THE HONG KONG POLYTECHNIC UNIVERSITY

DEPARTMENT OF BUILDING AND REAL ESTATE

DEVELOPING A FUZZY RISK ASSESSMENT MODEL FOR TARGET COST AND GUARANTEED MAXIMUM PRICE CONTRACTS IN THE CONSTRUCTION INDUSTRY OF HONG KONG

by

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A thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

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ABSTRACT

Both the Target Cost Contracts (TCC) and Guaranteed Maximum Price (GMP) schemes have been practised worldwide over the past few decades to achieve better value for money and more favourable project outcomes. However, a comprehensive review of previous research studies on TCC/GMP in Europe, the United States, Australia and Asia has indicated that there is a limited amount of empirical research focusing on the TCC/GMP procurement approach, particularly on risk issues in the Hong Kong context. This research study aims to identify, assess and allocate the key risk factors associated with TCC/GMP schemes, and to evaluate the effectiveness of various risk mitigation measures.

Based on a comprehensive literature review and a series of structured face-to-face interviews, a total of 34 key risk factors inherent with TCC/GMP contracts were identified. An empirical questionnaire survey was then undertaken to solicit the opinions of relevant industrial practitioners on risk identification and assessment, preference of the allocation on such risk factors and the effectiveness of 18 recommended risk mitigation measures. The key risk factors for TCC/GMP contracts were identified, whilst the preference of risk allocation and the effective risk mitigation measures of projects procured with these procurement strategies were also explored in the questionnaire survey.

A Fuzzy Risk Assessment Model for TCC/GMP construction projects was also developed using factor analysis and the fuzzy synthetic evaluation method, based on the results of the questionnaire survey. The top 17 Principal Risk Factors (after the

calculation of normalised values) were selected for undertaking factor analysis. Five Principal Risk Groups (PRGs) were then generated in descending order of importance as: (1) Design documentation risks; (2) Third party delay and tender inadequacy; (3) Economic and financial risks; (4) Lack of experience in TCC/GMP procurement process; and (5) Post-contract risks. It was found that “Design documentation risks” are the major hurdles to the success of TCC/GMP projects in Hong Kong.

The developed model was then validated by seven experts of TCC/GMP in Hong Kong and was confirmed as reliable and adequate for use. More importantly, an Overall Risk Index associated with TCC/GMP construction projects and the risk indices of individual PRGs can be generated from the model for reference by project stakeholders. An objective and reliable assessment can be achieved. The model has provided a solid platform to measure, evaluate and reduce the risk levels of TCC/GMP projects based on objective evidence instead of subjective judgments.

There are some potential applications of the model which could benefit the construction industry at large. At the pre-contract stage, the clients/developers may input the assessment of the 17 key risk factors into the model to generate a risk index for assessing the use of TCC/GMP schemes for a new construction project. Another possible application of this model is that the contractors may assess the risk level of a new project if procured by a TCC/GMP contract during the peer-review process in bidding at tender stage and they can then decide to bid for it or not. The Overall Risk Index may also help the contractors to quantify the risk exposure of the projects and help in pricing during the bidding exercise.

Another useful application of the model is that it has established a norm of TCC/GMP projects with respect to risk assessment in Hong Kong. If there is an adequate number of samples/projects procured with TCC/GMP schemes, a benchmarking model can be built up to help the industrial practitioners to benchmark the risk levels of their own TCC/GMP projects, for example, the Overall Risk Index is 80% of the norm (i.e. lower than the norm) or 120% of the norm (i.e. higher than the norm).

This research study has adopted an innovative approach to overall risk management of TCC/GMP construction projects in Hong Kong, in terms of risk identification, risk assessment, risk allocation and risk mitigation. Further research studies may focus on developing similar risk assessment models for projects procured with traditional fixed-price lump-sum contracts in order to compare and contrast the risk levels of projects procured with different contractual arrangements. The same research methodology may also be applied in different geographical locations to allow an international comparison between the East and the West for risk management of TCC/GMP construction projects.

LIST OF RESEARCH PUBLICATIONS OF JOSEPH CHAN (2008-2011)

Refereed Journal Articles (Published or In Press)

1. Chan, D.W.M., Chan, A.P.C., Lam, P.T.I. and **Chan, J.H.L.** (2010) Exploring the Key Risks and Risk Mitigation Measures for Guaranteed Maximum Price and Target Cost Contracts in Construction, *Construction Law Journal*, 26(5), July, 364-378.

2. Chan, D.W.M., Chan, A.P.C., Lam, P.T.I., Yeung, J.F.Y. and **Chan, J.H.L.** (2011) Risk Ranking and Analysis in Target Cost Contracts: Empirical Evidence from the Construction Industry, *International Journal of Project Management*, 29(6), August, 751-763.

3. **Chan, J.H.L**., Chan, D.W.M., Chan, A.P.C., Lam, P.T.I. and Yeung, J.F.Y. (2011) Developing a Fuzzy Risk Assessment Model for Guaranteed Maximum Price and Target Cost Contracts in Construction, *Journal of Facilities Management*, 9(1), February, 34-51.

4. **Chan, J.H.L.**, Chan, D.W.M. and Lord, W.E. (2011) Key Risk Factors and Risk Mitigation Measures for Target Cost Contracts in Construction - A Comparison between the West and the East, *Construction Law Journal, **accepted for publication*** on 15 November 2010; pending publication in Volume 27, Issue 6, September (in press).

5. **Chan, J.H.L.**, Chan, D.W.M., Lam, P.T.I. and Chan, A.P.C. (2011) Preferred Risk Allocation in Target Cost Contracts in Construction, *Facilities - Special Issue on Infrastructure Management*, ***accepted for publication*** on 28 February 2011; pending publication in Volume 29, Issue (13/14), October (in press).

6. Chan, D.W.M., Lam, P.T.I., **Chan, J.H.L.**, Ma, T. and Perkin, T. (2011) A Comparative Study of the Benefits of Applying Target Cost Contracts between South Australia and Hong Kong, *Project Management Journal*, ***accepted for publication*** on 1 August 2011 (in press).

Refereed Journal Articles (Under Review)

1. **Chan, J.H.L.**, Chan, D.W.M., Chan, A.P.C. and Lam, P.T.I. (2011) Risk Mitigation Strategies for Guaranteed Maximum Price and Target Cost Contracts in Construction - A Factor Analysis Approach, *Journal of Facilities Management,* submitted on 14 April 2011 via on-line submission under review.

Refereed Conference Papers (Published)

1. Chan, D.W.M., Chan, A.P.C., Lam, P.T.I., **Chan, J.H.L.**, Hughes, Will and Ma, Tony (2008) A Research Framework for Exploring Risk Allocation Mechanisms for Target Cost Contracts in Construction, *Proceedings of the CRIOCM 2008 International Research Symposium on Advancement of Construction Management and Real Estate,* 31 October - 3 November 2008, Beijing, China, 289-296.
2. Chan, D.W.M., Chan, A.P.C., Lam, P.T.I., Yeung, J.F.Y. and **Chan, J.H.L.** (2010) A Research Framework for Developing a Performance Evaluation Model for Target Cost Contracts in Construction, *Proceedings of the Fifth Scientific Conference on Project Management (PM-05) - Advancing Project Management for the 21st Century: Concepts, Tools and Techniques for Managing Successful Projects*, 29-31 May 2010, Heraklion, Crete, Greece, 144-151 (CD-Rom Proceedings).
3. **Chan, J.H.L.**, Chan, D.W.M. and Lam, P.T.I. (2010) A Critical Study of Risk Allocation in Guaranteed Maximum Price and Target Cost Contracts in Hong Kong, *Proceedings of the Second International Postgraduate Conference on Infrastructure and Environment*, 1-2 June 2010, Hong Kong, China, Volume 1, 205-215.
4. **Chan, J.H.L.**, Chan, D.W.M. and Lam, P.T.I. (2010) Application of Target Cost Contracting in the Construction Industry of Hong Kong, *Proceedings of the Sixth International Conference on Multi-national Joint Ventures for Construction Works*, 22-23 September 2010, Kyoto, Japan, 183-191.

5. Chan, D.W.M., **Chan, J.H.L.**, Lam, P.T.I. and Chan, A.P.C. (2011) A Critical Analysis of Risk Mitigation Measures for Target Cost Contracts in Construction Industry, *Proceedings of the CIB International Conference on Management and Innovation for a Sustainable Built Environment (MISBE 2011)*, 20-23 June 2011, Amsterdam, The Netherlands (USB Proceedings under the Theme "Construction Bidding and Contracting" with Book of Abstracts on Page 75; ISBN 978-905-26-9395-8).

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1.0

INTRODUCTION

CHAPTER 1 – INTRODUCTION

1.1 Background of the Study

The construction industry has long been suffering from a lack of cooperation, limited trust and misalignment of objectives, often inducing a confrontational relationship between the employer and the contractor, and eventually resulting in adverse project performance (Chan et al., 2004). Both contractors and consultants have little incentives to put in efforts more than meeting the minimum contractual requirements. The rationale of adopting the traditional procurement approach indiscriminately is often questioned by many industry review reports worldwide (Latham, 1994; Egan, 1998; Construction Industry Review Committee, 2001). There has been a strong wind of change in procurement approach to rectify the currently deteriorating situations.

According to Masterman (2002), novel alternative procurement strategies have been developed in the construction industry to satisfy the changing needs of employers and improve overall project performance. Incentivisation measures have been implemented successfully in both Australia and the United Kingdom to integrate the project delivery process and motivate service providers to seek continuous improvements in project outcomes (Construction Industry Review Committee, 2001). Previous overseas experiences (Trench, 1991; Walker et al., 2002) suggested that the contractual arrangement of guaranteed maximum price (GMP) contracts and target cost contracts (TCC) with a gain-share/pain-share arrangement, serving as a cost incentive mechanism, can accrue significant mutual benefits to all of the parties involved, provided that they are properly structured, implemented and managed. The report of the Construction Industry Review Committee (CIRC) published by the Hong Kong Special Administrative Region (HKSAR) in January 2001 pointed out that outstanding project performance can result from the implementation of alternative integrated procurement strategies such as GMP and TCC for complex and high-risk construction projects. It is claimed that the merits of these approaches lie in their incentives to the contractor to become efficient and to achieve cost savings, as well as to allocate risks on an agreed basis between the client and the contractor (Wong, 2006). The GMP style of arrangement based on a target cost concept has become increasingly popular in Hong Kong in recent years.

Incentivisation agreements (IA), being similar to TCC in principle, are set to take effect from an agreed commencement date, by which the risks associated with all works are monetarised and a gain-share/pain-share arrangement is mutually agreed between the client and the contractor based on an agreed share ratio formula for the works to be done. The client and the contractor would share savings (gains) if the final account figure turns out to be less than the target cost. Should the final account exceed the target cost, they would share the excess (pain) (Tang and Lam, 2003).

GMP is one form of TCC, which is popular with clients. Masterman (2002) defined GMP as an agreement which will reward the contractor for any savings made against the GMP value and penalise him when this sum is exceeded as a result of his/her own mismanagement or negligence. The contractor receives an agreed contract sum, together with a share of any savings accrued to the owner under this procurement approach. If the cost of the work exceeds the assured maximum, the contractor bears the excess costs (Walker et al., 2000). In this way a ceiling price is established, and the owner is assured it will not be exceeded (Clough and Sears, 1994; Patterson, 1999; Cantirino and Fodor, 1999). However, difficulties have often been experienced in setting the ceiling price; monitoring the ceiling price as variations to the work occur; and determining the cost-sharing formula for GMP projects.

A lot of researches were conducted to investigate how owners and contractors set the best cost-sharing fraction for target cost contracts in construction (Al-Subhi Al-Harbi, 1998; Perry and Barnes, 2000; Broome and Perry, 2002). In recent years, some researches on TCC/GMP in Hong Kong have also been reported in different academic journals and conference proceedings. For example, Chan et al. (2007a) conducted a detailed holistic investigation into the perceived benefits, potential difficulties, key risk factors, critical success factors as well as the suitability of using such TCC/GMP contractual arrangements in Hong Kong. Chan et al. (2010b) reported on a case study of an underground railway station modification works project under a TCC arrangement which was completed ahead of schedule, with cost saving and far less disputes or claims. Anvuur and Kumaraswamy (2010) presented their findings based on two case studies of building projects with a GMP arrangement. Their findings manifested that the project performance of the two cases was satisfactory in terms of time and cost. Seemingly, there has been increasing interests in both the academia and industry (as reflected by its wide application in recent years) about the global development of TCC/GMP. There is no statistics on the proportion of TCC/GMP construction projects in Hong Kong. They are still at a germinating stage of development, but their application will be increasing since the HKSAR Government has been launching a pilot study on using NEC Contracts, including Option C (target cost with activity schedule) since 2010 and the MTRC (a quasi-government massive transportation service provider) is also employing TCC for some of their underground railway works contracts (Cheung, 2008).

Based on the previous studies summarised above, a scarcity of research was done regarding the risk identification, risk assessment, risk allocation and risk mitigation measures for TCC/GMP contracts in Hong Kong. The lack of published literature in this respect reinforces the aim of this study. This research is thus essential and timely to further enrich the knowledge base on TCC/GMP in the construction industry of Hong Kong and to provide some valuable insights into the risk management of TCC/GMP projects to the industry for reference.

1.2 Application of TCC and GMP schemes in Hong Kong

Both TCC and GMP (TCC/GMP) appear to be innovative alternative procurement strategies in Hong Kong for employers to integrate the diverse interests of a complex construction project and offer incentives to service providers to achieve better project performance. TCC/GMP has been gaining popularity in the construction market of Hong Kong over the last decade. GMP was first introduced in Hong Kong to a private commercial development of 1063 King's Road in Quarry Bay, which was developed by Hong Kong Land Limited and was completed in August 1999 (Chan et al., 2007a). Table 1.1 shows a list of several TCC/GMP construction projects in Hong Kong.

Table 1.1 Selected TCC/GMP Cases for the Research in Hong Kong (adapted from Chan et al., 2007a)

Project Name		Project Nature	TCC/ GMP	Project Time frame	Covered in this study?
1.	Chater House	A prestigious rental commercial development in Central	GMP	Oct 2000-Jul 2002	Yes
2.	1063 King's Road	A rental commercial development in Quarry Bay	GMP	Nov 1997-Aug 1999	Yes
3.	Alexandra House Refurbishments	A prestigious rental commercial development in Central	GMP	Nov 2002-Nov 2003	Yes
4.	Tradeport Hong Kong Logistics Centre	A commercial logistics hub for the Asia region at Chek Lap Kok	GMP	Jul 2001-Dec 2002	Yes
5.	York House	A rental commercial redevelopment in Central	GMP	Jan 2005 - Oct 2006	Yes
6.	Renovation of Mandarin Oriental Hotel	Renovation works of an existing hotel building in Central	GMP	Dec 2005-Sep 2006	Yes
7.	The Orchards	A twin tower residential development in Quarry Bay	GMP	Aug 2001-Sep 2003	Yes
8.	One Island East	A 70-storey Grade A Office Tower	GMP	Apr 2006-Mar 2008	Yes
9.	Three Pacific Place	A prestigious rental commercial development in Wanchai	GMP	Jun 2002-Aug 2004	Yes
10.	Australian International School	A private educational building	GMP	Aug 2000-Aug 2001	Yes
11.	Tseung Kwan O Technology Park	A private technology park	GMP	Nov 2001-Dec 2002	Yes
12.	Hong Kong Park	A public recreational park	GMP	Unknown	Yes
13.	Public Housing Development at Eastern Harbour Crossing Site Phase 4	A public rental housing development in Yau Tong as a pilot study project	Modified GMP	Jun 2006 – Jun 2009	Yes
14.	DHL Asia Hub	A private express cargo sortation and delivery terminal building	GMP	Feb 2003-Jun 2004	Yes
15.	Tseung Kwan O Railway Extension with 5 Stations	13 civil engineering contracts, 4 building services contracts as well as 17 electrical and mechanical contracts	TCC	Mar 1999-Sep 2002	Yes
16.	Platform Screen Doors Installation for Tseung Kwan O Railway Extension with 5 Stations	Platform screen doors installation for Tseung Kwan O Railway Extension with 5 stations	TCC	Mar 1999-Sep 2002	Yes
17.	Tsim Sha Tsui Metro Station Modification Works	Tsim Sha Tsui Metro Station Modification Works	TCC	Apr 2002-Sep 2005	Yes
18.	Tung Chung Cable Car Project	A sightseeing transportation facility including civil and building works	TCC	Jun 2004-Dec 2005	Yes
19.	West Island Railway Line	West extension to existing under ground railway line on Hong Kong Island	TCC	Jul 2009-2014	Yes
20.	South Island Railway Line	South extension to existing underground railway line on Hong Kong Island	TCC	2011-2015	Yes
21.	Open Nullah Improvement Works in Sai Kung	An open nullah improvement works project at Fuk Man Road in Sai Kung	TCC / NEC	Aug 2009-May 2012	Yes
22.	Renovation of Pacific Place Mall (PP Mall)	Renovation works of Pacific Place Mall (PP Mall) in Admiralty	TCC	May 2008-Dec 2008	Yes

1.3 Research Problems

Although both TCC and GMP contracts (TCC/GMP) have been implemented in different parts of the world for several years, not all projects procured with these contractual arrangements have been equally successful in terms of performance outcomes. For example, Chan et al. (2010b) illustrated a case study of metro station modification and extension works in Hong Kong completed with significant savings in both time (20%) and cost (5%) by introducing the TCC procurement strategy. However, Rojas and Kell (2008) stated that the final construction cost of 75% of school projects investigated in the northwest of the United States exceeded the GMP value, while the same phenomenon was found in about 80% of non-school projects. These findings did not support the notion that GMP offers a guarantee on construction cost, and they generated a strong motive to launch this research study by capturing the lessons learned from previous TCC/GMP contracts.

The disparities in management systems, technological advances, level of construction experience and cultural background among the partners may lead to difficulties in launching TCC/GMP projects. There exists an urgent need for a more systematic and in-depth research to examine the risk aspects in delivering those TCC/GMP projects. It is indispensable for the client and the contractor to assess all the potential risks throughout the whole project life and to define clearly who is responsible for a particular risk. GMP contracts are particularly concerned with the risk of cost overruns caused by design development and late or inadequate project information (Mills, 1995). Systematic risk management allows an early detection of risks and encourages the project stakeholders to identify, analyse, quantify and respond to the risks (Broome and Perry, 2002), and take measures to effect risk mitigation. An extensive desktop search *(refer to Chapter 2)* indicated that there is a lack of published literature on risk assessment and analysis of TCC/GMP projects worldwide, especially in the Hong Kong context. In light of this finding from the desktop search, this research aims to fill the knowledge gap on risk management of TCC/GMP construction projects in Hong Kong.

1.4 Research Objectives

This research study aims to examine the implementation of TCC/GMP schemes in relation to risk identification, assessment, allocation and mitigation in the context of Hong Kong. The following essential objectives have been set out:

1) To determine the Key Risk Factors (KRFs) inherent with TCC/GMP projects and analyse their importance;
2) To solicit and compare the opinions of various project stakeholders on risk assessment of TCC/GMP projects in Hong Kong;
3) To explore and compare the preferences of various project stakeholders on risk allocation of TCC/GMP projects in Hong Kong;
4) To develop and validate an overall risk assessment model for TCC/GMP projects in Hong Kong; and
5) To recommend effective guidelines or measures for managing the potential risks associated with TCC/GMP projects.

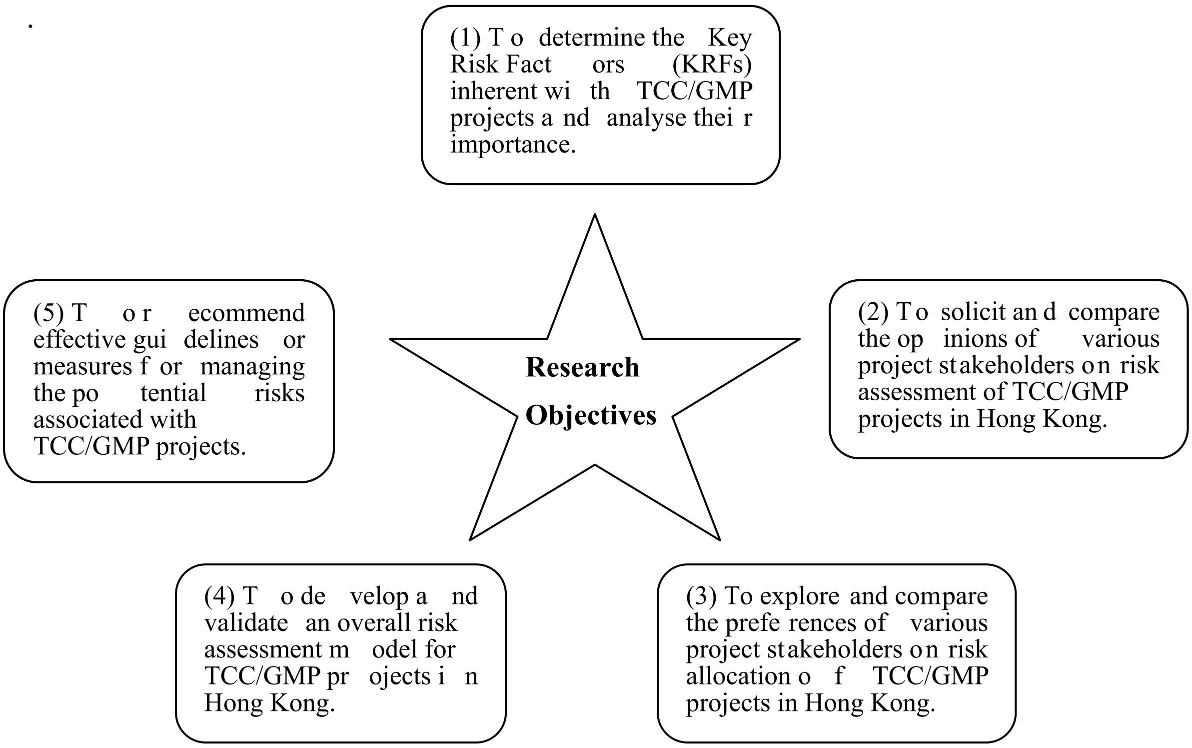


Figure 1.1 Research Objectives of this Study

1.5 Outline of Research Approach

The research was conducted through both qualitative and quantitative approaches. The research process started with a comprehensive review of reported literature on TCC/GMP in Hong Kong and overseas, in order to capture the lessons learned from other countries and identify the knowledge gap pertaining to the research problems. The qualitative approach included structured interviews and case studies in the pilot study, while an empirical questionnaire survey was undertaken as the quantitative approach. A series of structured interviews and a validation questionnaire survey were also carried out to validate the Fuzzy Risk Assessment Model for TCC/GMP contracts in Hong Kong which was developed using factor analysis and fuzzy synthetic evaluation method (*refer to Chapter 6*) at the final stage of this research. The proposed research objectives and the methods to achieve them are summarised in Table 1.2.

Table 1.2 Achievement of Research Objectives

Proposed research objectives	Methods to achieve
1. To determine the Key Risk Factors (KRFs) inherent with TCC/GMP projects and analyse their importance.	➢ Literature Review ➢ Structured Interviews ➢ Questionnaire Survey
2. To solicit and compare the opinions of various project stakeholders on risk assessment of TCC/GMP projects in Hong Kong.	➢ Literature Review ➢ Questionnaire Survey
3. To explore and compare the preferences of various project stakeholders on risk allocation of TCC/GMP projects in Hong Kong.	➢ Literature Review ➢ Questionnaire Survey
4. To develop and validate an overall risk assessment model for TCC/GMP projects in Hong Kong.	➢ Literature Review ➢ Questionnaire Survey ➢ Structured Interviews for Model Validation
5. To recommend effective guidelines or measures for managing the potential risks associated with TCC/GMP projects.	➢ Literature Review ➢ Questionnaire Survey

Pilot Study

A pilot study approach was applied to develop relevant questions and seek clarifications of underlying concepts of the research (Yin, 1994). It was conducted through a series of face-to-face structured interviews with related project participants of TCC/GMP in Hong Kong. According to Hallowell (2010), face-to-face interactions during interviews could ensure the respondents fully understand the questions being asked and provide the researcher with an opportunity to clarify the questions. A list of draft questions was prepared based on a comprehensive desktop literature review. Structured interviews and case studies were both applied at this stage of the study.

