. Choosing responsible and experienced designers and if possible getting the con- tractors/subcontractors involved early can help to illumi- nate the black box and improve accuracy.

* 1. *Risks related to contractors*

‘‘Contractors’ poor management ability’’ was recog- nized to inﬂuence all project objectives. A majority of Chinese contractors originated from labour and specialist contractors and generally lack managerial skills to con- tract 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 con- tractors. More importantly, from the viewpoint of con- tractors, they should always do their best to improve their management skills through formulating viable con- struction programs based on team work, deﬁning clear authority and responsibility, developing clear contractual terms with subcontractors, carrying out routine site meet- ings to identify problems and seek solutions, strengthen- ing 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, con- tractors should assess the clients’ ﬁnancial capacity and obtain relevant statements that guarantee the progress payments. As far as their own responsibilities are con- cerned, 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 estab- lish a good relationship with clients to minimize adverse- ness and uncooperative activities. If it does happen, contractors should take legal weapon to vindicate their rights.

‘‘Poor competency of labour’’ was recognized to inﬂu- ence 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 con- struction labour are dimissory farmers and unemployed

workers who start to work on construction sites without receiving professional training. To change this reality, con- struction labourers should be trained temporarily prior to commencing their work. In the long run they should receive formal professional education and obtain qualiﬁca- tions to work in construction projects.

‘‘Unavailability of suﬃcient professionals and manag- ers’’, ‘‘unavailability of suﬃcient amount of skilled labour- ers’’ 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 manage- ment/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 signiﬁ- cantly. This infers a fact that incompetent staﬀ and labour- ers 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 ven- ture. Accordingly, contractors need to develop a robust construction plan incorporating rational distribution of staﬀ and utilities. Moreover, they should map the construc- tion 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 per- ceived as signiﬁcant contributors to unsafe construction environment in China. Purchasing insurance for major equipment is not mandatory. Under an optimistic men- tality, most contractors do not intend to buy such insur- ance. 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 con- struction insurance scheme, the Chinese government needs to expedite construction legislation incorporating safety insurance as a necessity, increase the industry prac- titioners’ awareness, and establish a construction insur- ance agent system.

The signiﬁcant impact of ‘‘inadequate safety measures or unsafe operations’’ on construction safety was acknowl- edged. It reﬂects a lack of perception and/or commitment on construction safety among contractors and labourers. Contractors should examine and implement safety regula- tions 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 construc- tion activities. Legislations for the administration of irre- sponsible 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 legisla- tions. Furthermore, speciﬁcations concerned with the min- imization 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.

* 1. *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 nor- mally allocate their manpower and other resources to dif- ferent 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 subcon- tractors’ activities and further delay the overall perfor- mance 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 impor- tant 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 con- tractors’ 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.

* 1. *Risks related to government agencies*

‘‘Excessive approval procedures in administrative gov- ernment 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 nor- mally 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 adminis- trative 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 gov- ernment oﬃcers and communicating with them as much as possible and at the same time documenting everything.

* 1. *Risk related to external business environment*

‘‘Price inﬂation of construction materials’’ was identi- ﬁed within the external business environment. The price of construction materials is changing along with inﬂation and the relation between supply and demand in the con- struction material market. As this risk is usually unavoid- able, 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.

* 1. *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 prob- lem’’ may result from inappropriate project forecasting and planning at the feasibility stage, luxury design exceed- ing the project budget at the design stage, diﬃculty or var- iation in project ﬁnancing in the construction stage, and even failure of raising funding for project maintenance and operation. Also, these risks should be monitored regu- larly 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 oper- ation. 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 pro- cess. 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 fea- sibility, 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 inﬂu- ence 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 under- stand the client’s wants and needs. They should carry out comprehensive investigation of site conditions, artic- ulate 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. Cli- ents should minimize changes at their instigation and if variations are unavoidable, they should inform design- ers of any changes in time. Likewise, government agen- cies 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 min- imise 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 subcon- tractors. In this phase, the design is ﬁxed, the project progress no longer depends on creating a realistic sche- dule 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, con- tractors 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 com- munication, 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. Con- tractors 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 associ- ated with construction activities throughout the devel- opment processes.

In a word, diverse risks related to diﬀerent project stakeholders may occur at diﬀerent project stages. Impro- per management of these risks can signiﬁcantly inﬂuence the achievement of project objectives. In the Chinese con- struction 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 manage- ment knowledge should be employed to minimize con- struction risks and carry out safe, eﬃcient and quality construction activities.

1. Conclusions

Managing risks in construction projects has been rec- ognized 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 sur- veys 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 pro- jects. The unique risks included project funding problem, contractors’ poor management ability, diﬃculty in reim- bursement, 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 cli- ents, designers, subcontractors/suppliers and governmen- tal 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 stake- holders and life cycle under the Chinese industry back- ground and culture. It is concluded that clients, designers and government agencies should work cooper- atively 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 mini- mize 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 manage- ment. Standards Australia and Standards, New Zealand, 2004.
10. Association of Project Management, website: [<http://www.apm.org](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 tech- niques 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 identiﬁca- tion 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 inﬂuenc- ing 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 schedul- ing. J Constr Eng Manage 1999;125(1):8–15.
24. Lee S, Pen˜a-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 Ergono- mics 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 interna- tional 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/](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.