Structured Interviews

Project participants involved in TCC/GMP construction projects were invited for conducting face-to-face interviews in order to collect updated necessary information from practitioners with direct hands-on experiences so that any mismatch between theoretical studies and actual practices in real-life cases could be rectified. Structured questions on the application of TCC/ GMP, identification and assessment of key risk factors, risk allocation as well as risk mitigation measures for those construction projects were compiled for soliciting opinions and feedback from the interviewees.

Case Studies

Retrieval information and data about TCC/GMP construction projects in Hong Kong and project participants involved were gleaned to compile an updated project / contact list before carrying out any structured interviews. During the interviews, the interviewees were asked about the details of the TCC/GMP projects in which they were personally involved and information on other current TCC/GMP projects so that any differences between background knowledge and the actual real-life context can be sought and compared.

Empirical Questionnaire Survey

Based on the key findings derived from the structured interviews and an extensive desktop search, a draft empirical survey questionnaire was produced. The draft questionnaire was then sent to five pilot respondents for them to check on the clarity, adequacy, practicality and comprehensiveness of the survey form. Such validation could improve the overall quality of the survey form before its mass distribution. The final version of the survey form was subsequently dispatched to the target industrial practitioners within the construction industry of Hong Kong through both postal mails and electronic mails. Respondents were requested to indicate their perceptions on risk identification and assessment, preferences on risk allocation and effectiveness of risk mitigation measures for TCC/GMP construction projects in Hong Kong, according to their hands-on experiences and professional judgement. The survey data collected were then input into the statistical software program, SPSS for Windows Version 17.0 and analysed in a quantitative manner.

1.6 Significance and Value of the Research

A TCC approach can be an effective means to motivate contractors to achieve better value and project performance because the client will reward the contractor if the latter achieves agreed time and cost targets, and the client will share the losses with the contractor if the targets are not met (Construction Industry Review Committee, 2001). Lessons learned from the United Kingdom and Australian cases of TCC have demonstrated that in case the risk factors are properly identified, analysed, shared and managed, a plethora of significant mutual benefits can be bestowed to all of the contracting parties (Trench, 1991; Walker et al., 2000). The Construction Industry Review Committee (2001) of the Hong Kong SAR was in favour of more widespread use of TCC so as to strive for excellence in construction performance. Although TCC has been practised in Australia and the United Kingdom for several years, and numerous construction projects are employing the concepts, not all these projects have been equally successful and some of the projects have been exposed to very high risks or an uneven allocation of risks. Thus it becomes all the more important to identify the Key Risk Factors (KRFs) and evaluate the risk allocation for TCC projects. TCC is relatively novel in Hong Kong and so such a comprehensive study in relation to Hong Kong conditions is timely and indispensable. An investigation of risk management of TCC/GMP projects can bring several benefits to the whole construction industry. This study is expected to make a positive contribution to encouraging the application and appreciation of the alternative integrated contractual arrangements which would overcome some of the drawbacks of the traditional procurement strategies. The comparison of the responses from the client group, contractor group and consultant group in the survey enables industrial practitioners to better understand the local practices of TCC/GMP schemes and identify the key risk factors encountered in these projects warranting more particular attention. Another benefit from this study is that the research findings will help the decision-makers to generate useful insights into risk mitigation strategies when administering TCC/GMP projects at an early stage of project delivery and lay a solid foundation for further research on TCC/GMP in both the local and international context.

The development of a fuzzy risk assessment model would facilitate the decision-makers to carry out an overall assessment of the key risks inherent with TCC/GMP contracts at an early stage of project delivery, and to investigate how the risks may be overcome or mitigated. Such a study could also help the project team to determine the most influential "principal risk group" and then to implement appropriate risk mitigation measures for the projects.

1.7 Structure of the Thesis

This thesis is divided into seven chapters. This chapter (**Chapter 1**) gives the background information of this research study. It reports on the recent development and application of TCC/GMP schemes in the construction market of Hong Kong, and introduces the major research elements in terms of research problems, research objectives and research approach. The value and significance of this research are highlighted and the structure of this thesis is outlined in this chapter as well.

Chapter 2 contains an extensive literature review covering the pertinent literature about TCC and GMP implementation in developed countries such as Australia, the United Kingdom, and the United States. It aims to inform the readers about the application of TCC/GMP in different parts of the world. Particular attention will be paid to the application of such procurement approaches in Hong Kong. Essential published literature on risk management, particularly on risk assessment and risk allocation, is reviewed in this chapter.

Chapter 3 illustrates the overall research methodology for the study. Different methods of data collection through desktop search, a questionnaire survey as well as structured interviews will be explained in detail. Various statistical techniques such as the Cronbach's alpha reliability test, the Kendall's concordance test, the Spearman's rank correlation test and the Mann-Whitney U test, which are employed in the data analysis of the empirical questionnaire survey, are also mentioned.

Chapter 4 reports on the methodology and the key findings of seven interviews conducted in Hong Kong with regard to key risk factors, risk allocation and risk mitigation measures for TCC/GMP construction projects. The findings are explained with cross reference to published literature wherever deemed appropriate.

Chapter 5 provides the data analysis of the questionnaire survey launched in Hong Kong, with the results and discussions deduced from the data analysis. A five-level data analysis framework including: (1) the Cronbach's alpha reliability test; (2) descriptive statistics; (3) the Kendall's concordance test; (4) Spearman's rank correlation test; and (5) the Mann-Whitney U test, will be used in the data analysis approach to investigate any differences in perceptions between the client group, contractor group and consultant group on risk identification and assessment of TCC/GMP schemes in Hong Kong. In addition, the preferences on risk allocation in TCC/GMP contracts of the three groups of respondents are discussed with reference to other published research studies on risk allocation in construction. The data analysis regarding the effectiveness of various risk mitigation measures, in the form of descriptive statistics and factor analysis, are reported and explained in the last section of this chapter.

Chapter 6 presents the development of a fuzzy risk assessment model using factor analysis and fuzzy synthetic evaluation method. The potential applications of the model are discussed. The validation of the model in the form of several structured face-to-face interviews with experts having direct hands-on experiences with TCC/GMP contracts in Hong Kong is also documented in this chapter.

Chapter 7 summarises the main conclusions of the research study. The achievements of the proposed research objectives are reviewed. Contributions to existing knowledge base of this research and practical applications of the model are highlighted, and core directions for future studies are recommended in this chapter.

References and appendices are also attached at the end of the thesis for reference.

1.8 Chapter Summary

This introduction chapter has outlined the background of the work addressed in this thesis and the justifications for this research study. The research approach employed is described and the research problems and research objectives are illustrated. A summary of the value of this research is given, together with the structure of the thesis.

2.0

REVIEW OF PREVIOUS WORK

CHAPTER 2 – REVIEW OF PREVIOUS WORK

2.1 Introduction

This chapter focuses on the principles derived by different authors and researchers relating to the definitions of TCC/GMP, concepts of TCC/GMP, benefits and difficulties in applying TCC/GMP, risk management, risk factors, risk allocation, and risk mitigation measures for TCC/GMP construction projects. The purpose of review of previous work is to explore the underlying concepts and operational mechanisms of TCC/GMP, and then to identify what have been done in this research area and more importantly, what may be significant but has not yet been done (i.e. to identify the knowledge gap). A review of risk management framework is also provided in this chapter to gain basic understanding of risk management in particular to risk assessment and risk allocation, and to identify whether there are any risk assessment models which have been developed for TCC/GMP schemes in construction.

2.2 Definitions of TCC and GMP

The National Economic Development Office (NEDO) (1982) based in the United Kingdom considered that "target cost contracts specify a 'best' estimate of the cost of the works to be carried out. During the course of the works, the initial target cost will be adjusted by agreement between the client or his nominated representative and the contractor to allow for any changes to the original specifications". According to Trench (1991), the target cost contracting scheme is a contractual arrangement under which the actual cost of completing the works is evaluated and compared with an estimate or a target cost of the works, the differences within a cost band are shared between the client and the contractor based on a pre-agreed sharing ratio. Wong (2006) took a similar view that the contractor is paid the actual cost for the works done during the construction stage. When the final construction cost, termed the final total cost differs from the initial contract target cost, the difference would be shared between the employer and the contractor based on a pre-determined gain-share/pain-share ratio as stated in the contract as shown in Figure 2.1. Hughes et al. (2011) suggested that TCC is often referred as gain-share/pain-share arrangement in which the contracting parties specify an estimated cost (target cost) and sharing ratio which applies if the actual cost is higher or lower than the estimated cost. They also commented that TCC is justified to be used when: (1) the client is incentivised to actively help the contractor to generate cost efficient solutions; and (2) the client deliberately chooses the same contractor for repeated business.

Masterman (2002) defined GMP as an agreement which will reward the contractor for any savings made against the GMP and penalise him when this sum is exceeded as a result of his own mismanagement or negligence. The American Institute of Architects (AIA) (2001) viewed GMP as a sum established in an agreement between a client and a contractor as the cap of overall project cost to be paid by the client to the contractor for performing specified works on the basis of the cost of labour and materials plus overhead and profit. The contractor receives a prescribed sum, along with a share of any savings to the client under this procurement approach. If the cost of the works exceeds the assured maximum, the contractor bears the excessive costs (Walker et al., 2000). Under this situation, a ceiling price is established, and the contractor is solely responsible for any additional costs (Gould and Joyce, 2003).

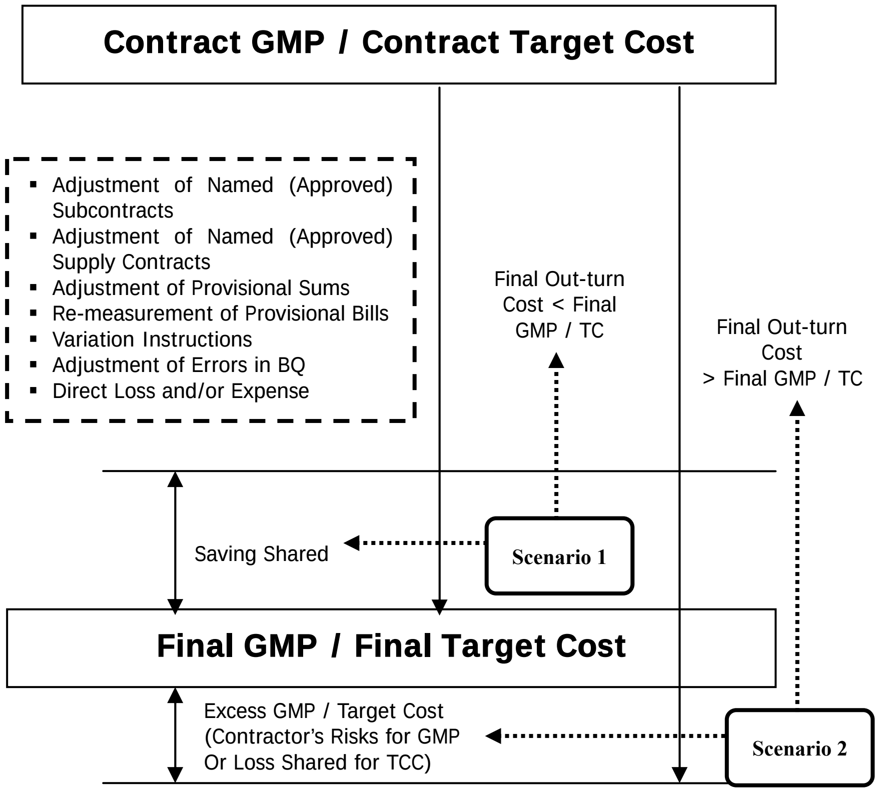


Figure 2.1 Gain-share/Pain-share Mechanism of TCC/GMP Schemes (adapted from Cheng, 2004)

2.3 Overview of Philosophy of TCC/GMP

According to Hughes et al. (2011), GMP is a TCC with an additional feature that the maximum amount to be paid by the employer is capped. Masterman (2002) shared a similar view that GMP is a variant of TCC. Boukenbour and Bah (2001) also opined that GMP can be considered as a target cost which provides a better hedge to owner. Actually, TCC and GMP are grouped together in previous research studies in Hong Kong. For example, Chan et al. (2007b) launched several interviews to investigate the underlying motives, benefits, difficulties, success factors, key risk factors, and optimal project conditions for applying TCC and GMP in Hong Kong. Chan et al.

(2007a) conducted a detailed holistic empirical questionnaire survey to identify the perceived benefits, potential difficulties and suitability of adopting TCC/GMP in construction industry of Hong Kong. Chan et al. (2010a) reported on the major findings of a questionnaire survey on critical success factors in the implementation of TCC/GMP schemes in Hong Kong. In view of the viewpoints of the researchers mentioned above, the similar nature of TCC and GMP and the practice of previous studies, TCC and GMP are put together in subsequent discussions.

Tendering method

When TCC/GMP is procured by selective tendering, tenderers will be invited to submit a preliminary proposal to detail their relevant work experience, past track record, expertise in alternative procurement methods, financial conditions, technical competence and the like. The proposal will be reviewed and assessed by the client and his consultant team. After the pre-qualification exercise, a group of pre-qualified contractors (usually not exceeding five contractors) will be shortlisted and invited to submit tenders (Chan et al, 2007a).

If two-stage tendering method is adopted, the selected tenderers after pre-qualification will be invited during the first stage to submit their tenders based on the preliminary documentation provided by the client and his team of consultants including: (1) a cost plan; (2) basic schematic/outline design drawings (e.g. 20% of design complete); (3) performance specifications for works packages; and (4) other available information.

After tender evaluation at the first stage, the shortlisted tenderers are then invited to submit more detailed proposals during the second stage based on the Bills of Quantities, drawings with more complete design documentation (e.g. 70% of design complete) and performance specifications for works packages (Chan et al, 2007a). As regards the information required for the TCC/GMP contracts, both target cost and guaranteed maximum price are estimated based on preliminary design supplied by the client and his team of consultants. The key components of the tender documents for a TCC/GMP contract consist of: (1) cost of main contractor's direct works (e.g. substructure works, reinforced concrete superstructure works, finishing works, etc); (2) domestic subcontractors' works packages (e.g. electrical and mechanical installation, plumbing and drainage, fire services installation, etc); (3) provisional quantities; (4) provisional sums; and (5) design development allowance (Hong Kong Housing Authority, 2006; Chan et al, 2007a). The information provided by the client is insufficient to complete the construction works, so the contractor would price a design development allowance, which is difficult to estimate accurately, in his tender. Further information will be provided by the client and his team of consultants after the GMP or target cost contract is agreed and issued under the Architect's instructions to the main contractor. The gain-share/pain-share mechanism under target cost contracts is illustrated in Figure 2.2.

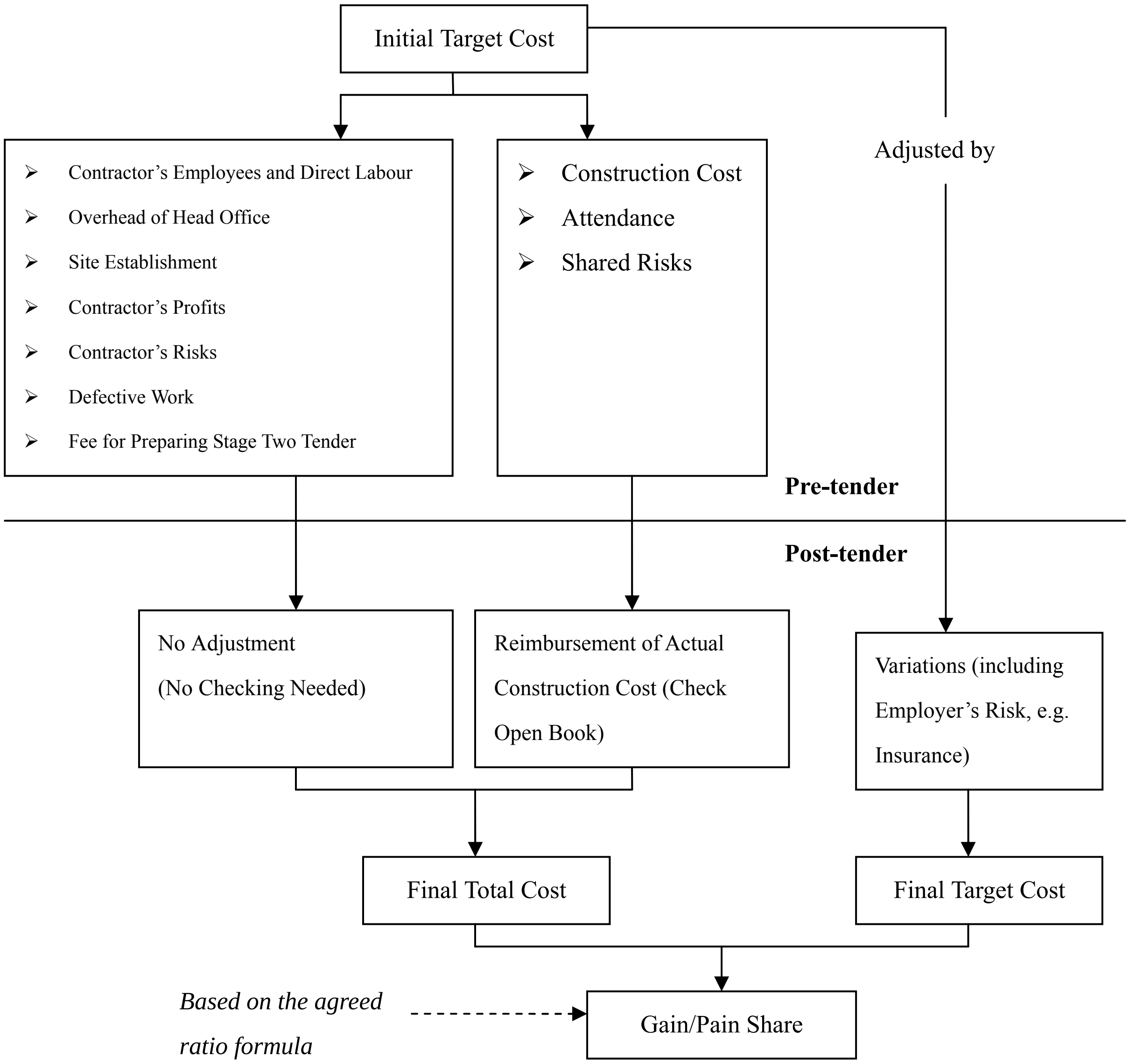


Figure 2.2 Gain-Share/Pain-Share Mechanism under Target Cost Contracts (Wong, 2006)

Open book accounting regime

Another unique feature of TCC/GMP scheme is the implementation of open book accounting. As Wong (2006) points out, the contractor is required to keep accounts of the actual cost of the works done. Both the client and contractor are required to operate in an open book environment for achieving an optimum project economics with a reasonable return for both of them. The contractor shall open a dedicated bank account under the name of the contract. All the payments from the client will be deposited in this account. On the other hand, all outgoing payments to subcontractors and suppliers by the main contractor will also be made by this account.

Under the spirit of the open book accounting philosophy, the main contractor should keep the accounts of actual cost, records of payment to be made and other records reasonably required by the client for assessing events which entitle the subcontractors to additional payments. The client will verify the main contractor's actual expenditure on a regular basis by checking payment receipts against the bank account, quantities of materials ordered, materials on site and the like (Wong, 2006).

Contract variations

TCC/GMP contracts are usually awarded based on schematic designs and much of the detail design is left for the contractor to develop and finalise at the construction stage, to achieve an early commencement of construction (Yew, 2008). According to Gander and Hemsley (1997), there are two kinds of variations under TCC/GMP contracts, namely non-GMP variations (i.e. variations on design development) and GMP variations. The design development variations do not trigger an adjustment of GMP or target cost as this kind of variations are deemed to be included in the fixed lump sum of main contractor's direct works and design development allowance in their tenders. The GMP or target cost can be adjusted in case of certified TCC/GMP variations and the adjustment will be based on the measured works and schedule of rates in the contract (Fan and Greenwood, 2004; Hong Kong Housing Authority, 2006). It can be a bone of controversy that whether a variation is classified as a TCC/GMP variation or not in many cases if the definition of GMP variations is not well defined early in the contract.

As Wong (2006) advocates, the TCC/GMP should not be re-calculated to reflect the initiatives, innovations, procurement benefits and the like proposed by either contracting party. This approach can make sure that the cost savings at the final project outcome can be best reflected. In general, an adjustment to GMP or target cost is allowed only because of: (1) change in the scope of works; (2) change in the functional areas; (3) change in the quality of an area; (4) adjustment of provisional quantities[1] and provisional sums[2]; (5) errors and omissions in contract documents; and (6) unexpected additional fees or charges imposed by statutory authorities (Fan and Greenwood, 2004).

Contractor's inputs in both design and construction

TCC/GMP can be regarded as a hybrid of the traditional design-bid-build procurement approach and design-and-build procurement system (Fan and Greenwood, 2004). Expertise in building design, innovations in construction and buildability, together with innovations in construction materials can be brought in TCC/GMP schemes (Masterman, 2002). Whilst design-and-build and TCC/GMP

[1] *Provisional Quantities means works quantified at the time of contracting based on a specification which is reasonably defined but where the design has not progressed to ascertain a defined quantity of work (Hong Kong Institute of Surveyors, 2004). For example, reinforcement bars in most construction projects are measured as provisional quantities at the pre-contract award stage.*

[2] *Provisional Sum shall mean a sum provided for work or for costs which cannot be entirely foreseen, defined or detailed at the time of the tendering documents are issued (Hong Kong Institute of Surveyors, 2004). For example, signage is included as a provisional sum in many construction projects.*

contracts can facilitate better use of contractor's innovation and enhance buildability, TCC/GMP can also allow an opportunity for the client to impose more control over the design throughout the whole project delivery process (Chan et al, 2007a).

2.4 Perceived Benefits and Difficulties of Applying TCC/GMP in Construction Industry

Various benefits and limitations of employing TCC/GMP in construction were identified from contemporary literature in terms of cost control, time control, quality control as well as working relationship between contracting parties.

2.4.1 Benefits of Applying TCC/GMP in Construction

More Stringent Cost Control

The procurement option of TCC/GMP offers a more realistic ceiling price or target cost of the project towards the owners (Perry and Barnes 2000). From the owner's point of view, adopting GMP can increase the control over project costs and he is only liable up to the agreed guaranteed maximum amount (Steele and Shannon 2005).

Moreover, TCC/GMP is a procurement method in which the contractor is rewarded for cost savings made but is penalised for budget overruns. This "carrot and stick" approach generates strong incentives for a contractor to be efficient and to achieve cost savings (Fan and Greenwood 2004). As both the owner and contractor may benefit from the cost saving, they will be more motivated to collaborate and achieve cost minimization (Tang and Lam, 2003).

Faster Project Delivery

One of the criticisms against the traditional design-bid-build procurement approach is that it cannot offer the fast-track arrangement between the design and construction phases (Construction Industry Review Committee, 2001). Gogulski (2002) stated that one of the perceived advantages of the GMP form of procurement is that it enables work to start ahead of the production of final drawings to minimise the risk of late completion for the owners. He further pointed out that the owner plays a more active role throughout the project delivery process. Trench (1991) shared similar perceptions and considered that TCC/GMP may speed up the process of problem solving. Seymour (2002) reported that the Tseung Kwan O Railway Extension Project of the Mass Transit Railway Corporation in Hong Kong adopted a TCC arrangement and achieved an early project completion of four and a half months.

Since the arrangements of change orders under the TCC/GMP approach are pre-agreed between the client and the contractor, the occurrence of claims / disputes might be reduced, and the preparation and agreement of the final project account tend to be finalised earlier than for the conventionally priced contract (Gander and Hensley, 1997). Another advantage that TCC/GMP can bring is the greater flexibility to accommodate design changes because of the straightforward change order claiming mechanism and the 'open book' accounting arrangement (Mills and Harris, 1995). Unlike the traditional contractual method, valuation of change orders can therefore be less time-consuming and more transparent leading to early settlement of final project account.

Better Quality Control

The third perceived benefit of TCC/GMP is the improvement of quality in construction projects. In construction contract bidding, the bidder usually wins if he/she has the lowest estimate of the cost of construction in many cases. According to Dyer and Kagel (1996), the low bidder is likely to suffer from a "winner's curse", winning the item but making below normal profit or even making a loss. Wong (2006) opined that the conventional lump-sum contract may result in poor quality, intractable contractual claims and even litigation. Finally the owner will suffer because of the rules of the game which award the contract to the party who has made mistakes in bidding. In contrast, TCC/GMP sets a more reasonable target price and facilitates the bidding of domestic subcontractors' works packages on an open basis and two-stage tendering method was applied in the majority of TCC/GMP cases in Hong Kong (Chan et al., 2007a; Bayliss et al., 2004). This arrangement ensures that the owner receives competitively priced bids from approved subcontractors and specialists (Tay et al., 2000). This bidding procedure helps the owner to select the right project team with adequate experience and enables the development of the owner's design intent, while the bid is adequately priced (Trench, 1991). This arrangement eliminates the non-value-adding multi-layered subcontracting and maintains the quality standards of the project and workmanship.

Case studies by Rose and Manley (2010) suggested that early contractor involvement in design could improve the integration of design and construction due to contractor's provision of advice on buildability to the design team. Another study by Sidwell and Kennedy (2004) obtained similar findings that the coordination of project team at early stage of construction projects could improve the certainty of construction outcomes. Clients would be more involved throughout the whole project life under TCC/GMP contracts. Tang and Lam (2003) stated that the client can also be motivated to put in more efforts in helping solve problems. On the contractor's side, the contractor is also brought in at the design stage to advise on construction costs, building design, project programming, construction materials, alternative construction techniques and other constructability issues. This arrangement can tap in the expertise and innovative ideas of contractors to further polish the design proposed by the design team (Hong Kong Housing Authority 2006). All these issues develop the potential for producing savings in both time and cost, and higher quality of products. Moreover, with the contractor's contribution at the early design stage of the project, a more cost effective contracting strategy with constructable designs can be formulated.

More Harmonious Working Relationship

Walker *et al*. (2002) advocated that the gain-share/pain-share mechanism encourages a team work approach to create innovative ideas in problem solving via the case study of the Australian National Museum. Bower *et al*. (2002) opined that the TCC/GMP contracting approach can be effective in motivating contractors to achieve better value for money and project performance by linking their own financial objectives to the overall objectives of the project. The gain-share/pain-share mechanism generates incentives for effective collaboration between client and contractor in order to minimise the out-turn cost of a project (Chevin 1996; Sadler 2004). Pre-construction planning for design development which involves all relevant project stakeholders can reduce the conflicts and disputes at later time (Chan *et al*. 2007a). This contracting approach also allows the contractor and employer to determine the appropriate ownership of risks and encourages various contracting parties to agree on an equitable allocation of risks, which is in the client's long-term interest (Sadler 2004). A fair and effective dispute resolution mechanism and communication opportunities are provided by means of adjudication meetings, not only leading to reduction in claim or dispute occurrence, but also improving working relationship amongst project team members and incorporating inter-disciplinary efforts into the project (Ting 2006).

Moreover, the TCC/GMP form of contract is useful in injecting the ‘partnering’ spirit into the relationships amongst the owner, main contractor, subcontractors and consultants, with the objective of introducing a more harmonious and less confrontational philosophy to the contract (Tang and Lam 2003; Hong Kong Housing Authority 2006). Chan *et al*. (2004) further suggested that the developments of the GMP contracting approach in a number of building projects and the incentivization agreement in the railway infrastructure projects in Hong Kong have proven to be effective in fostering a co-operative working atmosphere and a gain-share/pain-share working culture.

2.4.2 Difficulties in Applying TCC/GMP in Construction

However, TCC/GMP are not without limitations. One of the major problems encountered in implementing the TCC/GMP approach is the difficulty in defining the circumstances which constitute a scope change (Gander and Hemsley, 1997). Unclear explanations of any scope changes would probably cause disputes with the natural tendency of the client and contractor pulling in opposite directions to achieve their own objectives (Fan and Greenwood, 2004). Tang et al. (2008) echoed this view and opined that one of the unwanted effects of TCC was conflict in the interpretation of functional requirements and variations. The tendency of the contractor is to view variations as a 'scope change' to maximise his chance of getting extra payment whereas the client wants to keep as many changes as possible under 'design development' to minimise cost increase, not to mention a desire to achieve potential cost savings. Tang and Lam (2003) opined that it is difficult to evaluate the revised contract price when an alternative design is proposed by the contractor and it takes time to reassess the cost implication. Tay et al. (2000) also held similar perception that this is a pitfall of TCC/GMP approach which is not easy to administer. Hence, TCC/GMP schemes might not be an appropriate procurement approach for contracts where many changes are expected or it would be difficult to define the scope of works early (Trench, 1991).

High cost premium for TCC/GMP

As Kemp and Stephen (1999) suggested, incentive schemes would increase the total risks of contractors and may jeopardize their financial life. In general, the contractor under the TCC/GMP style of procurement takes on more responsibilities than the traditional approach and has included in his tender an allowance for design development and unforeseeable risks (Sadler, 2004). One common response is for the general contractor to simply pass the risks down the line to the subcontractors (Lewis, 2002). It has also been pointed out that this will then inflate the bid price for the contractor to commit to the guaranteed price by covering additional risks. In the majority of cases, tenders for GMP contracts may range between 1% and 3% higher than equivalent tenders sought under a JCT 80 with quantities standard form of contract under favourable conditions where the contract sum is the de-facto guaranteed maximum price (Mills and Harris, 1995). In other words, the client gains a degree of cost certainty, but the price is usually not the lowest price. However, where fixed price is more important than ascertaining the lowest price, a TCC/GMP contract may be the favourable answer.

Greater commitment by project participants

The TCC/GMP approach requires a greater level of commitment and involvement by all project parties to the contract arising from the methodology of tendering, not only for the main target cost contract, but also individually for the domestic subcontractor's works packages (Tang and Lam, 2003). Sadler (2004) claimed that the client has to be more involved and closely monitor the project when using the TCC/GMP approach because the design is being developed after the contractor has committed to a ceiling price. The design development should keep in good progress with main contractor's programme for tendering domestic subcontractor's works packages, otherwise potential delay may arise. These additional administrative requirements might result in the relevant parties having to commit more personnel to the project, together with the potential higher fees to be incurred by design consultants in evaluating tenders for domestic subcontracts after the award of main contract (Hong Kong Housing Authority, 2006). Furthermore, the complicated cost checking procedures, due to cost reimbursement nature of TCC, also increase the workload of contractors and consultants and thus the consultant fees in TCC may be inflated (Tang et al., 2008).

Unfamiliarity with TCC/GMP methodology

TCC/GMP is a rather new concept within the local construction industry. Project stakeholders unfamiliar with the corresponding contractual arrangements may easily generate intractable arguments between the contracting parties (Cheng, 2004). Project participants might not be used to working in this novel way and may find it uncomfortable and difficult to change the traditional way they work (Sadler , 2004). Difficulties have often been encountered in setting an agreed ceiling price; monitoring the ceiling price as changes to the work occur; setting allowances for design development and unexpected risks; and determining the cost-sharing formula of TCC/GMP projects. Gander and Hemsley (1997) also stated that the absence of standard form of TCC/GMP contract would result in a greater possibility of drafting errors and misunderstanding of liabilities between the parties. It is a complicated form of contractual agreement and some projects do not warrant the administrative efforts and support that is required to set up and implement this form of contract (Sadler, 2004).

To sum up, TCC/GMP may have the following potential difficulties during implementation (Chan et al., 2007a):

- Difficult to determine whether Architects/Engineers Instructions constitute TCC/GMP variations or are deemed to be design development i.e. unclear scope of works.
- Potential for incurring higher consultant fees due to increased commitment and involvement by project managers and design consultants in evaluating tenders for domestic subcontracts after the award of main contract.
- Design development must keep pace with main contractor's programme for tendering the domestic subcontractors' works packages otherwise leading to potential delay.

- Longer time in preparing contract documents.
- Unfamiliarity with or misunderstanding of TCC/GMP concepts by senior management.
- Difficult to develop mutual trust and understanding from contractor as a project team.
- More complicated cost checking procedures.
- More involvement of different contracting parties in the project.
- A project team may find it difficult to adapt to this new way of working (e.g. joining force between consultants and main contractor in design work).
- May not be suitable for projects in which it is difficult to define the scope of works early.

2.5 Project Performance of TCC/GMP in construction

Scholars have mixed views on the effectiveness of TCC/GMP schemes. Hughes et al. (2011) opined that TCC arrangement may not incentivise contractor to save cost. However, Chan et al. (2007b) reported on the key findings of eight face-to-face interviews in their study and concluded that providing financial incentives for contractor to achieve cost saving and innovate is one of the perceived benefits of the TCC/GMP arrangement. It would be interesting to look into the performance outcomes of construction projects employing TCC/GMP worldwide. In the United Kingdom, according to Mylius (2005), the New Wembley Stadium in London, procured with GMP form of contract, was opened in March 2007. It cost more than GBP 757 million (over original estimated budget of GBP 200 million in 1996) and opened almost 2 years behind schedule. However, the National Health Service found that their projects with GMP scheme of more than GBP 1 million are no more expensive that those procured with the traditional approach (ProCure21 Guide, 2011). In Australia, Hauck et al. (2004) advocated that the National Museum of Australia achieved outstanding project performance in terms of time, cost and quality. In the United States, Rojas and Kell (2008) studied around 300 school projects in the Northeast of the United States. The actual project cost exceeded the GMP value in 75% of the cases. In contrast, Bogus et al. (2010) conducted an analysis on performance data of public water and wastewater facilities in the United States. Their study revealed that contracts using cost plus fee with GMP arrangement performed better in terms of cost and schedule when compared with those with lump sum contracts. In Hong Kong, Chan et al. (2010b) launched a case study on an underground railway station modification and extension works, procured with TCC, with several face-to-face interviews with relevant project participants and documentation analysis. Their findings indicated that the project achieved a cost saving of 5% and time saving of 20%. Another case study for a private prestigious commercial development (Chan et al., 2011a) indicated that the GMP arrangement could align the individual objectives of different contracting parties together and the project achieved a cost saving of 15% and completed ahead of schedule by 6 days.

2.6 Application of TCC in Other Industries

In fact, the concepts of TCC were pioneered by the international oil industry during the 1950s and 1960s when the huge refinery and petrochemical complexes around the world were built (Ritz, 1994). Sakal (2005) reported on the concepts of target costing by the British Petroleum in the early 1990s with open book accounting regime. It was also advocated by Sakal (2005) that the projects with target cost contracting arrangement of the British Petroleum were successful with a significant cost saving and duration of 6 months ahead of schedule.

Not only were the concepts of target cost contracting adopted in the manufacturing sector of Japan and the oil industry of the United Kingdom, it was applied to the information technology (IT) industry as well with a view of fostering harmonious, productive client relationships (Eckfeldt et al., 2005). It was pointed out in their study that TCC can be as complex as traditional contracts with regard to changes in project scope. The two complexities presented in their case study project included: (1) deciding whether a change was an unanticipated complexity of an in-scope change feature or a new feature which could lead to a change in target cost; and (2) if the change was determined to be a new feature, figuring out the quantum of increase in fixed profit of the service provider in the IT industry (Eckfeldt et al., 2005).

About 30% of the 115 projects surveyed in a study in the defence industry of the United Kingdom introduced the concepts of target costing (Bourn, 2006). Apart from the oil industry, target cost contracting was widely adopted in the construction of health services sector premises by the Department of Health of the United Kingdom as well (ProCure21 Guide, 2010). Up to March 2011, there were 383 schemes completed under this procurement framework applying the New Engineering Contract Version 2 (NEC2) Option C (target cost with activity schedule) (National Health Service, 2011). It is claimed that there are time and cost savings in the projects procured with this framework, when compared with those under the traditional procurement approach in the United Kingdom (ProCure21 Guide, 2010).

2.7 Previous Research on TCC/GMP

Previous research studies which have been published in various international journals and conference proceedings related to TCC/GMP between 2000 and March 2011 are summarised in Table 2.1.

Europe

The procurement strategies of TCC/GMP have interested industrial practitioners worldwide over the recent decade. In Europe, Nicolini *et al*. (2000) studied two pilot construction projects using TCC in which the costs of some specific items were reduced due to the adoption of innovative solutions and methods, thereby suggesting that target costing may be one way to support supply chain integration, improve profitability and quality within the construction industry of the United Kingdom. This study also found that the relationship amongst project team members was less adversarial in projects with TCC. Bresnen and Marshall (2000) conducted six case studies using TCC in the United Kingdom and concluded that incentives can reinforce commitment and build mutual trust between organisations in the long run. However, significant changes and inconsistencies in internal policies and personnel can make any trust developed difficult to sustain.

Boukendour and Bah (2001) analysed GMP with option pricing theory and considered GMP as a hybrid system of cost reimbursement contract and optional contract hedging the owner from over-budget and provide him possibility of cost savings. Broome and Perry (2002) launched a series of interviews with practitioners to investigate the setting of sharing ratios in TCC for construction projects. This study suggested that utility theory may not be sufficient to deal with the interactions between factors governing the choice of sharing profiles. Pryke and Pearson (2006) conducted case studies in both France and the United Kingdom, investigating gain-share/pain-share arrangements under a prime contracting procurement approach and the use of GMP in standard form of building contract. This study opined that the adoption of GMP can lead to a change in attitude of the contractors when handling variations as the contractors become more proactive in financial control of inappropriate variations under this arrangement.

Badenfelt (2007) examined the control mechanisms used in the early phase of target cost contracts with a case study in Sweden, indicating that trust is fragile which must be continuously preserved in TCC, requiring a high level of mutual trust between the client and contractor. This study indicated that on one hand employers try to maintain the level of mutual trust by letting contractors be aware that they are knowledgeable and not easy to mislead. On the other hand, the contractors attempt to communicate that they cherish the existence of a long-term working relationship and a goodwill reputation. Badenfelt (2008) interviewed eight clients and eight contractors in the Swedish construction industry, followed by a case study of a large construction project procured with a target cost contract. This study concluded that an appropriate sharing ratio under TCC may be determined based on long-term relationships and perceived relational risks. Another investigation by a three-year longitudinal study by Badenfelt (2010a) identified a number of formal control mechanisms (e.g. open book accounting regime together with project and progress meetings) and informal control mechanisms (e.g. partnering arrangement and project diary) under TCC performed by project participants in the Swedish perspective. The findings showed that informal control mechanisms conducted by employers appear to be the most effective means to preserve mutual trust. In addition, it is found that behaviours of contracting parties are affected by previous experience of working together. This research also revealed that a business relationship solely built on mutual trust appears to be rare, even in a trust-based collaborative setting, contracting parties should place more attention to trust- nurturing actions to ensure the smooth delivery of TCC.

Lahdenpera (2010) considered the problem of late involvement of the contractor in design under TCC, proposing a two-stage target cost arrangement to combine early contractor involvement and price containment. It is claimed by Lahdeenpera (2010) that this model can spur both the employer and the contractor to invest in the critical pre-implementation development phase. This mechanism is believed to be able to provide a means for various contracting parties to enter a co-operative working relationship which is of value for projects with special challenges and high uncertainty.

The United States

Arditi et al. (1998) launched a questionnaire survey on incentive/disincentive provisions in highways contracts within the United States. It was suggested that the frequency and magnitude of change orders in incentive/disincentive contracts were larger than those in non-incentive/disincentive contracts. Bower et al. (2002) examined three projects with different contractual arrangements, including one with

TCC, to illustrate the effective use of incentive mechanisms. Their findings suggested that contract incentive structures should provide appropriate incentives to contractors to meet the targets of cost, schedule and quality; correctly allocate risks and allow a suitable level of client's involvement in the projects.

Rojas and Kell (2008) analysed the data of 297 completed school projects in Oregon and Washington. The project cost exceeded the GMP value in 75% of the cases. The findings contradict the general perception that GMP is a guarantor of maximum construction cost. They suggested that the cost overrun may be due to scope creep, unforeseen conditions, force majeure, and design errors and omissions. Kaplanogu and Arditi (2009) investigated the practice of pre-project peer review process of GMP of contractors in the United States by means of an empirical questionnaire survey. Their findings indicated that it is necessary to carry out a pre-project peer review in GMP or lump sum contracts. It is also found that such a pre-project peer review is justified by contractors as its benefits include minimising the risk of underestimating the project cost, evaluating the appropriateness of project schedule and reviewing contract conditions and the like.

Bogus et al. (2010) analysed the performance data collected from public water and wastewater facility owners and compared project performance based on cost growth and time growth measures. It was concluded that cost plus fee with GMP contracts provide better performance in terms of cost and time certainty.

Australia

Walker et al. (2002) launched a case study on the Australian National Museum with TCC arrangement. It was found that the risk/reward arrangements encouraged a teamwork approach to innovative problem solving with successful project outcomes in terms of both time and quality. Hauck et al. (2004) also scrutinized the same case and opined that the National Museum of Australia project was the first example of project alliance in major commercial buildings in Australia which was completed on time and below budget. Davis and Stevenson (2004) conducted ten interviews on the benefits and limitations of procuring projects using GMP in Western Australia. Their findings concluded that price certainty, time saving and the encouragement of better team relationships were considered as the major advantages of GMP by the interviewees. In contrast, a lack of common understanding of the underlying concepts of GMP, standard form of contract for GMP scheme, appropriate skills in design management and capital cost being compromised, were perceived as the key limitations of GMP.

Rose and Manley (2007) identified the motivational drivers affecting the effectiveness of financial incentives in a large-scale building project with a less than satisfactory project outcome in Australia. This research recommended that the construction risks could be shared equitably between the client and contractor with flexibility being provided in the contract to handle unforeseen situations and relationship management in order to design a financial incentive mechanism strategy. A more recent investigation also by Rose and Manley (2010a) involving four case studies of large Australian building projects suggested that the benefits of financial incentives could be maximised through equitable contract risk allocation, early contractor involvement in design development, value-driven tender selection, holding relationship workshops and offering future business opportunities.

Asia

Al-Subhi Al-Harbi (1998) applied utility theory to explain how employers and contractors determine sharing ratios from their points of view with numerical examples. It was perceived that both parties may need to discuss the extent of project variability and identify the basis of their decisions during the negotiation of sharing ratios in TCC. Tang et al. (2008) undertook a research project on the use of incentives in the Chinese Mainland construction industry using a questionnaire survey together with a case study of the Three Gorges Project. It was found that incentives could be developed based on project type, delivery system, project risks and participants' needs and their experiences to enable incentives to improve the efficiency of project delivery process.

Bayliss et al. (2004) reported on a successful case of applying construction partnering under a TCC arrangement and opined that both partnering review workshops and the use of an incentivisation scheme underpinned the success of a railway extension project in Hong Kong. Wong (2006) explored the application of a computerised financial control system to the development of a cable car construction project with TCC in Hong Kong. He opined that TCC exercised a rigorous control over tendering, subcontracting and contract administration during project delivery.

Tang et al. (2008) conducted a questionnaire survey on use of incentives in construction in Mainland China. Their findings revealed that the respondents agreed that incentives could make risk allocation fairer, since those incentives could be considered as the sharing of rewards from good performance. It was also found that the respondents in general regarded incentives as effective in providing motivation for project participants to perform better. Chan et al. (2010a) identified critical success factors for target cost contracts in the construction industry of Hong Kong by means of an empirical questionnaire survey. Reasonable share of cost saving and risks, early involvement of contractor in design development, well-defined scope of works, right selection of project team and cultivation of partnering spirit, were perceived as the most essential determinants of a successful TCC/GMP project. Chan et al. (2010b) launched a case study on an underground railway station modification and extension works project with TCC arrangement. It was discerned that the TCC arrangement generated a multitude of benefits including aligning individual objectives together, providing a cost incentive for contractor to work more efficiently and achieving better value for money as well as more satisfactory project performance in terms of time and quality. Senam et al. (2010) evaluated the suitability of applying the GMP approach as an alternative procurement method for public sector projects in Malaysia. It was indicated that industrial practitioners had little experience or awareness of the concepts of GMP but would welcome the introduction of these concepts to the construction industry in Malaysia.

Anvuur and Kumaraswamy (2010) launched a series of semi-structured interviews and a review of project documentation, together with a direct observation of project meetings in two GMP building project cases in Hong Kong. Their findings suggested that the GMP mechanism offers two potential values to employers including: (1) GMP mechanism can provide some flexibility of responding to market changes in short term; and (2) it can be a useful tool for project work group integration. Chan et al. (2011a) carried out a case study of a private commercial development in Hong Kong, via a number of structured face-to-face interviews, in order to investigate the operational mechanism, project performance, motives, benefits, difficulties and success factors for applying the GMP contractual arrangement in Hong Kong. It was concluded that the GMP mechanism helped to achieve competitive price, value for money, high quality of products as well as strong incentives to innovation and cost saving.

Table 2.1 Some Recent Research Studies Published Related to TCC/GMP Contracts between 2000 and March 2011 (adapted from Chan et al., 2010c)

Authors	**Year**	**Journal/ Conference**	**Country**	**Focus**	
Nicolini et al.	2000	BJM	UK	Two case studies of TCC in the United Kingdom	**Europe**
Perry and Barnes	2000	ECAM	UK	Tender evaluation of TCC	
Bresnen and Marshall	2000	CME	UK	Six case studies of construction projects with TCC	
Boukendour and Bah	2001	CME	UK	Analysis of GMP with option pricing theory	
Broome and Perry	2002	IJPM	UK	Determination of sharing ratios of TCC with utility theory	
Pryke and Pearson	2006	BRI	France	Three European case studies to investigate the gain-share/ pain-share mechanism developed under the prime contracting approach	
Badenfelt	2007	ARCOM Conference	Sweden	Trust and control in TCC projects	
Badenfelt	2008	ECAM	Sweden	Sharing ratio in TCC in Sweden	
Badenfelt	2010a	IJPM	Sweden	Cases in construction industry and IT industry with TCC	
Badenfelt	2010b	CME	Sweden	A longitudinal study of a large-scale laboratory construction project with TCC in Sweden	
Lahdenpera	2010	CME	Finland	Proposing a two-stage target cost arrangement to combine early contractor involvement and price containment	
Arditi et al.	1997	JCEM	US	Perceptions of owners and contractors on incentive/disincentive contracting in construction projects	**The United States**
Bower et al.	2002	JME	US	Comparison of incentive features of 3 case studies	
Rojas and Kell	2008	JCEM		Comparison of cost growth performance between construction	

			US	at risk with GMP and design-bid-build approach in school projects in the United States	
Kaplanogu and Arditi	2009	ECAM	US	Timing, benefits, effectiveness of pre-project peer review in GMP/lump sum contracts in the United States	
Bogus et al.	2010	PWMP	US	Evaluation of cost and time performance of GMP contracts	
Walker et al.	2002	SCM	Australia	Case study of Australian National Museum with TCC arrangement	
Davis and Stevenson	2004	AIPM Conference	Australia	Ten interviews conducted to investigate the benefits and limitations of GMP in Western Australia	
Hauck et al.	2004	JCEM	Australia	Case study of Australian National Museum with TCC arrangement	**Australia**
Rose and Manley	2007	CIB Congress	Australia	Report of a failure case of financial incentive mechanism and the effective recommendations for improvement	
Rose and Manley	2010	ECAM	Australia	Four case studies applying financial incentives (including TCC arrangement)	
Al-Subhi Al-Harbi	1998	IJPM	Saudi Arabia	Sharing ratio in TCC	
Bayliss et al.	2004	IJPM	Hong Kong	Case study of a underground railway station project with TCC	
Wong 2	006	ITCon	Hong Kong	Study on a computer system for cost monitoring in cable car project with TCC in Hong Kong	
Tang et al.	2008	JCEM	Mainland China	Perception of industrial practitioners on use of incentives in construction industry	
Chan et al.	2010a	JFM	Hong Kong	Identification of critical success factors of TCC in construction industry	**Asia**
Chan et al.	2010b	Facilities	Hong Kong	Case study of a underground railway station modification and extension works project with TCC	
Senam et al.	2010	MNJVCW Conference	Malaysia	Evaluation of suitability of employing GMP mechanism in Malaysia	
Anvuur and Kumaraswamy	2010	ARCOM Conference	Hong Kong	Two case study of building projects with GMP mechanism	
Chan et al.	2011a	ECAM	Hong Kong	Case study of a private commercial development with GMP mechanism	

Notes: AIPM Conference: Australian Institute of Project Management National Conference; ARCOM Conference: Conference for Association of Researchers in Construction Management; BJM: British Journal of Management; CIB: CIB World Congress; CME: Construction Management and Economics; ECAM: Engineering, Construction and Architectural Management; IJPM: International Journal of Project Management; JCEM: Journal of Construction Engineering and Management; JFMPC: Journal of Financial Management of Property and Construction; JME: Journal of Management in Engineering; ; MNJVCW: International Conference on Multi-National Joint Venture for Construction Works; PWMP: Public Works Management and Policy; SCM: Supply Chain Management: An International Journal.

Judging from the extensive literature review of the TCC/GMP practices in Europe, the United States, Australia and Asia, it seems what has not been adequately addressed but may be significant is a holistic analysis of the key risk factors and risk mitigation measures as well as the preference of risk allocation for TCC/GMP projects in the construction industry. Thus, this study is intended to fill the knowledge gap in this respect. Despite a fair amount of research related to TCC/GMP, empirical studies especially on the risk aspects of TCC/GMP are rather limited. Identification and analysis of major risk factors, proper risk allocation and effective risk mitigation measures for TCC/GMP contracts are particularly lacking in existing literature, where risk factor is defined as "an event, activity or situation that could lead to the possibility of suffering some loss" (Jha and Devaya, 2008). When compared with the conventional design-bid-build delivery method, TCC/GMP stakeholders will be exposed to a higher level of risk as they typically set an agreed GMP or target cost value in the contract well before the full completion of project design. Meanwhile, previous research revealed that the success of a construction project depends very much on the extent to which the risks involved can be identified, measured, understood, reported, communicated and allocated to the appropriate competent parties. Thus, it is essential to identify and understand the associated risks as early as possible, so that suitable strategies can be developed and implemented either to retain some particular risks by a certain party or to transfer them to other more capable parties to minimise any likely negative impact they may have on the project (Wang et al., 2004).

Interestingly, the literature search indicated that there are several research studies on the advantages and disadvantages, the operational mechanism, sharing ratio and overall performance of TCC and GMP projects. However, few, if any, research studies have been carried out on key risk factors and risk management of these forms of procurement. Such observation underlies the rationale of this study. Its aim is to identify the key risk factors and assess their impacts, investigate the preference of risk allocation and risk mitigation measures of TCC/GMP construction projects.

2.8 Overview of Risk Management Process

There is indeed a considerable amount of literature which documents the elements in risk management. Risk can be defined as "the chance of something happening that will have an impact upon the objectives" (AS/NZS3460:2004 – Risk Management). Risk is related to the likelihood and consequences of an event, and the resultant influence on project objectives (Environment, Transport and Works Bureau, 2005). Risk can be managed, diminished, transferred or accepted, but it should not be ignored in construction projects (Latham, 1994). The objectives of risk management are to make sure that: (1) risk is allocated to the party who can best handle it; (2) risks are shared as much as possible; and (3) allowance for every unavoidable cost associated with the risk which is assumed to be made somewhere in the project delivery (Ahmed et al., 1998). Risk management comprises risk planning, risk identification, risk analysis, risk evaluation and risk treatment supported by continuous monitoring, review and recording of the identified risks, together with effective communication and consultation with project stakeholders (Environment, Transport and Works Bureau, 2005) and they are illustrated in Figure 2.3.

Since the HKSAR Government is one of the largest clients in the construction market in Hong Kong, the risk management process described in the Environment, Transport and Works Bureau (2005) is applied to all Works Departments under the Development Bureau (Environment, Transport and Works Bureau was renamed as Development Bureau in 2008). While in the private sector, risk management is less structured and is performed mainly by experience and intuition, so the more systematic framework of risk management as adopted by the HKSAR Government was chosen as the starting point for literature review.

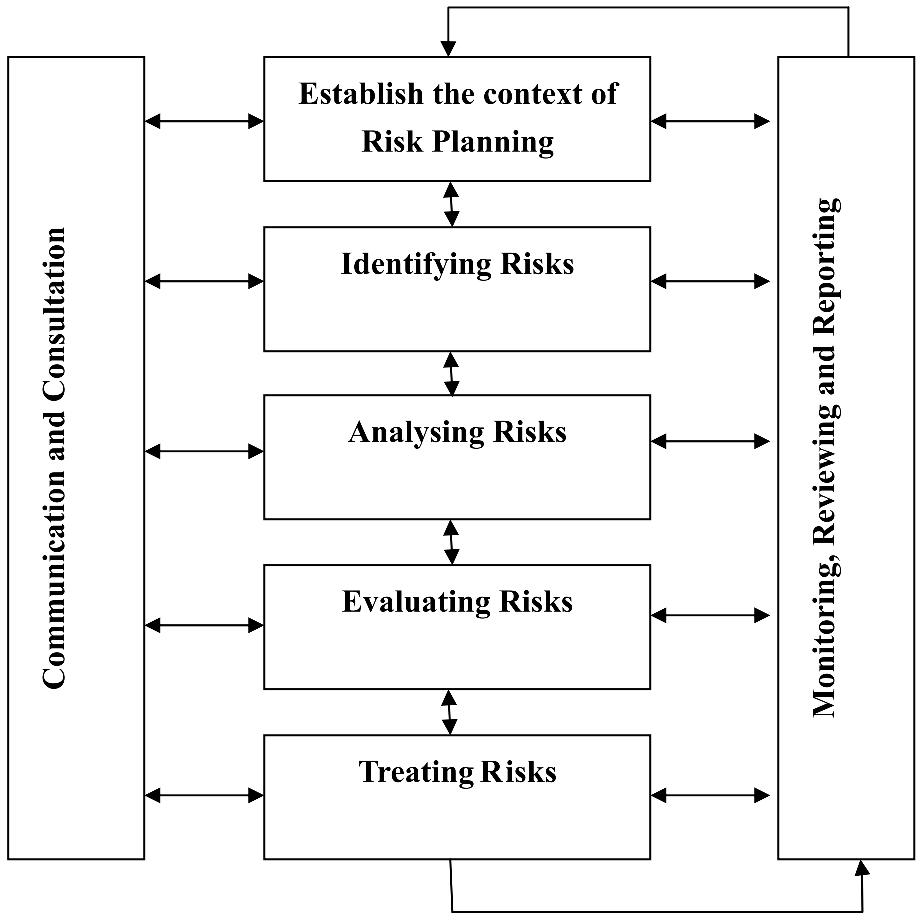


Figure 2.3 **Systematic Risk Management Process (adapted from Environment, Transport and Works Bureau, 2005)**

Establishment of context and risk planning

The first element of the risk management process is the establishment of context and risk planning. The criteria against which risk would be evaluated should be established and the structure of analysis should be defined (Environment, Transport and Works Bureau, 2005). Project risk management should be conducted according to the intent as well as the structure of risk management process as specified in the risk management plan.

Risk identification

The purpose of this stage is to identify the sources and types of risks which would have impact on the achievement of project objectives (Flanagan and Norman, 1993; (Environment, Transport and Works Bureau, 2005). There are different classifications of risks such as controllable and uncontrollable risks, dependent risk and independent risk, project risk and individual risk and the like (Flanagan and Norman, 1993). There are a number of approaches which can be applied in risk identification solely or in combination (e.g. brainstorming under a workshop environment, use of risk register check list and interviewing with experts in a particular field) ((Environment, Transport and Works Bureau, 2005). The use of the above approaches depends on the project nature and resources available.

Risk analysis

Following the risk identification, the risks need to be analyzed and quantified. The objective of this stage is to establish an understanding of the level of risk and its nature for the manager. It can provide some insights to the decision makers on whether the risks need to be treated and how they should be treated. The level of risk is gauged by two measurements: probability of occurrence and level of impact of the risk, and risk analysis matrix can be a good tool for risk analysis (Environment, Transport and Works Bureau, 2005).

Risk analysis can be conducted depending on the degree of details of the risks, the information, data and resources available. Analysis can be divided into qualitative analysis and quantitative analysis and a combination of the two approaches in broad terms ((Environment, Transport and Works Bureau, 2005). However, the limitations in the use of qualitative approach such as expert judgment are highlighted by a number of scholars who put emphasis on the significance of applying formal methods of risk assessment and decision making (Flanagan and Norman, 1993; Chege and Rwelamila, 2000). Quantitative analysis can also be adopted to realise further benefits including refined contingency setting, monitoring draw-down of contingency and insurance benefits. Some of the quantitative techniques available for risk analysis include those based on expected monetary value, decision tree diagram, sensitivity analysis and simulation technique.

Risk evaluation

The aim of risk evaluation is to gain an understanding of the level of risk and give some ideas to managers for making decisions on actions dealing with the risks and define priorities of such actions. A sample set of risk evaluation criteria as proposed by the Environment, Transport and Works Bureau (2005), to provide a method by which decisions can be made is given in Table 2.2:

Table 2.2 Sample Set of Risk Evaluation Criteria (Environment, Transport and Works Bureau, 2005)

Level of Risk	Recommended Level of Management Attention
Extreme	Immediate actions from top management needed, action plans required to develop with clear assignment of responsibility and timeframe for each party
Very High High	Top management attention required, action plans required to develop with clear assignment of responsibility and timeframe for each party
Medium	Risk requires specific ongoing monitoring and review, to make sure that the l level of risk would not rise further. Otherwise, managed by routine procedures
Low	Risk can be accepted or even ignored. Managed by routine procedures, unlikely to need specific application of resources.

Risk treatment

The risk treatment can take any of the following four forms (Flanagan and Norman, 1993):

1. Risk retention
2. Risk reduction
3. Risk transfer (risk sharing)
4. Risk avoidance

Selection of the preferred risk treatment is indeed a cost benefit decision, with preference given to treatments providing the best outcome to the project Environment, Transport and Works Bureau (2005)..

Risk monitoring and review

With the advancement of construction technology, the unique nature of construction projects and increasing complexity of projects and organizational structure over the recent years, management of risk is a dynamic process. The level of impact and the probability of occurrence of the risk would change over the project delivery process (Environment, Transport and Works Bureau, 2005). New risk may also emerge when the project proceeds. It is of paramount significance for project success that the whole risk management process be kept alive and interactive to the environment throughout the duration of project. The risk and the effectiveness of risk treatment should be monitored as they will change with time. The Environment, Transport and Works Bureau (2005) further proposed to conduct risk reviews on a regular basis at key milestones during the project delivery.

Risk communication and consulting

As Figure 2.3 indicates, communication and consulting is involved in each step of the risk management process. The internal stakeholders are involved in the risk management process by direct involvement in workshops or information distribution. They are highly encouraged to communicate with each other and contribute to the process of risk management in order to achieve continuous improvement of the whole process (Environment, Transport and Works Bureau, 2005).

Classification of Risk Factors in TCC/GMP Projects

Whilst there are certain perceived advantages of procuring construction projects with the TCC/GMP arrangement, the inappropriate use of TCC/GMP philosophy would create a lot of problems with the project delivery and expose both contracting parties to considerable risks.

According to Ashley et al. (1989), economic pressure would place the client and contractor in adversarial positions. This would also minimise contractor's design constructability input and motivation to improve quality. Thus, from the clients' point of view, economic pressure could be a risk factor in the delivery of a project procured with the GMP arrangement.

As Al-Harbi and Kamal (1998) suggested, with different attitudes towards risks, the owner and contractor would value the sharing fractions and final project cost differently. It is not easy to arrive at a sharing fraction which best fits both parties. Imbalance of sharing fraction, which would affect the incentive of the contractor, can be viewed as one of the risk factors involved in this kind of procurement approach.

Yew (2008) pointed out that the ambiguous tender design brief, vaguely defined contractor's design responsibilities, unclear liability for errors and omissions, together with little contractor's involvement in design development would increase the risk exposure of contractors in construction projects with the GMP arrangement. Indeed, risk factors in typical construction projects are widespread in risk management literature which are listed in Table 2.3. Since some of the risks are common in construction projects in general and those procured with TCC/GMP (e.g. Act of God), one of the objectives of this study is to identify the key risk factors associated with the construction projects procured under TCC/GMP schemes. In order to achieve this objective, a series of structured face-to-face interviews were conducted *(refer to Chapter 4)* to determine the major risk factors associated with projects with TCC/GMP.

Table 2.3 Risk Factors Associated with Typical Construction Projects (Chan et al., 2008a).

References / Risk factors (Year)	Bernhard 1988	Ahmed et al 1998	Al-Harbi and Kamal 1998	Ahmed et al 1999	Broome and Perry 2002	Haley and Shaw 2002	Rahman and Kumaraswamy 2002	Cheng 2004	Fan and Greenwood 2004	Oztas and Okmen 2004	Sadler 2004	ETWB 2005	Li et al 2005	Tang 2005	HK Housing Authority 2006	Shen et al. 2006	Ng and Loosemore 2007	Chan et al. 2007a	Chan et al. 2007b	Yew 2008	**Total number of hits of a certain risk factor**
Act of God				*			*					*	*			*	*				**6**
Adequacy of design		*										*									**2**
Buildability / Constructability							*					*									**2**
Change in government regulations				*			*					*	*								**4**
Client may pay more as contractor would inflate the tender sum to cover additional risks								*						*	*			*	*		**5**
Conflict of documents							*														**1**
Contractor may incur a loss due to unclear scope of work						*			*					*				*			**4**
Contractor may not foresee design development risks								*	*		*			*			*	*	*	*	**8**
Defective Design				*			*														**2**
Delayed payment on contracts				*			*														**2**
Delay in availability of labour, materials and equipment		*		*			*			*			*								**5**
Delay in resolving contractual issues				*			*														**2**
Design changes							*			*											**2**
Difficult to value revised contract price							*					*						*		*	**4**
Difficult to use successfully on contracts when many																		*			**1**

changes are expected																					
Disputes may arise due to c hange in sc ope of work						*	*		*	*	*				*			*	*	*	**9**
Exchange r ate variation												*									**1**
Errors a nd omissions in te nder d ocuments / Insufficiency of tender		*					*					*					*	*		*	**6**
Financial fa ilure of contractor				*			*					*									**3**
Financial fa ilure of owner				*			*														**2**
GMP may not be the “maximum” at end o f the day						*								*							**2**
Inaccurate topographical data												*									**1**
Inclement weather							*			*		*	*								**4**
Inexperienced contractor m ay jeopardize the GMP/TCC process				*		*	*	*						*	*			*			**7**
Inflation		*		*			*			*		*					*				**6**
Labour a nd e quipment productivity				*			*														**2**
No sta ndard fo rm of contract l eads t o misunderstanding of responsibilities of parties						*		*						*				*		*	**5**
Oil / e nergy / commodity pric e fluctuation												*									**1**
Quality of work				*			*														**2**
Subcontractor failure				*			*						*								**3**
Third pa rty de lay (risk)		*		*			*			*											**4**
Uneven s haring fraction of sa ving / overrun of budget	*		*		*																**3**
Unforeseen gr ound conditions				*			*			*		*	*			*	*				**7**
Total n umber o f r isks identified fr om each publication	**1**	**5 1**		**15**	**1 5**		**22**	**4 3 7**	**2**			**13**	**6 6 3**	**2**			**5 9 3**			**5**	**118**

Note: The previous studies are ranked in increasing chronological order of year of publication, followed by the alphabetical order of surnames of authors.

2.9 Risk Assessment in Construction Projects

There have been a cons iderable nu mber of previous studies on risk assessm ent in construction projects. According to La ryea and Hughes (2008) , the findings of interviews with five estim ators of construction fir ms in the United Kingdom manifested that four of them applied a risk register mechanism in practice (i.e. risk impact as a f unction of probability m ultiplied by severity). The risk assessm ent started with a brainstorming review workshop and the participants identified the risks of the project in the workshop. After that, the risks were evaluated with a spreadsheet matrix which helped to work out the contingencies based on the severity value and the probability value based on the hands-on experience and intuitive judgement of the participants. Adams (2008) commented that risks in construction projects are often analysed in an arbitrary manner. Contractors tend to resort to the addition of a single arbitrary cost contingency to give their overall impression of the total risk instead of assessing the risks they are asked to carry. This view is supported by an earlier study by Akintoye and Macleod (1997). They investigated how contractors performed risk analysis through a questionnaire survey launched in the United Kingdom. They drew a similar conclusion with Adams (2008) that formal risk analysis techniques were rarely used in the industry due to lack of knowledge and doubts of suitability of those techniques in the construction industry.

Risk management is beneficial to a project development if it is implemented in a systematic approach from the planning stage up to project completion, in order to help project participants to make better and more informed decisions (Baloi and Price, 2003). The unsystematic and arbitrary nature of risk management inherent with the construction industry could endanger the success of projects. Indeed, risk management is an art as well as a science (Baloi and Price, 2003). Despite the fact that there is a large amount of literature and continuous development of the risk management in the construction management discipline, it appears that industrial practitioners have not much appreciated their significance (Flanagan and Norman, 1993). Unlike other industries such as the oil industry and petrochemical industry, there seems to be a considerable gap between existing theories and current practices in risk management of the construction industry (Thompson and Perry, 1992).

In recent years, a plethora of risk assessment models have been developed to enrich the body of knowledge of risk management in construction discipline. For example, Baloi and Price (2003) developed a fuzzy decision framework to model the global risk factors affecting construction cost. Zhang and Zou (2007) established a risk assessment model for joint venture projects in Mainland China with the Fuzzy Analytical Hierarchy Process. Ng et al. (2007) proposed a simulation model for a public partner (government) to determine the concession period of a public-private partnership scheme, based on the expected investment and tariff. Zeng et al. (2007) applied the fuzzy reasoning techniques to generate a tool for handling risks in construction projects. However, no risk assessment model (few if any) has been developed for the TCC/GMP schemes in the construction industry. The above findings from the desktop search further reinforce the primary aim of this study (i.e. to develop a risk assessment model for TCC/GMP construction projects in Hong Kong).

2.10 Risk Allocation in Construction Projects

There has exhibited an emerging trend of application of TCC and GMP (being a variant of TCC) contracts in the private sector and quasi-government sector in Hong Kong over the recent years (Chan et al., 2007a). Moreover, the HKSAR Government has introduced the New Engineering Contract Version 3 (NEC3) Option C (target cost with activity schedule) to a pilot project commissioned by the Drainage Services Department which was started in August of 2009 (Cheung, 2008). TCC has been practised in the infrastructure sector of Hong Kong such as the Tseung Kwan O Railway Extension with 5 Stations, Tung Chung Cable Car Project, Tsim Sha Tsui Metro Station Modification Works (Chan et al., 2007a; Chan et al., 2010a), West Island Railway Extension and South Island Railway Extension.

However, not every TCC/GMP project has been equally successful in terms of time, cost and quality performances. This may be due to the employers traditionally applying exculpatory clauses to minimise their own obligations in the contracts. This onerous allocation of risks may not be in the interest of the construction industry in the long run. Mosey (2009) also suggested that some clients tend to transfer the risk arbitrarily and both the client and contractor are actually gambling on whether the risk has been accurately priced. The short-term benefits of shifting as many risks as possible to contractors in contracts may create an atmosphere of hostility that generates a considerable number of contractual disputes and, even worse, a reluctance to tender for works in future (Zaghloul and Hartman, 2003). Despite the increasing trend of application of TCC/GMP, there has been very scarce published literature touching on the risk allocation of TCC/GMP projects in Hong Kong. Hence this study also aims to determine the party best capable to take such risks in the Hong Kong context, apart from identifying the key risk factors associated with TCC/GMP construction projects.

Such a study is expected to benefit both academic researchers and industrial practitioners in exploring the preferred risk allocation of TCC/GMP projects, and in providing a strong base for further research such as an international comparison of different risk allocation schemes in those projects procured with this kind of contractual arrangement.

Risk allocation can be defined by Li et al. (2005) as primary measures of risk assignment between the contracting parties in a project. If both parties are assigned certain risk outcomes, then there is a shared risk allocation mechanism.

The risk allocation can be achieved through contractual language within the construction industry, and exculpatory clauses such as the "No damage for delay" clauses and indemnification clauses are commonly used to shift one's responsibility in common law to another party. However, as Ashley et al. (1989) suggested, their enforceability would be subject to questions. They further pointed out that even if those exculpatory clauses were enforceable, most contractors would merely pass on their cost to the client by inflating the tender prices. Ahmed et al. (1998) shared a similar view that misallocation of risk would result in owners paying more than necessary due to bid contingency. Hence, a fair and even allocation of risks is of significant importance to a successful project delivery.

Citing from Ward et al. (1991), Edwards (1995), Abednego and Ogunlana 2006), Flanagan and Norman (1993) pointed out that five conditions should be satisfied to determine if project risks are properly allocated, namely,

1. Risk should be allocated to the party who can best handle it.
2. Risk should be properly identified, understood and evaluated by parties concerned.
3. A party must be capable in terms of management and technology to manage the

risks

4. A party must have sufficient capital to sustain the consequence of the risk and/or prevent those risks from occurring.
5. A party must be willing to accept the risks.

2.11 Risk Mitigation in Construction Projects

After the risks of a project have been identified and analysed, the contracting parties should decide how to treat the risk and formulate suitable risk mitigation measures (Wang et al, 2004).

The aim of project control is to make sure the projects can be completed within budget, on time but without sacrificing quality and achieve other objectives such as safety and environmental concerns in the construction industry. Olawale and Sun (2010) conducted a research study to identify the factors inhibiting effective time and cost control and mitigation measures for such factors in the British perspective. However, there seems to be a lack of empirical research studies in Hong Kong focusing on risk mitigation measures for TCC/GMP contracts.

Some risk mitigation measures for TCC/GMP contracts as derived from different literature are listed below:

1. Implementation of partnering spirit (Chan et al, 2007a)
2. Reasonable share of cost saving/ overrun of budget in case of TCC (Chan et al, 2007a)
3. Clearly defined scope of works in client's project brief (Chan et al, 2007a)

4. Development of standard forms of contract for GMP and TCC schemes (Chan et al, 2007a)
5. Early involvement of contractor in design development (Chan et al, 2007a)
6. Confirming a GMP/Target Cost after the contract document is 100% completed (Davis Langdon and Seah, 2003)
7. Adjustment of incentive as work proceeds and variations are introduced. (National Economic Development Office, 1982)
8. Mutual confidence between the parties to the contract (National Economic Development Office, 1982)
9. Right selection of project team (Chan et al, 2007a)
10. Maintaining a clear risk register throughout the project (Environment, Transport and Works Bureau, 2005)

In light of the limited amount of literature on TCC/GMP schemes, a series of in-depth interviews were conducted with industrial practitioners with direct hands-on experience of TCC/GMP projects to explore the risk mitigation measures in Hong Kong (*refers to Chapter 3*). The interviews provided some insightful findings from practitioners and formed a solid foundation for the development of the empirical questionnaire survey in this study.

2.12 Chapter Summary

This chapter has provided a comprehensive review of the relevant TCC/GMP researches and contemporary literature. The definitions of TCC and GMP, operational mechanisms of TCC/GMP, perceived benefits and potential difficulties of applying TCC/GMP, risk management, risk factors and their allocation, and risk mitigation measures for TCC/GMP contracts, have also been fully reviewed and discussed in this chapter. More importantly, a comprehensive review of related previous work has been undertaken to identify the knowledge gap and reinforce the primary aim of this study. The extensive literature review exercise can serve as a sound theoretical foundation for launching the current research study.

3.0

RESEARCH METHODOLOGY AND TOOLS FOR DATA ANALYSIS

CHAPTER 3 – RESEARCH METHODOLOGY AND TOOLS FOR DATA ANALYSIS

3.1 Introduction

This chapter serves as an overview of different types of scientific research methodologies available for construction management discipline, followed by depicting the approaches and methods adopted in this research study. Various statistical tools for data analysis in this research will also be introduced in this chapter.

3.2 Research Methods for Construction Management

Fellows and Liu (2008) considered that research methodology refers to the principles and procedures of logical thought applied to a scientific investigation while research methods concern the techniques which are available and those which are actually employed in a research project. Sekaran (1999) held the view that a scientific research should include the features of purpose, rigour, testability and repeatability which indicate a true state of affairs, precision, confidence, objectivity, and ability to generalise.

The research of construction management is commonly carried out with four standard methods, including: (1) literature review; (2) case study; (3) interview; and (4) questionnaire survey (Chow, 2005). Fellows and Liu (2008) pointed out that the selection of an appropriate research method is dependent on the scope and depth of a research. Bryman and Bell (2003) opined that research design is the way which the data are collected and analysed in order to answer research questions posed and to provide an overall framework implementing the research. An interesting analysis was conducted by Dainty (2010) on every journal paper published in the "*Construction Management and Economics*" in Volume 24 (i.e. Year 2006), to examine the methodological positions and research methods used by various construction management researchers worldwide. It is found that out of a total of 107 published papers, 76 of them (71.0%) applied quantitative methods, followed by 12 papers (11.2%) adopted mixed methods (i.e. combining qualitative and quantitative methods), 10 papers (9.4%) were based on a holistic review of reported literature and only 9 articles (8.4%) used qualitative methods exclusively. A combination of qualitative and quantitative methods is employed in this study to derive the respective benefits of using both approaches. The following sub-sections describe the research methods used in this study.

3.2.1 Literature Review

An essential early stage of conducting a research study is searching and examining the relevant theory and literature (Fellows and Liu, 2008)..Literature review is the collection of background information of a research study in general. The aim of a literature review is to consolidate all previous studies related to the research by other researchers and understanding of the current practices (Chow, 2005). Academic journals are useful to research community especially to new researchers. A holistic review of previous work could help a researcher to gain a wide perspective of a field in interest (Xe et al., 2009). A systematic analysis of previous work would assist the researchers to explore the current status and continue from what the previous work left. A comprehensive literature review would be useful for the researcher to dig out the research problems. According to Bell (1999), the main point of a literature review is to the readers with a picture of the state of knowledge and the major problems of the subject area being investigated. Literature review is not just about reading the relevant publications but rather about presenting critiques of existing work in order to identify gaps in knowledge.

As stated in Chapter 2, a review of relevant previous work from Europe, the United States, Australia and Asia on TCC/GMP showed that research studies on risk management of TCC/GMP projects are scare. Given the fact that the Hong Kong SAR Government is now launching projects using NEC3 Contracts (including options of Target Cost Contract) and TCC/GMP are claimed to be applied in the construction projects with high risks (Wong, 2006), what have not yet been done but may be important is to investigate the key risk factors associated with TCC/GMP schemes, the preference of risk allocation, the implementation of risk mitigation measures, and more importantly, the development of an objective and reliable risk assessment model for TCC/GMP contracts which may help in the management of such projects.

3.2.2 Case Study

The case study approach facilitates in-depth investigation of particular instances within the research scope (Yin, 2009). Data could be collected in the rawest form and yield deep but narrow results. However, it is of interest to note that resources constraints may limit the number of studies that could be conducted (Fellows and Liu, 2008). Proverbs and Gameson (2008) opined that the main benefit of case study is that it allows researchers to evaluate different sources of information to test a particular concept on the basis that a consensus of the findings would yield a robust result. A case study should be drawn up explicitly at the beginning of the research and the research design could be tailored within the research period for any changing conditions that the fieldwork throws up. To determine how to undertake a case study, the researcher should consider: (1) the time available to carry out the investigation; (2) the availability of documentary information; (3) the access to people involved; (4) aim of the investigation; and (5) the number of cases required (Proverbs and Gameson, 2008).

3.2.3 Interview

There are three kinds of research interviews, including: (1) structured interviews; (2) semi-structured interviews; and (3) unstructured interviews. A structured interview is conducted with reference to either a questionnaire or pre-designed set of questions. It is worth noting that the issue of personal interaction between the researcher and interviewee during the interviews should be carefully managed. Haigh (2010) held a similar perception that a structured interview involves one person asking another one a set of pre-determined questions about a carefully selected topic. As Naoum (1998) suggested, the questioning may start with some open-ended questions, but will move towards a closed question format. In this study, the interviews were started by asking the interviewees to briefly introduce the TCC/GMP project(s) which they were personally involved in. Then a set of closed questions such as requesting them to suggest some major risk factors encountered in those TCC/GMP construction projects were then asked in the interview.

According to Simister (1995), interviews should be conducted with dexterity and care to avoid the collection of useless data. In addition, the interview questions should be designed with thorough thought to avoid any misunderstanding. Appropriate interview techniques should also be adopted so as to achieve the result effectively and efficiently. In addition, Fellows and Liu (2008) recommended that tape recording the interviews with the permission of the interviewees can be very helpful at later stage of analysis, through subsequent scrutiny, help to ensure the accuracy, adequateness and objectivity in the recording responses. Strauss and Corbin (1997) suggested that interview dialogues should be tape-recorded, transcribed and analysed using a coding process in which the interview data are categorised using qualitative methods.

In this study, the interview dialogues were duly analysed with the concepts of content analysis technique in a matrix table format (i.e. each question posed against answers from each interviewee and the answers were classified into different groupings according to the nature of contents) to capture any similarities and differences for comparisons *(refer to Chapter 4).* Interview dialogues were classified and reduced into more relevant and manageable bits of data (Weber, 1990). This method can be applied to situations under which the information and understanding of issues relevant to general aims and specific objectives of a research project are obtained (Gillham, 2000). Results derived from the analysis of interviews were cross-referenced to the published literature wherever appropriate and to complement each other for validation.

3.2.4 Questionnaire Survey

Survey may be generally accepted as the most preferable method in construction management studies because data with standardised form could be collected from samples of a population (Chow, 2005). Therefore, researchers can reach statistical inferences after data analysis. In fact, the statistical inference can move from particular observations of a sample to the wider generalisations of whole population (Oppenheim, 1992).

Conducting questionnaire surveys for construction management studies have a number of merits because surveys: (1) are relatively inexpensive; (2) allow a large number of respondents to be evaluated within a relatively short period of time; (3) facilitate respondents to have adequate time to answer the questionnaire and look up information and data if necessary; (4) provide privacy for responding; (5) generate visual data input rather than auditory input solely; (6) help respondents to answer the questionnaire at their convenience; (7) allow respondents to read and understand the context of a series of questions; and (8) insulate respondents from the expectations of interviewer (Mangione, 1995).

Questionnaire is an effective tool in conducting a survey research for observing and recording data beyond the physical reach of the observer, and for sampling the opinions of individuals in spatially diverse locations. This is because questionnaire is usually designed to get standardised data from the respondents by giving a set of choices for each question for them to select. The questionnaire designed should be unambiguous and easy to answer, and no extensive data collection by the respondents is required before answering. Fellows and Liu (2008) stated that each question should only concern one issue and the answer should be requested in an unthreatening manner.

A possible adverse consequence of using questionnaire survey is the low response rate. It is normally expected to get 25-35% of valid response rate for postal questionnaires. Nevertheless, even this expected response rate is difficult to attain. Chan (1998) pointed out that the following aspects should be paid more attention so as to obtain prompt feedback and higher response rate, including: (1) clarity and courtesy; (2) questionnaire design should focus on the specific research objectives; (3) simple expression and ease of understanding; (4) brevity; (5) consistency; (6) a self-addressed return envelope with stamp; and (7) an offer of the result summary of the survey to respondents. In the questionnaire survey of this research, a total of 300 self-administered blank questionnaires were sent out in February 2009. One hundred and forty one completed questionnaires were received in March 2009, representing a response rate of 47% which was higher than the norm and was considered satisfactory.

Perhaps, this satisfactory response rate was attributed to the established personal networking with the target respondents and the follow-up actions taken by the researcher, such as sending email reminders and then followed up by direct phone calls. It should also be noted that self-completed responses can be prone to bias and distortions (Fellows and Liu, 2008), giving the answers which the respondents believe “should be given”, rather than providing their “true answers”. The nature of the questions asked on the survey form were mainly about the perceptions on the level of severity and likelihood of occurrence of key risk factors associated with TCC/GMP projects, preference of risk allocation as well as the effectiveness of risk mitigation measures. The respondents would less probably give the answers that the researcher wanted, since both respondents and the researcher did not know which risks would have given a higher perceived severity and likelihood at the beginning of the survey. Another potential caveat of questionnaire survey is casual ticking box format without serious consideration. This problem was overcome by using the Kendall’s concordance test to measure the internal consistency of the data obtained (Chan et al, 2003).

3.3 Research Methodology for this study

As stated in Chapter 1, the research objectives of this study are set out as follows:

1. To determine the Key Risk Factors (KRFs) inherent with TCC/GMP projects and analyse their importance.
2. To solicit and compare the opinions of various project stakeholders on risk assessment of TCC/GMP projects in Hong Kong.
3. To explore and compare the preferences of various project stakeholders on risk allocation of TCC/GMP projects in Hong Kong.
4. To develop and validate an overall risk assessment model for TCC/GMP projects in Hong Kong.
5. To recommend effective guidelines or strategies for managing the potential risks associated with TCC/GMP projects.

The research methods to be applied to achieve the research objectives mentioned above include a comprehensive literature review, together with structured interviews and a questionnaire survey. This study is based on the model of research process suggested by Walker (1997). Figure 3.1 illustrates the flow of the research. Both qualitative and quantitative approaches will be employed in this study to investigate the perceptions of industrial practitioners in Hong Kong.

3.3.1 Literature Review

The research study began with an extensive review of related literature from textbooks, professional journals, conference proceedings, academic journals, research monographs, dissertation reports, workshop seminars, magazines, newsletters and internet materials, to capture background knowledge about and prevailing practice framework for the TCC/GMP approach and associated issues, especially risk aspects, across different countries including the United Kingdom, Australia and Hong Kong. The review exercise aims to develop an overall research framework and to prepare an appropriate template for the structured interviews and questionnaire survey.

3.3.2 Structured Face-to-face Interviews

Haigh (2010) is in the opinion that interview is a popular method of collecting data by researchers in the built environment. According to Punch (1998), the approach of structured interviews is one of the effective tools in collecting data in qualitative research, where interview questions are planned and standardised in advance. Sekaran (2000) considered that it is applied to study the perspectives of participants at a preliminary stage and it is best used when it is known what information is needed at the outset. The merit of structured interview is that it allows replication of the interview with others and the possibility of generalizing to the population from which the interview sample came. The main reason why structured interview is adopted in this study is that data are more reliable as the issue being investigated in a consistent way. Another benefit of structured interview is that it is a powerful tool to gather greater depth of information (Haigh, 2000). Moreover, the researcher can obtain, code and interpret data more quickly and efficiently with this method.

The purpose of the structured face-to-face interviews was to collect updated necessary information from practitioners with direct hands-on experiences so that any mismatch between theoretical studies and actual practices in real-life cases could be rectified. Another important purpose of conducting the interviews was to determine whether those key risk factors identified from the literature review were appropriate, clear, sufficient and representative. The interviews also enabled the researcher to know more about the real-life practices of TCC/GMP schemes. The interview findings can help the researcher to enhance the comprehensiveness and clarity of the proposed risk factor list to be used in the questionnaire survey, and to avoid any missing key risk factors which were not identified from the literature review but suggested by the interviewees. For example, two new risk factors: "Market risk due to the mismatch of prevailing demand of real estate" and "Difficult to obtain statutory approval for alternative cost saving designs" were added to the questionnaire after the face-to-face interviews.

In order to facilitate the interviews, a list of open-ended questions were attached to the letter of invitation and asked the TCC/GMP participants for the background information of the cases that they were personally involved in and their views on key risk factors, risk allocation and risk mitigation measures. Purposive sampling was employed in which only participants having satisfied particular pre-determined criteria are considered as target respondents (Ng et al, 2002) for the interview survey. In this study, the selected interviewees should have acquired hands-on experience in running at least one TCC/GMP construction project in Hong Kong. The following methods were used to identify the experienced participants in the industry:

1. By referring to local professional / trade journals and websites of the respective client, contractor and consultant organisations;
2. By referring to relevant theses or dissertations at undergraduate level and postgraduate level;
3. By referral of the top management of relevant target organisations; and
4. By directly contacting the relevant organisations for referring to suitable interviewees.

The same strategies were applied by Lam et al. (2006) to investigate the lessons learnt in design-and-build construction projects in Hong Kong. In order to make the interviewees understand the objectives of this research, an invitation letter stating the research aim of this study was sent to the respondents by postal mails or electronic emails (see ***Appendix 1*** and ***Appendix 2***). Based on the project list in Table 1.1 “Selected TCC/GMP cases for the research in Hong Kong”, invitation letters were sent to the 25 relevant project participants identified from previous research studies by Chan et al. (2007a). Finally, a total of seven structured face-to-face interviews were conducted with eight respondents having direct hands-on experience with TCC/GMP construction projects in Hong Kong, to explore current practice framework, typical risk elements, risk allocation and suggestions for mitigating the potential risks in implementing TCC/GMP schemes. The interview dialogues are documented in ***Appendix 3*** for reference.

Considering that the potential pool size of target interviewees was not large and the limited examples of TCC/GMP projects in Hong Kong, seven interviews were regarded as sufficient. Since all of the interviewees were senior construction personnel having abundant direct hands-on experience with TCC/GMP construction projects in Hong Kong, the interview opinions and findings were considered representative and valid for general applications.

Their feedback and comments will be incorporated to produce the final empirical questionnaire for detailed investigation. The interview findings can help the researcher to explore the major risk factors, the preference of risk allocation and effective risk mitigation measures for TCC/GMP projects which may not be fully identified in the literature review to enhance the contents of the survey form. The results of the seven interviews were reported in a journal paper (Chan et al., 2010a) and they will be summarised in ***Chapter 4***.

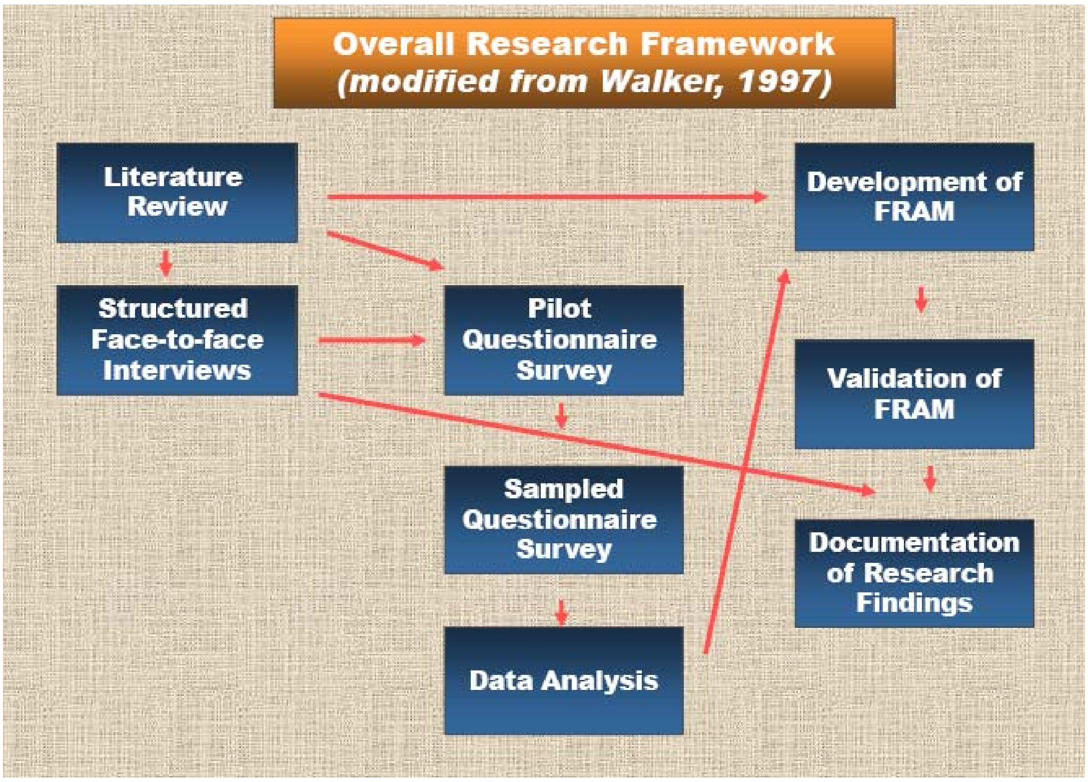


Figure 3.1. Research Framework of this Study (modified from Walker, 1997)

3.3.3 Pilot Questionnaire Survey

Based on the extensive literature review and the interview findings, a pilot questionnaire survey form was developed. Before launching an empirical questionnaire survey in Hong Kong, a pilot questionnaire survey was conducted to improve the suitability and practicality of the survey. A pilot survey form was sent to five experts in TCC/GMP construction projects in Hong Kong and they were requested to go through and vet the draft survey form and offer their comments, including the way the questions were set, the clarity of the questions, suitability of the options available, for improvement of the draft survey questionnaire. However, no adverse comments were obtained from the panel of experts and the draft survey form was regarded as clear and sufficient.

3.3.4 Empirical Questionnaire Survey

Figure 3.2 portrays the procedures for developing the empirical survey questionnaire used in this study. A survey questionnaire is considered as a pre-formulated written set of questions to which respondents record their answers, usually within rather closely defined alternatives (Sekaran, 2000). An empirical questionnaire survey was launched in Hong Kong. The survey form consists of four parts. The first part is about respondents' personal profiles. The second part focuses on the perceived level of severity and likelihood of occurrence of the 34 listed key risk factors in relation to TCC/GMP construction projects, after consolidation of findings from literature review and structured interviews, with a five-point Likert scale where 1 denotes "very low" and 5 denotes "very high" severity and a seven-point Likert scale where 1 denotes "very very low" and 7 denotes "very very high" likelihood. The respondents are also requested to choose the party best able to manage each of the key risks elicited. The third part is related to some recommended risk mitigation measures of TCC/GMP construction projects. The fourth part is optional and the respondents are welcome to express their personal preference on GMP or TCC with their supporting reasons. A sample of the invitation letter to those target respondents and the standard questionnaire template are attached in ***Appendix 4*** and ***Appendix 5*** respectively for reference.

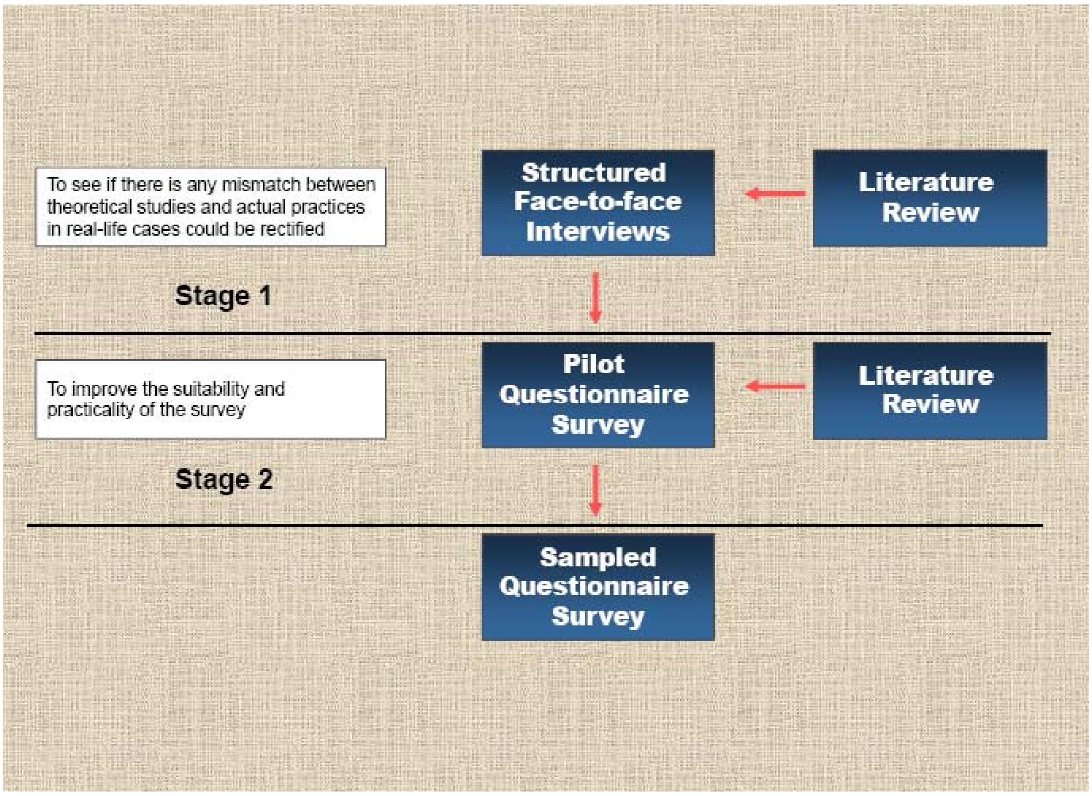


Figure 3.2 Development of the Empirical Survey Questionnaire

3.4 Tools for Data Analysis

After determining the research methodology, it is also important to determine the tools to be applied in data analysis. Data analysis is of utmost importance to turn raw data into useful information by quantitative methods so meaningful conclusions can be drawn. Data collected from the questionnaire survey were first inputted into the computerised database system and the statistical software, Statistical Package for Social Sciences (SPSS) was employed to facilitate the data analysis.

Various statistical tools were employed including the Cronbach's alpha reliability test, descriptive statistics, Kendall's concordance test, Spearman's rank correlation test, Mann-Whitney U Test in data analysis to test for consistency and compare the perceptions of different groups of respondents on risk assessment of TCC/GMP projects. Factor analysis and Fuzzy Synthetic Evaluation Method, which is one of the applications of fuzzy set theory, will be adopted in developing a fuzzy risk assessment model for TCC/GMP construction projects in Hong Kong. Factor analysis will be employed to extract the underlying grouped factors from 18 proposed risk mitigation measures in the questionnaire survey.

3.4.1 Cronbach's Alpha Reliability Test

Reliability is concerned with the internal consistency of the measurement scale (i.e. whether the scale used behaves the same when administered by different people or not) (Hoxley, 2010). Shen (2003) pointed out that measurement of reliability is essential to the validity of results of a questionnaire survey. According to Hoxley (2010), the most commonly used reliability coefficient is the Cronbach's alpha value which ranges from 0 to 1, with higher figure indicating greater reliability. Lu and Yan (2007) tested the reliability of the five-point Likert scale used on their survey form investigating the incentives of strategic partnering in China. They suggested that if the value of Cronbach's alpha is higher than 0.50, then the Likert scale can be considered as reliable. The Cronbach's alpha value was used by Akintoye et al. (2000) to confirm the reliability of Likert scale in their study on key success factors on the development of supply chain management. Lam et al. (2006) adopted the same tool to test the reliability of a five-point Likert scale on contributions of designers to improvement of buildability and constructability. This statistical tool is also applied in the data analysis of the survey to test the reliability of the Likert scale used.

3.4.2 Descriptive Statistics

Risk factors listed in the questionnaire survey are ranked in descending order of the mean scores on the perceived risk impact to identify the important risk factors associated with TCC/GMP projects (Shen et al., 2001). Chan et al. (2003) carried out the ‘‘mean score’’ method to establish the relative importance of difficulties encountered in the implementation of partnering in construction in Hong Kong, as perceived by the clients, consultants, and contractors. The data collected from the current study was also analysed using the same technique within various groups, as categorised according to the role of the parties involved in construction projects which were procured using TCC/GMP in Hong Kong. The same technique is applied in this study to show an overall picture of the perceptions of respondents.

3.4.3 Kendall's Concordance Test

According to Chan et al. (2003), the ranking exercise in a questionnaire survey with Likert scale is based on the individual perceptions of the respondents, but not an objective judgment. A subjective assessment of the ranking result is made for the analysis of the perception of the risk factors in the survey of this study. The caveat that such subjective judgment cannot provide any absolute value on ranking positions has been duly recognised. Emphasis is only given to the risk factors which are placed as the most significant and the least significant in the ranking exercise. Moreover, since the Likert scale of measurement was used in the questionnaire survey and the data are ordinal in nature, non-parametric statistical tests are considered as more appropriate to be applied in this study. The Kendall's concordance analysis, which is a non-parametric test, was used to measure the level of agreement of different respondents on their rankings of factors based on mean scores within a particular group. This statistical test aims to ascertain whether the respondents within a particular group respond in a consistent manner or not (Kvam and Vidakovic, 2007). The value of the Kendall's coefficient of concordance (W) ranges from 0 to 1, where 0 reveals perfect disagreement and 1 indicates perfect agreement. A significant value of W (actual p-value < allowable value of 0.05) can reject the null hypothesis that there is a complete lack of consensus amongst respondents within one group (Chan, 1998). Therefore, it can be concluded that there is a significant degree of agreement on the rankings of factors among the respondents within the group.

3.4.4 Spearman's Rank Correlation Test

The Spearman's rank correlation test is a non-parametric test for measuring the statistical significance and the strength of relationship between the rankings of two groups (El-Sayegh, 2008). This technique has been widely applied in the construction management research involving ranking exercise. For example, Wong et al. (2000) adopted this technique to test if there was any correlation on the rankings of project specific criteria in civil engineering works and building works by clients in the United Kingdom. Odeh and Battaineh (2002) applied this tool to test the association of the rankings by contractors and consultants on the causes of delay in construction projects.

The level of association between any two respondent groups on their rankings of various risk factors of TCC/GMP schemes was measured by the Spearman's Rank Correlation Coefficient (r_s) (Fellows and Liu, 2008). The coefficient (r_s) ranges between –1 and +1. A value of +1 indicates a perfect positive correlation, while a value of –1 indicates a perfect negative correlation. For a positive correlation, if the ranking on one group is increased, the ranking for the other group is also increased. In contrast, for a negative correlation, if the ranking on one group is increased, the ranking for the other group is decreased, and vice versa. If the value of correlation is zero, it means that there is no relationship between the two groups on the variable under study (Kottegoda, 1997). If the Spearman's rank correlation coefficient (r_s) was statistically significant at the 0.05 significance level, the null hypothesis that no significant correlation between the two groups on the rankings can be rejected. It can be concluded that there is significant association between the two groups on the ranking exercise. This statistical technique is considered as appropriate, since a ranking exercise is involved in this questionnaire survey and the analysis approach (i.e. descriptive statistics with the Kendall's Concordance Analysis and Spearman's Rank Correlation Test) is well-established and widely applied in several researches on construction management published in internationally recognised scholarly journals such as Chan et al. (2003), Lu and Yan (2007) and El-Sayegh (2008), and non-parametric tests are considered suitable for the analysis of ordinal data with a Likert scale of measurement.

3.4.5 Mann-Whitney U Test

The next step of data analysis is to measure whether the perceptions between any two of the three respondent groups (i.e. Client group, Contractor group and Consultant group) are statistically different from each other. The Mann-Whitney U Test is a non-parametric test which is applied in hypothesis testing involving two independent variables (Gibbons and Chakraborti, 2003). If the test result is significant (actual p-value < allowable value of 0.05), it means that there is a statistically significant difference between the two sample medians (Sheskin, 2007). It is applied to test if there is any statistically significant difference in median values of the same factor under study between any two respondent groups. Three paired comparisons between respondent groups (client vs contractor, contractor vs consultant and client vs consultant) were undertaken in this study. The same technique was applied by Zhang (2005) to the selection of private sector partners under public-private partnership (PPP) arrangement and by Yu *et al*. (2008) for the comparison of the perceptions on variables of construction project briefing of project managers and architects between Hong Kong and western countries. The Mann-Whitney U Test was employed to test the null hypothesis that "there is no statistically significant difference between the two populations so that they have the same median" (Sheskin, 2007).

Null hypothesis: There is no statistically significant difference between the two populations so that they have the same median.

$H_0 : \ \theta_1 = \theta_2$

Alternative hypothesis: There is a statistically significant difference between the two populations so that they have different medians.

$H_1: \theta_1 \neq \theta_2$

Level of significance (α) for testing these hypotheses is set at 0.05. The results can be interpreted by the Z-values and p-values. When the actual p-value is less than the pre-determined significance level of 0.05, H_0 is rejected and thus it can be concluded that there is a statistically significant difference between the two populations in the test.

3.4.6 Factor Analysis

Factor analysis is used to identify underlying variables or factors which explain the pattern of correlation within a set of observed variables. It is often employed in data reduction by identifying smaller number of factors which explain most of the variables observed in such larger number of variables (Kula, 2009). It is regarded as a statistical technique for aggregating a number of variables into a few underlying factors, dimensions or constructs (Hoxley, 2010). This technique is powerful to reduce and regroup the factors identified from a large number to a smaller and more critical one by factor scores of the responses. This method is applied to extract, reduce and regroup 18 suggested risk mitigation measures listed on the survey questionnaire in ***Chapter 5***. The same statistical technique is adopted to extract the principal risk groups from 17 key risk factors in developing the fuzzy risk assessment model in ***Chapter 6***.

3.4.7 Fuzzy Synthetic Evaluation Method

The application of fuzzy set theory has been gaining popularity in construction management research over the past decade (Chan et al, 2009). Indeed, fuzzy set theory has long been developed and applied since 1965 (Zadeh, 1965). Chan et al. (2009) opined that fuzzy set theory is considered as a branch of modern mathematics to model vagueness intrinsic in human cognitive process. It has been adopted to tackle ill-defined and complex problems due to incomplete and imprecise information which characterise the real world system (Baloi and Price, 2003). Sadiq et al. (2004) was of a similar opinion that fuzzy set theory was an important tool for modelling uncertainty or imprecision due to human perceptions and subjectivity should be accounted for in a rational manner to decision making. In view of the risk assessment of TCC/GMP construction projects involves a number of risk factors and principal risk groups (mentioned in the previous sub-section), it would be desirable to apply the fuzzy synthetic evaluation method to solve this multi-attribute and multi-level problem (Sadiq et al, 2004).

Fuzzy synthetic evaluation, as an application of fuzzy set theory, has been widely used in research in many fields. For example, Lo (1999) applied fuzzy synthetic evaluation method in developing a fire risk assessment system for buildings in Hong Kong. Chang et al. (2001) adopted fuzzy synthetic evaluation method to assess water quality conditions in Taiwan. Based on the previous studies using the fuzzy synthetic evaluation method, it can be observed that this method is suitable in handling complicated evaluation involving multi-attributes and multi-levels. Since the risk assessment of TCC/GMP construction projects are often multi-layered and fuzzy in nature, involving subjective judgments, fuzzy synthetic evaluation is considered as an appropriate tool to develop the risk assessment model in this research.

Table 3.1 illustrates how the proposed research objectives will be achieved through different data collection methods and data analysis tools in this study.

Table 3.1 Achievement of Research Objectives and Data Analysis Tools

Research Objectives	Methods to achieve Data	Analysis techniques
1. To determine the Key Risk Factors (KRFs) inherent with TCC/GMP projects and analyse their importance.	➢ Literature Review ➢ Structured Interviews ➢ Questionnaire Survey	➢ Content analysis for interviews ➢ Descriptive Statistics
2. To solicit and compare the opinions of various project stakeholders on risk assessment of TCC/GMP projects in Hong Kong.	➢ Literature Review ➢ Questionnaire Survey	➢ Cronbach's alpha reliability test ➢ Descriptive Statistics ➢ Kendall's Concordance Test ➢ Spearman's Rank Correlation Test ➢ Mann-Whitney U Test
3. To explore and compare the preferences of various project stakeholders on risk allocation of TCC/GMP projects in Hong Kong.	➢ Literature Review ➢ Questionnaire Survey	➢ Descriptive Statistics
4. To develop and validate an overall risk assessment model for TCC/GMP projects in Hong Kong.	➢ Literature Review ➢ Questionnaire Survey ➢ Structured Interviews for Validation of Model	➢ Descriptive Statistics ➢ Normalisation of Mean Scores ➢ Factor Analysis ➢ Fuzzy Synthetic Evaluation Method
5. To recommend effective guidelines or measures for managing the potential risks associated with TCC/GMP projects.	➢ Literature Review ➢ Questionnaire Survey	➢ Descriptive Statistics ➢ Factor Analysis

3.5 Chapter Summary

To achieve significant research outputs, an appropriate research methodology has to be applied. Preliminary data collection in this study was conducted through a comprehensive literature review. The information was consolidated and the aim of research ‘to develop a reliable risk assessment model for TCC/GMP construction projects in Hong Kong’ has been finalised. Five research objectives were developed to: (1) Determine the Key Risk Factors (KRFs) inherent with TCC/GMP projects and analyse their importance; (2) Solicit and compare the opinions of various project stakeholders on risk assessment of TCC/GMP projects in Hong Kong; (3) explore and compare the preferences of risk allocation of TCC/GMP projects in Hong Kong; (4) Develop and validate an overall risk assessment model for TCC/GMP projects in Hong Kong; and (5) Recommend effective guidelines or measures for managing the potential risks associated with TCC/GMP projects.

A combination of literature review, qualitative and quantitative content analyses, face-to-face interviews with field experts, and empirical questionnaire survey have been adopted to achieve the research aim and objectives. A number of statistical techniques employed in data analysis have also been introduced in this chapter. The research outputs are harvested throughout the study period, including preparation, presentation, and publication of different conference papers, journal articles and this PhD thesis as the major deliverables for dissemination.

4.0

STRUCTURED INTERVIEWS

CHAPTER 4 –STRUCTURED INTERVIEWS

4.1 Introduction

The results of structured interviews are reported in this chapter. A series of seven structured interviews were conducted to solicit the views of industrial experts about the key risk factors, risk allocation and risk mitigation measures of TCC/GMP construction projects in Hong Kong. The opinions of interviewees were also mapped to the four cases they were personally involved in to compile the case studies at the end of this chapter. The interview findings in this chapter have been documented in a journal article (Chan et al., 2010c).

Since the TCC/GMP form of procurement is relatively new within the local construction industry, application and experience are confined to a limited number of leading property developers and major construction companies. Table 4.1 shows those projects applying the TCC/GMP concepts in Hong Kong. Invitation letters were sent to those key project participants with direct hands-on experience in handling at least one TCC/GMP project at a professional grade listed in Table 4.1, followed up by phone calls. A total of seven semi-structured in-depth face-to-face interviews with eight relevant project representatives who played different roles in the four cases were launched from June to July of 2008 to identify the key risk factors, together with the recommended risk mitigation measures for TCC/GMP projects in Hong Kong.

Table 4.1 Selected TCC/GMP Cases for the Research in Hong Kong (Chan et al., 2007a)

	Project Name	Project Nature	TCC/GMP
1.	Chater House	A prestigious rental commercial development in Central	GMP
2.	1063 King's Road	A rental commercial development in Quarry Bay	GMP
3.	Alexandra House Refurbishments	A prestigious rental commercial development in Central	GMP
4.	Tradeport Hong Kong Logistics Centre	A commercial logistics hub for the Asia region at Chek Lap Kok	GMP
5.	Landmark Redevelopment Phase 6 – York House	A rental commercial redevelopment in Central	GMP
6.	The Orchards	A twin tower residential development in Quarry Bay	GMP
7.	Three Pacific Place	A prestigious rental commercial development in Wanchai	GMP
8.	Public Housing Development at Eastern Harbour Crossing Site Phase 4	A public rental housing development in Yau Tong as a pilot study project	Modified GMP
9.	Tseung Kwan O Railway Extension – the sixth operational railway line with 5 stations	13 civil engineering contracts, 4 building services contracts as well as 17 electrical and mechanical contracts	TCC
10.	Tsim Sha Tsui Metro Station Modification Works	Tsim Sha Tsui Metro Station Modification Works	TCC
11.	Tung Chung Cable Car Project	A sightseeing transportation facility including civil and building works	TCC

The details of the interviewees are summarised in Table 4.2. Copies of relevant materials including the project scope of work, contract terms and letters of award on TCC/GMP, in-house guidelines or best practice framework for implementing TCC/GMP scheme, case reports, as well as on-line materials, were obtained as secondary source of evidence to support primary opinions and information gleaned during the interviews. As all of the interviewees were senior construction personnel having direct hands-on experience with at least one TCC/GMP construction project in Hong Kong and at least 15 years experience in the construction industry of Hong Kong, the interview opinions and findings were considered representative and valid for general applications in this type of contractual arrangement.

Table 4.2 Details of 8 Interviewees for 7 Semi-structured Interviews

ID	Sector	Stakeholder	Position of Interviewee	Organisation	Case
1	Private	Contractor 1	Managing Quantity Surveyor	Major construction contractor	Case 3
2	Private	Contractor 2	Assistant General Manager	Major construction contractor	Case 1
3	Qusai-government	Client 1	General Manager – Procurement and Contracts	Qusai-government mass railway service provider	Case 2
4	Private	Client 2	Project Manager	Leading property developer	Case 4
5	Private	Client 3	Senior Project Manager	Leading property developer	Case 3
6	Public	Consultant 1	Architect	Public housing developer	Case 1
7	Private	Consultant 1	Technical Director	Quantity surveying consultant	Case 1
8	Private	Consultant 2	Director	Quantity surveying consultant	Case 4

Notes: Interviewees 6 and 7, who were involved in a public housing project engaging a private quantity surveying consultant, were both interviewed in one single meeting held on 11 June 2008 and their opinions were consolidated as views of "Consultant 1" in this study.

The opinions obtained from the interviews were first audio-recorded and later transcribed into written dialogues. The interview dialogues (see ***Appendix 3***) were later forwarded back to corresponding interviewees for verification via email transmission. A systematic account of information and data obtained from in-depth interviews were archived for subsequent analysis. The interview dialogues were duly analyzed with the concepts of content analysis technique in a matrix table format (i.e. each question posed against answers from each interviewee and the answers were classified into different groupings according to the nature of contents) to capture any similarities and differences for comparisons. Interview dialogues can be classified and reduced into more relevant and manageable bits of data (Weber, 1990). This method can be applied to situations under which the information and understanding of issues relevant to general aims and specific objectives of a research project are obtained (Gillham, 2000). Content analysis can be regarded as a technique of data analysis which is applicable to construction research (Fellows and Liu, 2008). It is often applied to determine the major facets of a set of data, by simply counting the number of times an activity happens or a topic is depicted. The steps of conducting content analysis are: (1) to identify the materials to be analyzed; and (2) to determine the form of content analysis to be employed which includes qualitative or quantitative methods. The choice depends on the nature of the research. The choice of categories depends on the issues to be addressed in the research if they are known. Emphasis is put on determining the meaning of data (i.e. grouping data into categories) in qualitative content analysis. Quantitative content analysis extends the approach of qualitative form to generate numerical values of the categorised data which may be subject to statistical analysis. Comparisons may be made and hierarchies of categories can be examined (Fellows and Liu, 2008). The data collected in the interviews are given coded allocation according to the categories and respondents from whom the data were obtained, so a matrix table of categorised data against the respondents is structured. This technique was applied in investigating the critical success factors in construction project briefing (Yu et al., 2006). Outcomes derived from the analysis of interviews were cross-referenced to the published literature wherever appropriate and to complement each other for validation.

Open-ended questions were asked during the interviews in order to convey ideas of the information solicited, and the interviewees were encouraged to express freely on the issues concerned, without being restrained by the pre-determined questions including:

1. Can you briefly describe the scope of work of a GMP/TCC project in which you were engaged (e.g. project nature, project duration, contract sum, GMP/TCC implementation mechanism, gain-share/pain-share arrangement, etc)?

2. Can you name some important risk factors associated with those TCC/GMP contracts that you had encountered?
3. Can you provide some strategies or guidelines to mitigate the risks involved in TCC/GMP projects?

Both the interview questions and interview dialogues are attached in ***Appendix 1*** and ***Appendix 2*** respectively for reference.

4.2 Interview Findings and Discussions

Table 4.3 summarises the key findings of the interviews on the aforesaid **second and third** research questions pertaining to the perceived key risk factors as well as the suggested risk mitigation measures for those TCC/GMP construction projects, as gleaned from the seven interviews.

Table 4.3 Summary of the Interview Findings on Perceived Key Risk Factors for TCC/GMP Construction Projects in Hong Kong (Chan et al, 2010a)

	Contractor 1	**Contractor 2**	**Client 1**	**Client 2**	**Client 3**	**Consultant 1**	**Consultant 2**	**Total no. of hits**
Contractual Risks								
1. Nature of variations	√	√		√	√		√	**5**
2. Quality and clarity of tender documents	√	√		√	√		√	**5**
3. Change in scope of work		√		√		√		**3**
4. Setting a genuine maximum price or target cost in contract				√				1
Physical Risks								
5. Unforeseen ground conditions	√		√		√	√	√	**5**
6. Inclement weather							√	1
Economic Risks								
7. **Fluctuation of materials price**		√	√			√	√	**4**
8. Market trend in building design							√	1
Design Risks								
9. Approval from regulatory bodies for alternative cost saving designs	√	√				√		**3**
10. Lack of involvement of contractor in issuing variation orders	√							1
Others								
11. Unfamiliarity with TCC/GMP methodology by project team members			√				√	2
12. Selection of competent project team					√	√		2
13. Implication of construction project to surrounding environment			√					1
Total number of key risk factors identified from each interviewee	**5**	**5**	**4**	**4**	**4**	**5**	**7**	

4.2.1 Perceived Key Risk Factors for TCC/GMP Contracts

All of the risk factors, each of which was suggested by 3 or more interviewees, will be discussed in this section (as highlighted in Table 4.3). "Nature of variations" was considered as the most common risk factor inherent with TCC/GMP projects in Hong Kong by the five interviewees. That is, whether an architect/engineer instruction should be classified either as TCC/GMP variation which would trigger an adjustment of the agreed GMP or target cost value in contract or regarded as a design development change. This echoes the commentary made by Chan *et al.* (2007a) and Fan and Greenwood (2004) that the nature of variation can be a main source of disputes in TCC/GMP schemes. Two interviewees (Contractor 1 and Consultant 2) expressed that the changes in building services installation and structural building frame erection were usually classified as design development items which would not alter the TCC/GMP contract value. In other words, if there is no change in client's requirements, the additional cost for this kind of change would be at the main contractor's risk and such changes were deemed to have been covered in the fixed lump-sum price of main contractor's direct works.

The second perceived key contractual risk factor was "quality and clarity of tender documents". The contract document comprising the tender documents is a fundamental vehicle for risk allocation. If errors, omissions or discrepancies occur within the contract document at the outset of the project, they would give rise to a huge number of intractable disputes or conflicts and unnecessary contract variations during the post-contract stage. One contractor interviewee reported that his company had to cover the risk of inaccuracy of firm quantities in the Bills of Quantities of his project, for which his company finally incurred a loss. Yew (2008) shares a similar perception that contractors are bound to take all of the risks under TCC/GMP contracts, including errors and omissions in tender documents in Singapore. Recent case studies by Laryea (2011) also indicated that a lack of clarity is identified as a main source of claims and disputes during the construction stage. It was also found that the quality of tender documents is perceived to have dropped in the past 15 to 20 years and this has caused significant problems to tenderers.

The third significant contractual risk reported by the interviewees is "change in scope of work". Disputes may arise due to changes in the scope of work (Tang and

Lam, 2003). Three interviewees emphasised that when the standard specifications of the architect and/or client organisation change, the quality standard of TCC/GMP projects under the umbrella of the client organisation will also change accordingly. Since unexpected changes in scope of work may induce several TCC/GMP variations (Fan and Greenwood, 2004), it would prolong the overall development programme as well as incur significant cost escalations to the project. Besides, the extent of design development changes would also be difficult to define. Improper handling on these issues may certainly provoke adversarial disputes and thus diminish the mutual trust and partnering relationship developed within the project team (Sadler, 2004).

As noted from Table 4.3, five out of the seven interviewees perceived that "unforeseen ground conditions" was a key physical risk factor associated with the TCC/GMP procurement approach. The underground conditions would affect the progress of foundation works and hence the progress of the whole construction project (Fung, 2008). In addition, this finding is consistent with that reported by Shen (1997) suggesting that unexpected ground conditions were a key risk contributing to project delay in Hong Kong. The main contractor would be liable to liquidated damages if the project could not be completed on or before the date for completion as stipulated in the contract due to difficult ground conditions, provided that the extension of time granted could not cover the delay. The main contractor would also probably bear the cost consequence in many cases.

As for economic risks, according to four interviewees, "fluctuation in materials price" was regarded as one of the key risk factors encountered in adopting the

TCC/GMP form of procurement. For example, the cost of steel reinforcement bars rose from HK$6.50/kg to HK$10.50/kg, accounting for a 62% increase within a period of one year (Rider Levett Bucknall, 2008). It is a common practice of the Hong Kong construction industry to insert the Special Conditions of Contract to delete the fluctuation clause in the General Conditions of Contract in the private sector (i.e. the fluctuation of material prices is at contractor's risk). One representative from the contractor side commented that his company suffered a loss due to the sharp increase in material prices in 2008, even though a fluctuation clause was applicable to his project, which was a public housing development. It is logical to deduce that the contractors engaged in the private sector building projects who had committed themselves to fixed price contracts also suffered losses of this nature.

"Approval from regulatory bodies for alternative cost saving designs" was considered as a key design risk factor. Three interviewees opined that when the main contractor comes up with an alternative proposal, he has to submit its design proposal to regulatory bodies for verification and approval. If the contractor is not familiar with the practice and operation of those regulatory bodies, this certainly increases the difficulty in obtaining design approval from the relevant statutory units. The delay of this approval process would affect the overall progress of the project. Moreover, if the proposal is rejected, the time and cost implications would be solely borne by the contractor.

Table 4.4 Summary of the Interview Findings on Risk Mitigation Measures for TCC/GMP Construction Projects in Hong Kong (Chan et al, 2010a)

	Contractor 1	**Contractor 2**	**Client 1**	**Client 2**	**Client 3**	**Consultant 1**	**Consultant 2**	**Total no. of hits**
Tendering Process								
1. Conduct more thorough site investigations	√	√	√					**3**
2. More upfront work of tender documentations				√			√	**2**
3. Tender briefing and tender interview					√		√	**2**
4. Pre-qualification of main contractors					√	√		**2**
5. Use of Named Subcontractor rather than nominated subcontractors					√			1
Design Management								
6. More communication between the architect and main contractor before issuing variation orders	√							1
7. Application of value engineering			√					1
8. Design review workshops		√						1
9. Setting up contingency plans		√						1
10. Monitoring system set up by main contractor			√					1
Relationship between client and contractor								
11. Adoption of partnering approach		√	√		√		√	**4**
12. Support from top management to project team	√							1
13. Adjudication committee to resolve disputes				√				1
Total number of risk mitigation measures suggested by each interviewee	**3**	**4**	**4**	**2**	**4**	**1**	**3**	

4.2.2 Risk Mitigation Measures for TCC/GMP Contracts

Apart from the key risk factors involved in implementing the TCC/GMP contractual arrangement, the interviewees also suggested a plethora of risk mitigation measures to minimise the above-mentioned risks which are consolidated in Table 4.4. Only those risk mitigation measures which were advocated by at least two interviewees are highlighted for further discussion under this section.

The first risk mitigation measure related to tendering process as proposed by the interviewees was conducting more thorough site investigations during the tender stage. Contractor 1 advocated that more thorough site investigations should be conducted by the main contractor at the tender stage to better understand the soil conditions. Contractor 2 shared a similar view and expressed that the information about ground conditions in tender documents was only provided in good faith (i.e. the accuracy was not guaranteed). Moreover, Client 1 also recommended undertaking more detailed site investigations, as well as mitigating the risk of "unforeseen ground conditions" inherent with TCC/GMP projects. The cost of launching comprehensive site investigations is minimal to the total project sum (Chan and Yeong, 1995). However, clients in general do not allocate adequate resources in performing such investigations. In fact, more in-depth understanding about the underground conditions would help the contractor price a reasonable allowance for such risk within his tender sum and hence eliminate a source of potential disputes at the post-contract stage.

Placing more emphasis on upfront work in tender documentations was proposed by both Client 2 and Consultant 2. They both concurred that more concerted efforts should be devoted to the upfront work of tender documentations and Consultant 2 suggested using historical statistical data from past reference projects, to ascertain the initial GMP value. A clearly drafted contract can definitely minimise the number of disputes during the post-contract stage. The GMP is neither really guaranteed nor maximum. At the tender stage, it is important for the client/consultants to review draft tender documents to appreciate the specific risks involved and a properly drafted set of tender documents is essential to the success of TCC/GMP contracts (DLS, 2004).

In addition, “tender briefing and tender interview” was perceived as a risk mitigation measure for TCC/GMP projects by two interviewees. It is believed that the tender briefings could be arranged before inviting tenders to enable interested contractors to gain a basic understanding of the special features and contractual requirements of the project such as the methodology of TCC/GMP contractual arrangement. The tender briefing should be comprehensive, transparent and fair to all of the potential bidders. Tender interviews can enable the tenderers to really understand and recognise the potential risks involved in the project before contract award. This recommendation is consistent with the propositions by Yew (2008) as well as those of Chan and Yeong (1995).

Besides, pre-qualification of main contractors may be an effective means to mitigate the risks inherent in projects procured with the TCC/GMP arrangement. The capability of a contractor to succeed in a project depends on many inherent attributes such as project complexity, technical expertise and risk management competency. A robust pre-qualification process for selecting the right contractor is a very important step towards project success (Arslan et al, 2008). The purpose of pre-qualification is to shortlist suitable tenderers who have a clear understanding about the scope of work and are capable to undertake the potential risks associated with the construction project. The assessment criteria for a pre-qualification exercise include but are not limited to financial stability, current workload, past track record of similar projects and the like (ETWB, 2005). Selection of the right project team appears to be a critical success factor for TCC/GMP projects in Hong Kong (Chan *et al*, 2004). Client needs to constitute a project team which is receptive to innovative ideas. The commitment and capability of the contractor are particularly important. The main contractor has to be proactive and willing to communicate with other project participants based on the partnering concepts.

As regards the relationship between client and contractor, four out of the seven interviewees pointed out that the adoption of a partnering approach which facilitates developing harmonious working relationship, building up mutual trust and achieving common goals (Chan et al., 2004) could be an effective risk mitigation measure for this kind of project. The TCC/GMP style of procurement in conjunction with the partnering spirit would promote deeper collaboration between the client and the main contractor. Regular partnering review meetings and the adjudication committee operating under the TCC/GMP umbrella would establish a solid platform to discuss any difficulties encountered and resolve any confrontational issues. This finding is in line with that in the study by Chan *et al.* (2008), advocating that the implementation of partnering concepts together with target cost contracts can improve overall project performance by resolving unnecessary conflicts and intractable arguments.

4.2.3 Mapping of Interview Findings to Case Studies

As stated in the earlier sections in this Chapter, the interviewees were selected from four local TCC/GMP cases. Their views are mapped to background information of the cases to provide an overall picture of those selected cases. Based on the perceptions of the various target project participants obtained from the structured interviews, a mapping summary of the major interview findings to those case study projects is considered to be useful and necessary to assess the whole implementation process by which project participants make TCC/GMP work.

Table 4.5 Mapping Summary of Major Interview Findings to Case Study Projects

	Case 1 (Public Housing Development with Modified GMP approach)	**Case 2 (Underground Railway Station Modification Works with TCC)**	**Case 3 (Private Commercial Development with GMP)**	**Case 4 (Private Office Development with GMP)**
Project nature	Public rental domestic building project including the construction of: (1) three 41-storey Non-standard Domestic Blocks providing total 2,369 flats including foundations; (2) a lift tower and footbridge connected to Yau Tong Estate; (3) one Neighbourhood Elderly Centre; (4) an at grade bus stop; (5) a double-deck walkway connected to EHC Phase 3; (6) site formation and retaining walls; (7) a drainage reserve; and (8) external works	Railway station modification works involving connection of the pedestrian subway links in Tsim Sha Tsui, Kowloon	Grade A private office development project with GMP contractual arrangement including the construction of a 34-storey high office tower for a typical floor gross floor area of about 1,700 m^2, a 3-level podium, three basement car parking floors, and an underground pedestrian tunnel link.	A 29-storey high commercial building in the hub of Central District in Hong Kong, accommodating high-end retail areas on lower floors with Grade A standard. This project consisted of a 3-storey basement, a 3-storey podium and a 23-storey commercial tower.
Contract Sum	Around HK$435 million	Around HK$300 million	Around HK$1.0 – 1.1 billion	Around HK$1.2 billion
Contracting approach	Modified GMP with two-stage tendering process	Target Cost Contracting with two-stage tendering process	GMP with two-stage tendering process	Negotiated GMP
Gain-share arrangement	Client : Contractor = 50 : 50	Client : Contractor = 50 : 50	Client : Contractor = 50 : 50	Client : Contractor = 60 : 40
Pain-share arrangement	Nil	Client : Contractor = 50 : 50	Nil	Nil

Key risk factors	▪ Approval from regulatory bodies for alternative cost saving designs ▪ Nature of variations ▪ Quality and clarity of tender documents ▪ Selection of a competent main contractor ▪ Fluctuation in price of materials	▪ Unforeseen ground conditions ▪ Impact of construction process on surrounding environment ▪ Unfamiliarity with methodology of TCC	▪ Nature of variations ▪ Unforeseen ground conditions ▪ Quality and clarity of tender documents ▪ Selection of competent project team	▪ Quality of tender documents ▪ Nature of variations ▪ Market trend in building design ▪ Unfamiliarity with methodology of GMP
Risk mitigation measures	▪ Pre-qualification of main contractor ▪ Tender briefing and tender interviews ▪ Adoption of partnering approach	▪ More thorough site investigations ▪ An effective monitoring system set up by main contractor ▪ Adoption of partnering approach ▪ Application of Value engineering	▪ More thorough site investigations ▪ Adoption of partnering approach ▪ Tender briefings and tender interviews ▪ Use of named subcontractor system	▪ Adjudication committee to resolve disputes ▪ Tender briefings and tender interviews
Time performance	Within planned timeframe	Completed 7 months ahead schedule	Completed with delay	Completed 6 days ahead schedule
Cost performance	Completed with around 1% of cost saving	Completed with 5% cost saving	Main contractor made a loss	Saving of 15% of the original budget

4.3 Chapter Summary

This chapter has reported on the key risk factors and risk mitigation measures as perceived by the interviewees, contributing to the development of effective risk management strategies for TCC/GMP construction projects in Hong Kong. It is found that a number of key risk factors are related to design variations. The suggested risk mitigation measures are pertaining to the tendering process and applying partnering concepts to improve the working relationship between client and contractor. The interview findings are particularly valuable in identifying the key risk factors and risk mitigation measures for TCC/GMP schemes. They also form a solid foundation in developing an empirical survey form, together with the comprehensive literature review as reported in Chapter 2. The findings of an empirical questionnaire survey launched in Hong Kong on risk identification and assessment, preference of risk allocation and effectiveness of risk mitigation measures will be reported and discussed in the next chapter.

5.0 QUESTIONNAIRE SURVEY

CHAPTER 5 – QUESTIONNAIRE SURVEY

5.1 Introduction

An empirical questionnaire survey was launched to solicit the views of industrial practitioners on the risk identification and assessment, risk allocation as well as risk mitigation measures of TCC/GMP construction projects in Hong Kong between March and June of 2009. The questionnaire design and survey findings are reported and discussed in this chapter.

5.2 Development of Empirical Survey Questionnaire

5.2.1 Literature Review

A pilot questionnaire survey was designed to explore the key risk factors encountered with TCC/GMP construction projects. The pilot questionnaire was developed based on the risk factors documented in previous research studies by Bernhard (1988), Ahmed et al. (1998), Al-Subhi Al-Harbi Kamal (1998), Ahmed et al. (1999), Broome and Perry (2002), Haley and Shaw (2002), Rahman and Kumaraswamy (2002), Cheng (2004), Fan and Greenwood (2004), Oztas and Okmen (2004), Sadler (2004), Environment, Transport and Works Bureau (2005), Li et al. (2005), Tang (2005), Hong Kong Housing Authority (2006), Shen et al. (2006), Ng and Loosemore (2007), Chan et al. (2007a), Chan et al. (2007b), Yew (2008), together with seven structured interviews with experienced industrial practitioners with abundant hands-on practical experience in those TCC/GMP procurement approaches (Chan et al., 2010b) *(refer to Chapter 2)*. The interviewees suggested that the nature of variations, change in scope of work, quality and clarity of tender documents, unforeseen ground conditions, fluctuation of materials price, and approval from regulatory bodies for alternative cost saving designs were the key risk factors associated with TCC/GMP contracts in Hong Kong (Chan et al., 2010b). The results of pilot survey enabled the development and fine-tuning of the empirical research questionnaire. For example, "Market risk due to the mismatch of prevailing demand of real estate" and "Difficult to obtain statutory approval for alternative cost saving designs" were added in Part B of the questionnaire, in order to reflect more potential risk factors inherent with TCC/GMP construction projects in Hong Kong. The purpose of the questionnaire survey is to solicit the opinions of industrial practitioners on the risk assessment, preference of risk allocation and effectiveness of risk mitigation measures of TCC/GMP construction projects which are not available from current literature base.

5.2.2 Pilot Questionnaire Survey

As Naoum (1998) pointed out, one of the limitations of adopting questionnaire surveys in research is that this technique is inflexible in the sense that it does not allow opportunities for probing. In order to minimise this limitation, a pilot questionnaire survey was launched to ensure the clarity and comprehensiveness of the key risk factors for TCC/GMP contracts to be included in the subsequent empirical questionnaire survey. The survey form was developed based on the findings of those interviews reported in ***Chapter 4*** and the results of extensive literature review. A total of five experts with abundant direct hands-on experience in

TCC/GMP construction projects in Hong Kong participated in the pilot survey to comment on the clarity of the instructions, meanings of various major risk factors identified, as well as the adequacy of key risk factors included on the survey form. There were ultimately no adverse comments from them after interview.

The major risk factors sought from the interviews are discussed in this section. "Nature of variations" was considered to be the most common risk factor inherent with TCC/GMP contracts in Hong Kong. That is, whether an architect/engineer instruction should be classified either as a TCC/GMP variation which would trigger an adjustment to the agreed GMP value (or target cost value) in contract or as a design development change, for which the contractor has to absorb the cost impact. This finding echoes the comments made by both Chan et al. (2007a) and Fan and Greenwood (2004) that the nature of variation can be a main source of disputes arising from TCC/GMP schemes.

The second key risk factor as perceived by the interviewees was "Quality and clarity of tender documents". The contract conditions comprising the tender documents and post tender correspondence is a fundamental tool for risk allocation. If there exists errors, omissions or discrepancies within the contract document at the outset of the project, they would give rise to a huge number of intractable disputes or conflicts and unnecessary contract variations during the post-contract stage. Yew (2008) shared a similar perception that contractors are bound to take all of the risks under TCC/GMP contracts, including errors and omissions in tender documents in Singapore.

The third significant contractual risk reported is "Change in scope of work". Disputes may arise due to the changes in the scope of work (Tang and Lam, 2003). Since unexpected change in scope of work due to changing user's requirements may generate a considerable number of TCC/GMP variations (Fan and Greenwood, 2004), it would prolong the overall development programme as well as incur significant cost escalations to the project. Besides, the extent of design development changes would also be difficult to define. Improper handling of these issues may provoke adversarial disputes and thus diminish the mutual trust and partnering relationship developed within the project team (Sadler, 2004).

"Unforeseen ground conditions" was discerned as a key physical risk factor associated with the TCC/GMP procurement approach. This finding is similar to that reported by Shen (1997), who suggested that unexpected ground conditions constitute a key risk factor leading to project delay in Hong Kong.

As for economic risks, "Fluctuation in materials price" was regarded as one of the key risk factors encountered in adopting TCC/GMP form of procurement. It is a common practice of the Hong Kong construction industry to insert the Special Conditions of Contract to delete the standard fluctuation clause in the General Conditions of Contract in the private sector (i.e. the fluctuation of materials prices is at contractor's risk). One representative from the contractor side commented that his company suffered a loss due to the sharp increase in material prices in 2008, even though a fluctuation clause was applicable to his project which was a public housing development. It is logical to deduce that the contractors engaged in the private sector building projects, who had committed themselves to fixed price contracts, also suffered losses of this nature.

"Approval from regulatory bodies for alternative cost saving designs" was considered as a key design risk factor. When the main contractor comes up with an alternative proposal involving structure, sanitation, environmental or fire safety aspects, he has to submit its design proposal to regulatory bodies for verification and approval. If the contractor is not familiar with the practice and operation of those regulatory bodies, this would almost certainly increase the difficulty in obtaining design approval from the relevant unit. Such delay of this approval process would discourage the main contractor from contributing his expertise by proposing alternative designs and hence hinder the benefits of using TCC or GMP contractual arrangement (Chan et al., 2010c).

5.2.3 Empirical Questionnaire Survey

The survey form (see ***Appendix 5***) consisted of four parts. The first part was about respondents' professional profiles. The second part focused on the perceived level of severity and likelihood of occurrence of the 34 listed risk factors in relation to TCC/GMP construction projects with a five-point Likert scale where 1 denoted "very low" and 5 denoted "very high" for severity and a seven-point Likert scale where 1 denoted "very very low" and 7 denoted "very very high" for likelihood as suggested by Tah and Carr (2000) proposing a project risk assessment model based on fuzzy logic methodology in their earlier study about risk assessment of construction projects. It is found that various scales of assessment are used in risk management literature in construction management discipline. Wyk et al. (2008) reported on a 10 x 10 risk assessment tool (i.e. a ten-point Likert scale is used in assessing the risk severity and risk likelihood) in their case study on risk management practice of an electricity company in South Africa. Roumboutsos and Anagnostopoulos (2008) applied a 5 x 5 assessment scale in their questionnaire survey about the perceptions on the risk severity and likelihood for risks in private-public partnership in Greece. Zou et al. (2007) employed a 3 x 3 assessment tool for assessing the key risks in construction projects in China. There appears to be no absolute norm for setting the scale of risk assessment for questionnaire surveys. Considering the similar nature of this research with that of Tah and Carr (2000)'s study, their suggested scale was adopted in this research.

The respondents were also requested to choose the party best capable to manage each of the key risks elicited. The third part was related to some recommended risk mitigation measures for TCC/GMP construction projects. The fourth part was optional and the respondents were welcome to express their professional preference on future application of TCC or GMP contractual arrangement with their supporting reasons. However, only the survey findings regarding the risk assessment of the 34 key risk factors (including severity and likelihood) are reported and discussed in this study. Respondents were also requested to list out and score any other unmentioned risks derived from their professional experience but no new items were obtained from them. It should be stressed that even though the pilot questionnaire survey indicated no adverse comments received from the respondents as described in the previous sub-section, there is still possible for the respondents in the sampled empirical questionnaire survey to cast doubts about the instructions and/or the meanings of the risk factors listed on the survey form. In view of this potential drawback of using the survey methodology, the contact details (including both the telephone number and email address) of the researcher were provided on the survey form. The respondents were most welcome to raise any queries to the researcher in case of any doubts about the instructions/meanings of any parts of the survey form. However, no query was received from those target survey respondents. This is indicated that the respondents were very clear about the contents of the survey form including the meaning of each risk factor.

A total of 300 self-administered blank survey forms were distributed to construction professionals associated with the Hong Kong construction industry. The target survey respondents were first identified from previous research studies in TCC/GMP in Hong Kong undertaken by the authors (Chan et al., 2007a). A snowball sampling technique was employed in this study due to the limited number of TCC/GMP projects completed in Hong Kong. As the name of snowball sampling implies, sample elements are identified by convenience and through referral networks (Sambasivan and Soon, 2007). Salganik and Heckathorn (2004) shared similar view and they opined that snowball sampling is a non-probability method used when the desired samples are rare. Vogt (1999) considered the snowball sampling technique as a sampling method in which one subject gives the researcher the name of another subject, who in turn provides the name of the third one and so on. Thus, snowball sampling relies primarily on referrals from initial subjects to generate subsequent additional subjects. The same sampling technique was applied in previous research on construction management such as Ling and Gui (2009), El-Tayeh (2007) and Fong and Lung (2007).

Using snowball sampling technique would take the advantage of trusted relationships among the respondents in order to gain the number of respondents (Sheu et al., 2008). This sampling method was considered suitable for this study due to the fact that there were not many construction projects procured by TCC/GMP in Hong Kong (Chan et al., 2007a), and hence the number of industrial practitioners with hands-on experience and/or basic understanding about such procurement approaches was also limited. According to Tashakkori and Teddlie (2003), snowball sampling involves using informants which would be useful in the study. Hendricks and Blanken (1992) had similar perception that in attempting to study special population for whom adequate lists and consequently sampling frames are not available, then snowball sampling technique would provide practical advantage in obtaining information in need for the study. Respondents are selected by using the expert judgment of the researcher or some available resources identified by the researcher and through enquiries with practicing professionals in both public and private sectors. With the snowball sampling technique, the researcher is likely to glean the genuine opinions of the target population. Questionnaires were dispatched to those representatives from the clients, main contractors and consultants engaged in those TCC/GMP construction projects between March and April of 2009 via postal mail. And they were requested to pass the questionnaires to their in-house project team members with direct hands-on experience in TCC/GMP projects concerned and colleagues with basic understanding of TCC/GMP operational mechanism to fill in the questionnaires. This is verifiable by checking the experience levels as stated by the respondents in the replies. As most of the key active players in adopting TCC/GMP had been included in the questionnaire survey, it was considered that their opinions and perceptions could substantially represent the TCC/GMP project pool in Hong Kong over the past decade of 1998-2007. Hence, the chosen sample was regarded as truly representative of the survey population given the relatively small number of construction projects procured with the TCC/GMP approach in Hong Kong (about 20 as cited by Chan et al., 2007a). The similar snowball sampling technique was also applied in the field of construction management research by Lu and Yan (2007) to study the benefits of construction partnering in Mainland China where partnering was not popular at that time.

5.3 Results of Questionnaire Survey on Risk Assessment in Hong Kong

5.3.1 Profile of Respondents

The findings in this section (Section 5.3) have been documented in a published journal article (Chan et al., 2011e). A total of 141 duly completed survey forms were returned in June of 2009, representing a response rate of 47%. Among these 141 responses, 47 respondents declared that they had "No hands-on experience in procuring TCC/GMP construction projects" and they were advised not to complete the survey forms and just returned the forms for record. The remaining 94 respondents either had acquired hands-on experience in procuring TCC/GMP projects or they declared to have basic understanding of the underlying principles of TCC/GMP schemes via conferences, seminars, workshops, journals and internal sharing from their counterparts even though without the direct exposure to TCC/GMP contracts before.

Therefore, only the data and perceptions obtained from these 94 responses were used for further data analysis. Although only 94 samples were collected, the number of samples was considered adequate and representative when compared with other similar studies on risk management in construction. For example, 35 responses were obtained in Kartam and Kartam (2001)'s questionnaire survey on risk management in the Kuwaiti construction industry; 92 survey responses were collected by Rahman and Kumaraswamy (2005) on joint risk management in Hong Kong and 70 responses were collected in El-Sayegh (2008)'s research on risk assessment and risk allocation in the construction industry of the United Arab Emirates. In addition, Table 5.1 shows that the target survey respondents covered all the known TCC and GMP construction projects completed up to 2007 and hence the results of this study are regarded as sufficient, valid and representative of the whole project population concerned.

Table 5.1. Selected TCC/GMP cases for the research in Hong Kong
(Adapted from Chan *et al.*, 2007b)

	Project Name	**Project Nature**	**TCC/GMP**	**Covered in this study?**
1.	Chater House	A prestigious rental commercial development in Central	GMP	Yes
2.	1063 King's Road	A rental commercial development in Quarry Bay	GMP	Yes
3.	Alexandra House Refurbishments	A prestigious rental commercial development in Central	GMP	Yes
4.	Tradeport Hong Kong Logistics Centre	A commercial logistics hub for the Asia region at Chek Lap Kok	GMP	Yes
5.	York House	A rental commercial redevelopment in Central	GMP	Yes
6.	The Orchards	A twin tower residential development in Quarry Bay	GMP	Yes
7.	One Island East	A 70-storey Grade A Office Tower	GMP	Yes
8.	Three Pacific Place	A prestigious rental commercial development in Wanchai	GMP	Yes
9.	Australian International School	A private educational building	GMP	Yes
10.	Tseung Kwan O Technology Park	A private technology park	GMP	Yes
11.	Hong Kong Park	A public recreational park	GMP	Yes
12.	Public Housing Development at Eastern Harbour Crossing Site Phase 4	A public rental housing development in Yau Tong as a pilot study project	Modified GMP	Yes
13.	DHL Asia Hub	A private express cargo sortation and delivery	GMP	Yes

		terminal building		
14.	Tseung Kwan O Railway Extension	13 civil engineering contracts, 4 building services contracts as well as 17 electrical and mechanical contracts	TCC	Yes
15.	Tsim Sha Tsui Metro Station Modification Works	Tsim Sha Tsui Metro Station Modification Works	TCC	Yes
16.	Tung Chung Cable Car Project	A sightseeing transportation facility including civil and building works	TCC	Yes

In view of the possible disparities in perceptions among survey respondents with different roles, they were divided into three major groups for further data analysis according to their roles involved in the projects (i.e. client group, contractor group and consultant group). Table 5.2 summarises the personal profiles of survey respondents.

Table 5.2. Personal Profiles of Survey Respondents

Category	Respondents	
	Frequency	%
Role in Project		
Client Organisation	33	35.1
Main Contractor	22	23.4
Architectural Consultant	2	2.1
Engineering Consultant	3	3.2
Quantity Surveying Consultant	19	20.2
Project Management Consultant	2	2.1
Subcontractor	2	2.1
Academic	9	9.6
Others	2	2.1
TOTAL	94	100
Grouping by Role in Project		
Client	33	35.1
Contractor	27	28.7
Consultant	34	36.2
TOTAL	94	100
Experience Level		
Below 5 years	17	18.1
5-10 years	11	11.7
11-15 years	11	11.7
16-20 years	12	12.8
Over 20 years	43	45.7
TOTAL	94	100

Some of the survey respondents (39 out of a total of 94) have obtained basic understanding of the underlying principles of TCC/GMP scheme (but did not have direct hands-on experience in TCC/GMP projects) and they were classified as the informed group. Experienced group were those who have participated in TCC/GMP projects before.

Independent two-sample t-test was applied to test the agreement on the risk assessment of each listed risk factor between the experienced group and informed group as adopted by Ke et al. (2010). The result of the statistical test indicated that there are no statistically significant differences on the risk assessment of each of the risk factors of TCC/GMP projects between the experienced group and informed group. It was concluded that the two sets of opinion data can be lumped together for further analysis and the survey findings are regarded as being consistent, reliable and representative.

5.3.2 Approach of Data Analysis

Tam *et al*. (2007) launched a survey on quality risks in the foundation works of public housing projects with construction professionals in Hong Kong and classified them into three groups : architect, engineer and surveyor. The concordance of mean values of risk impact between the three groups was tested with F-test. However, no two-group comparison was drawn in the study. El-Sayegh (2008) investigated the risk assessment and allocation within the UAE construction industry using the relative importance index and Spearman's rank correlation test as tools of data analysis and no analysis was conducted to identify the particular items which account for significant differences in perceptions between groups of respondents. A similar approach was applied in a study by Shen *et al*. (2001) about risk assessment for construction joint ventures in Mainland China. The current study is an attempt to take a further step in research on risk assessment and a five-level data analysis approach was adopted (illustrated in Figure 5.1). At the first level, the reliability of the measurement scale is tested with the Cronbach's alpha reliability test. The purpose of this statistical test is to make sure that the scale of measurement behaves the same as administered by different respondents. At the second level, the individual risk factors are ranked in descending order of the mean scores on the perceived risk impact to identify the important risk factors. This shows an overall picture of the perceptions of respondents. At the third level, the agreement of respondents' perceptions within a particular group is checked by the Kendall's concordance analysis. At the fourth level, the association on the rankings of risk factors between any two groups is verified using the Spearman's rank correlation test. At the fifth level, the Mann-Whitney U Test is applied to enable two-group comparisons to identify if there is any individual risk factor on which different perceptions between any two groups of respondents are tested.

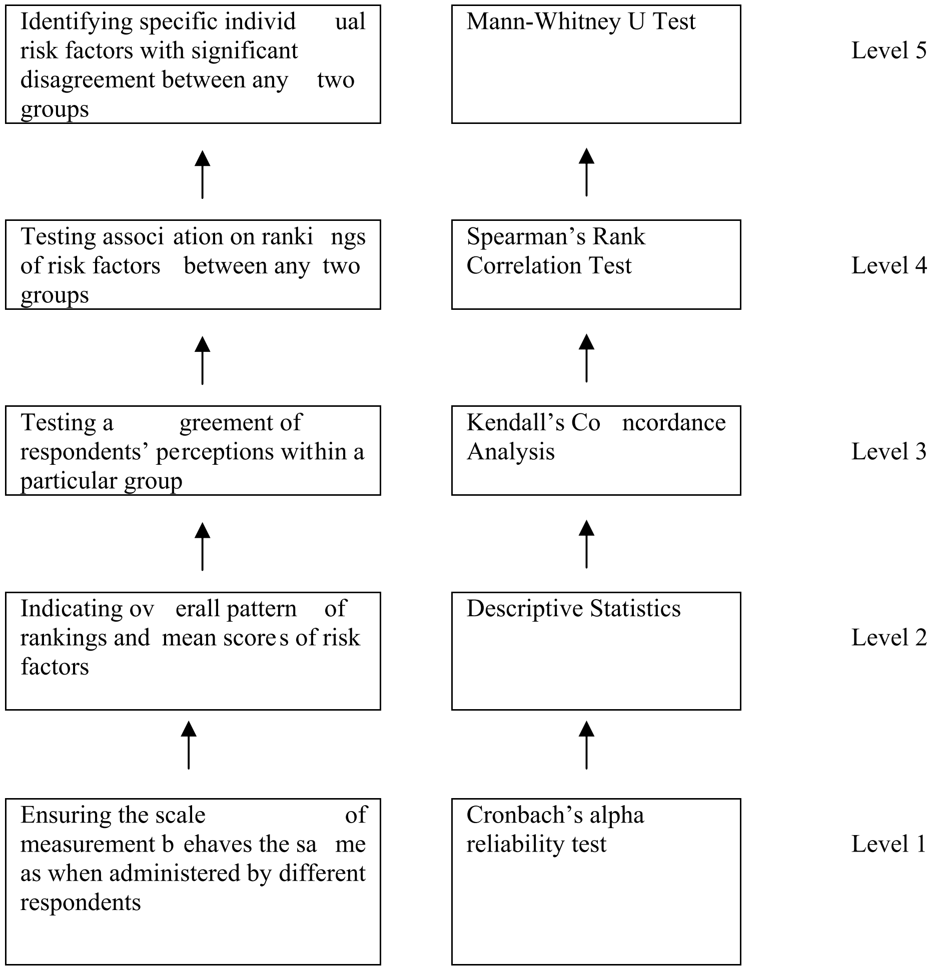


Figure 5.1 Five-level Data Analysis Framework (adapted from Chan et al., 2011e)

5.4 Research Findings and Discussion

It is generally accepted that the impact of a risk is calculated by the product of its level of severity and likelihood of occurrence (Cox and Townsend, 1998; Bunni, 2003; Garlick, 2007). Shen *et al.* (2001) applied a similar approach to the calculation of the significance scores for the 58 risks encountered with joint ventures in Mainland China. Zou *et al.* (2007) used this approach for the computation of the significance index scores for risk factors inherent with construction projects in Mainland China. Roumboutsos and Anagnostopoulos (2008) adopted the same method to assess the risks associated with public-private partnership schemes in their survey for construction sector, public sector and financial sector in Greece. The same method of analysis was adopted in this paper. Risks are assessed based on the mean values of their impacts (i.e. the product of severity and likelihood).

5.4.1 Results of Cronbach's Alpha Reliability Test

The first step of the data analysis is to adopt the Cronbach's alpha reliability test to examine the internal consistency of responses under the constructs of severity and likelihood of the 34 risk factors in the survey. The value of Cronbach's alpha for the impact (i.e. product of severity and likelihood) of all respondents is 0.946 (F-statistics = 5.681, p = 0.000) which is well above the threshold of 0.50 recommended by Yip and Poon (2009) and Lu and Yan (2007) for general attitude or perception assessment similar to this study. It can be concluded that the scale used for measuring the impact of the risk factors is reliable at 5% significance level.

5.4.2 Overall Rankings of Risk Factors of TCC/GMP in Hong Kong

Table 5.3. Impacts of Risk Factors Encountered with TCC/GMP Schemes by all Respondents

ID	Risk Factor	Mean	Standard Deviation	Rank
5	**Change in scope of work**	**16.41**	8.26	**1**
17	**Insufficient design completion during tender invitation**	**15.46**	7.38	**2**
20	**Unforeseeable design development risks at tender stage**	**14.54**	7.20	**3**
6	**Errors and omissions in tender document**	**14.51**	7.52	**4**
21	**Exchange rate variations**	**14.49**	7.39	**5**
29	**Unforeseeable ground conditions**	**14.25**	7.68	**6**
1	**Actual quantities of work required far exceeding estimate**	**13.97**	8.09	**7**
32	**Lack of experience of contracting parties throughout TCC/GMP process**	**13.91**	7.74	**8**
22	**Inflation beyond expectation**	**13.81**	7.04	**9**
3	**Unrealistic maximum price or target cost agreed in the contract**	**13.76**	7.95	**10**
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor	13.51	7.42	11
7	Difficult for main contractor to have back-to-back	13.31	8.53	12

	TCC/GMP contract terms with nominated or domestic subcontractors			
26	Global financial crisis	13.19	8.19	13
18	Poor buildability / constructability of project design	13.11	6.56	14
2	Delay in resolving contractual disputes	13.11	7.21	15
9	Loss incurred by main contractor due to unclear scope of work	13.07	7.24	16
16	Delay in work due to third party	12.64	5.89	17
28	Inclement weather	12.43	7.37	18
8	Inaccurate topographical data at tender stage	12.40	7.25	19
19	Little involvement of main contractor in design development process	12.36	7.66	20
15	Selection of subcontractors with unsatisfactory performance	12.17	6.43	21
31	Difficult to obtain statutory approval for alternative cost saving designs	12.16	6.43	22
33	Impact of construction project on surrounding environment	12.15	7.43	23
12	Poor quality of work	12.07	7.53	24
11	Technical complexity and design innovations requiring new construction methods and materials from main contractor	11.92	7.22	25
23	Market risk due to the mismatch of prevailing demand of real estate	11.86	6.98	26
24	Change in interest rate on main contractor's working capital	11.33	6.87	27
34	Environmental hazards of constructed facilities towards the community	11.17	6.97	28
13	Delay in availability of labour, materials and equipment	11.03	6.10	29
25	Delayed payment on contracts	10.81	6.82	30
30	Change in relevant government regulations	10.80	6.48	31
10	Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage	10.72	6.57	32
14	Low productivity of labour and equipment	10.09	5.68	33
27	Force Majeure (Acts of God)	8.66	6.74	34

Based on the survey results, the risk factors were ranked in the descending order of mean scores for their perceived impact in Table 5.3 with the top 10 most important risks in bold font. It is indicated from Table 5.3 that "change in scope of work" was perceived as the most significant risk amongst the 34 risks identified on the survey form. This finding is in line with a study by Septelka and Goldblatt (2005) which investigated change order data on 46 school and non-school projects with GMP arrangement in the United States, suggesting that change in scope of work accounted for more than half (52%) of change cost in those projects. Another research launched by Cox *et al*. (1999) in the United Kingdom revealed that change in employers' requirements was one of the most frequently cited reasons for design changes in their cases explored.

"Insufficient design completion during tender invitation" was considered to be the second most significant risk associated with TCC/GMP schemes. Due to the very tight schedule of project development, the design is immature during tender invitation in many projects within the local construction industry. It is inevitable for the architect/engineer to issue variation orders at the post- contract stage. It may be controversial to decide whether a variation is evaluated as a change in scope of work or a design development which does not alter the pre-determined target cost or GMP value (Haley and Shaw, 2002). Yew (2008) held a similar view that disputes may arise at the post-contract stage as to whether the refinement and development of the project design which amounts to an enhancement of the original design intent or a change in employer's requirements constituting a variation and a change in GMP.

As may be observed in the same table, "Unforeseeable design development risks at tender stage" was viewed as the third most important risk factor encountered with TCC/GMP contracts. The contractor has to abide by the contract sum to develop the partially completed design at tender stage. In other words, the contractor has to abide by a fixed contract sum to complete works which are not well defined. If the contractor underestimates the quantities needed during the stage of design development which is included in tender sum, it would probably suffer from a monetary loss. Yew (2008) opined that the contractors were usually bound to take all risks associated with GMP agreements including shortcomings of originally tendered design schemes. Davis Langdon and Seah (2004) commented that agreeing on the GMP too early based on incomplete design information is risky for both employer and contractor. Fan and Greenwood (2004) suggested that design development is a grey area under GMP schemes and a source of contractual disputes. Oztas and

Okmen (2004) opined that clients should develop a set of comprehensive clients' requirements in tender documents to avoid unnecessary subsequent design changes. This risk may arise from the insufficient tendering period for the contracts concerned, so the tenderers may not have full knowledge about the scope of work and potential pitfalls embedded in the conditions of contract.

"Errors and omissions in tender document" was discerned as the fourth most significant risk inherent with TCC/GMP schemes. The contract document comprising the tender documents is a fundamental tool for risk allocation. If there exist errors, omissions or discrepancies within the contract document at the outset of the project, they would give rise to a huge number of intractable disputes or conflicts and unnecessary contract variations during the post-contract stage. Laryea (2011) found that a lack of clarity in tender documents was a main source of claims and disputes at post-contract stage of construction projects. Yew (2008) shared a similar perception that contractors are bound to take all of the risks under TCC/GMP contracts, including errors and omissions in tender documents.

"Exchange rate variations" was perceived as the fifth most significant risk encountered with TCC/GMP schemes. However, Tam *et al.* (2007) reported that the same risk was considered as a minor one in their study in Hong Kong. Seemingly, the finding may be due to the fact that the respondents are concerned more with exchange rates at the time of financial crisis over recent months.

5.4.3 Agreement of Respondents within each Respondent Group

The results of the mean risk impacts of the 34 risks by all respondents, the client group, contractor group and consultant group, together with the results of Kendall's Concordance analysis are presented in Table 5.4. As the number of factors is greater than seven (34 factors in this case), the values of chi-square are to be tested with the critical values obtained from a table in Siegel and Castellan (1988), instead of considering the value of W. The actual values of chi-square in the client group and contractor group are larger than the critical values from the table (Siegel and Castellan, 1988) and the p-values are all less than 0.05. The null hypothesis that "the respondents' sets of rankings within a certain group are unrelated (independent) to each other" is therefore rejected for these two groups of respondents. This statistical result implies that there is a statistically significant agreement amongst the respondents within the client group and contractor group during the ranking exercise of risks encountered with TCC/GMP construction projects. However, the null hypothesis cannot be rejected for the consultant group since the actual value of chi-square is smaller than the critical value of chi-square from table. This result may be explained by the fact that the consultant group respondents come from different professions such as quantity surveyors, architectural consultants and engineering consultants. Each profession may have different concerns about the impact of risks.

Table 5.4 Rankings and Results of Kendall's Concordance Test of Risk Factors Encountered with TCC/GMP Construction Projects

ID	Risk Factor	All Respondent Group		Client Group		Contractor Group		Consultant Group	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
5	Change in scope of work	16.41	1	15.61	2	18.22	1	15.66	1
17	Insufficient design completion during tender invitation	15.46	2	15.94	1	16.19	4	14.35	2
20	Unforeseeable design development risks at tender stage	14.54	3	13.90	10	16.30	3	13.65	4
6	Errors and omissions in tender document	14.51	4	14.90	5	16.00	6	12.88	10
21	Exchange rate variations	14.49	5	13.77	11	16.15	5	13.78	3
29	Unforeseeable ground conditions	14.25	6	14.03	9	15.30	8	13.55	5
1	Actual quantities of work required far exceeding estimate	13.97	7	14.10	8	15.69	7	12.44	15
32	Lack of experience of contracting parties throughout TCC/GMP process	13.91	8	14.58	6	14.33	14	12.87	12
22	Inflation beyond expectation	13.81	9	15.16	4	14.81	10	11.66	23
3	Unrealistic maximum price or target cost agreed in the contract	13.76	10	15.32	3	13.22	19	12.69	13
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor	13.51	11	14.55	7	14.44	12	11.65	24
7	Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors	13.31	12	11.42	25	16.56	2	12.41	16
26	Global financial crisis	13.19	13	13.70	13	12.70	22	13.13	7
18	Poor buildability / constructability of project design	13.11	14	12.90	16	14.85	9	11.81	21
2	Delay in resolving contractual disputes	13.11	15	12.71	17	13.88	16	12.88	10
9	Loss incurred by main contractor due to unclear scope of work	13.07	16	11.83	22	14.59	11	12.94	9
16	Delay in work due to third party	12.64	17	11.94	21	12.41	24	13.53	6
28	Inclement weather	12.43	18	11.32	26	13.67	18	12.45	14
8	Inaccurate topographical data at tender stage	12.40	19	13.06	14	12.56	23	11.63	25
19	Little involvement of main contractor in design development process	12.36	20	11.65	24	13.78	17	11.84	20
15	Selection of subcontractors with unsatisfactory performance	12.17	21	12.00	20	11.26	28	13.09	8
31	Difficult to obtain statutory approval for alternative cost saving designs	12.16	22	10.90	27	13.96	15	11.84	19
33	Impact of construction project on surrounding environment	12.15	23	11.74	23	14.41	13	10.58	31
12	Poor quality of work	12.07	24	13.77	12	10.11	32	12.06	18
11	Technical complexity and design innovations requiring new construction methods and materials from main contractor	11.92	25	12.19	19	12.96	20	10.78	30

23	Market risk due to the mismatch of prevailing demand of real estate	11.86	26	12.96	15	11.85	26	10.91	28
24	Change in interest rate on main contractor's working capital	11.33	27	12.20	18	10.42	30	11.25	26
34	Environmental hazards of constructed facilities towards the community	11.17	28	10.55	28	12.81	21	10.38	32
13	Delay in availability of labour, materials and equipment	11.03	29	10.42	30	10.30	31	12.25	17
25	Delayed payment on contracts	10.81	30	9.55	32	11.15	29	11.75	22
30	Change in relevant government regulations	10.80	31	9.52	33	12.15	25	10.90	29
10	Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage	10.72	32	10.47	29	11.81	27	10.03	34
14	Low productivity of labour and equipment	10.09	33	10.42	30	8.33	33	11.25	26
27	Force Majeure (Acts of God)	8.66	34	8.43	34	7.22	34	10.13	33
	Number (N)	81		27		25		29	
	Kendall's Coefficient of Concordance (W)	0.075		0.114		0.138		0.057	
	Actual Value of Chi-square	200.392		101.506		113.889		54.508	
	Critical Value of Chi-square in table	67.985		67.985		67.985		67.985	
	Degree of freedom (df)	33		33		33		33	
	Level of Significance	<0.001		<0.001		<0.001		0.011	

Ho = Respondents' sets of rankings are unrelated (independent) to each other within each group.
Reject Ho if the actual value of chi-square is larger than the critical value from table

5.4.4 Agreement of Respondents between any Two Groups

The level of agreement amongst the respondents on the ranking exercise was tested via the Spearman's rank correlation test as indicated in Table 5.5. The results showed that the null hypotheses that no significant correlation between clients-contractors, clients-consultants and contractors-consultants on the rankings of GMP/TCC risk factors can be rejected. This reflects significant correlations on the perceptions of the risk impacts encountered with the GMP/TCC projects between any two respondent groups. As observed in Table 5.4, 8 of the top 10 risk factors perceived by the client group fall within the top 10 risk factors ranked by the contractor group. Similarly, 6 of the top 10 risk factors rated by contractor group fall within the top 10 rated by the consultant group. Furthermore, 5 of the top 10 risk factors perceived by the client group fall within the top 10 ranked by the consultant group. Such similarities in rankings are supported by the statistical results that the rankings of three groups are consistent in general.

Table 5.5 Results of Spearman's Rank Correlation Test between Respondent Groups

Comparison	r_s	Sig. Level	Conclusion
Client's ranking vs Contractor's ranking	0.607	<0.001	Reject H_0 at 1% significance level
Client's ranking vs Consultant's ranking	0.552	<0.001	Reject H_0 at 1% significance level
Contractor's ranking vs Consultant's ranking	0.562	<0.001	Reject H_0 at 1% significance level

H_o = No significant correlation on the rankings between two groups
H_a = Significant correlation on the rankings between two groups
Reject H_o if the actual significance level (p-value) is less than the allowable value of 5%

5.4.5 Results of Mann-Whitney U Test

The next step of data analysis is to conduct the Mann-Whitney U Test to identify the particular risks in which any two groups of respondents hold different perceptions on the level of severity and likelihood of occurrence of those risks concerned. The same test was applied in Roumboutsos and Anagnostopoulos' (2008) study to compare the risks associated with public-private partnership schemes between respondents from contractor group and those from the public sector; between construction and financial sectors; and between public and financial sectors. A similar statistical technique has been used to compare the perceptions between Hong Kong and western respondents on construction project briefing (Yu *et al.*, 2008); and to compare the perceptions of financial criteria between different groupings (Zhang, 2005). The results of the Mann-Whitney U Tests for severity, likelihood and risk impact (i.e. the product of severity and likelihood) are presented in Table 5.6.

The client group and contractor group hold different views towards the severity of "Exchange rate variations" and "Change in relevant government regulations". These findings may reflect the fact that since it is the contractor, who is the builder by nature, to procure materials, , the contractor would probably suffer from a loss if the exchange rate fluctuates, since most materials for construction, such as water pipes and electrical wires, are procured from other countries. For "change in relevant government regulations", since the construction site is under the management of contractor, but not the client, the contractor respondents would provide a higher rating on the severity of change in relevant government regulations. In fact, such changes would have financial implications on them.

The contractor group provided a higher rating on the severity of "Impact of construction project on surrounding environment" than the consultant group. Similar to the factors discussed before, this result may be due to the fact that the contractor is the party operating the construction site. Therefore, the contractor is probably accountable to the impact, such as noise and pollution generated from construction site to the environment nearby. However, the consultant group probably does not have such a perception as their daily works are more related to paperwork and documentation.

In addition, both the client group and consultant group assign high ratings on the severity of "Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor". The finding may be due to the fact that the consultant group is independent of the interest of client and contractor. They may be less sensitive to this risk which is directly related to the profit of the client. On the other hand, so long as the client organisations are profit-driven, it is not surprising for them to rate a higher severity on this risk than the consultant group.

To compare the likelihood of risk occurrence, the contractor perceived that the risk of "Difficult for main contractor to have back-to-back GMP/TCC contract terms with nominated or domestic subcontractors" is more likely to occur than the consultant group. One of the possible reasons is that the contractors are the party to make subcontracts with specialist subcontractors. Thus, they may face a lot of problems in having back-to-back contracts with GMP/TCC arrangement, but the consultant group does not. In contrast, the consultant group provided a higher rating on the likelihood of "Low productivity of labour and equipment" because the consultant group may be responsible for supervising the progress of construction works, and they may perceive that productivity is a prime concern over their daily work.

Moreover, the client group regarded "Inflation beyond expectation" as more likely to materialise than the consultant group. Similar to "Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor", the consultant group is impartial and independent of the profit of clients; hence they may be less sensitive to the occurrence of inflation beyond expectation.

To compare the overall risk impact of 34 key risks, the contractor group rated a higher impact in "Difficult for main contractor to have back-to-back GMP/TCC contract terms with nominated or domestic subcontractors" than the client group. This may be due to the difference in role playing in the construction project development of contractor who has a direct contractual link with all subcontractors. Similarly, the client group perceived a greater impact on "poor quality of work"; it is because the clients themselves are possibly the end-users of the buildings. If the quality of work is not as good as expected, the client will suffer a lot. Statistical differences in perception on risk impacts of "Low productivity of labour and equipment" and "Inflation beyond expectation" are noted. Since the risk impact is the product of risk severity and risk likelihood in this survey, statistical differences in perception on the risk impact should be reflected when statistical differences in either risk severity or risk likelihood are noted.

Table 5.6. Results of the Mann-Whitney U Tests (Asymptotic Significance < 0.05)

ID	Risk Factor	Risk Severity			Likelihood of Risk			Risk Impact		
		Client-Contractor	**Contractor-Consultant**	**Client-Consultant**	**Client-Contractor**	**Contractor-Consultant**	**Client-Consultant**	**Client-Contractor**	**Contractor-Consultant**	**Client-Consultant**
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor			0.046						
7	Difficult for main contractor to have back-to-back GMP/TCC contract terms with nominated or domestic subcontractors				0.038		0.042			
12	Poor quality of work							0.033		
14	Low productivity of labour and equipment					0.029			0.036	
21	Exchange rate variations	0.045								
22	Inflation beyond expectation					0.015				0.022
30	Change in relevant government regulations	0.049								
33	Impact of construction project on surrounding environment		0.035							

Note: The figures represent asymptotic significance of the Mann-Whitney U test

5.5 Results of Questionnaire Survey on Risk Allocation in Hong Kong

The research findings reported in this section (Section 5.5) have been documented in an accepted journal article (Chan et al., 2011b). The research findings reported herein was modified based on El-Sayegh (2008) who focused on risk assessment and risk allocation in the construction industry of the United Arab Emirates. In El-Sayegh (2008)'s study, the survey respondents were asked about the proper allocation of 42 identified risks. A similar approach was adopted in the present study and the target survey respondents were invited to determine the party (whether client or contractor) who is best capable to manage a particular risk associated with TCC/GMP contracts or equally shared between them, according to their lessons learned from previous TCC/GMP experience. A general principle is that each risk should be allocated to the party who is best capable to manage it at the least possible cost (Cooper *et al.*, 2005). In other words, an optimal risk allocation is not to pass all risks to one party, but to seek a solution minimising both the total management costs of the client and contractor organisations (Ke *et al.*, 2010).

Table 5.7 gives the meanings of each option in relation to the preference of risk allocation between client and contractor. The respondents were requested to choose the "party best capable to manage the risk" corresponding to each of the 34 risk factors with the scale below:

Table 5.7. Meanings of Choices in the Survey

1	Client (100%)	Client is best capable to manage the risk
2	Client > Contractor	Client is more capable than Contractor to manage the risk
3	Client = Contractor	Both Client and Contractor are equally capable to manage the risk
4	Contractor > Client	Contractor is more capable than Client to manage the risk
5	Contractor (100%)	Contractor is best capable to manage the risk

The "perceived party best capable to manage the risk" is for the party which has more than 50% of vote for such risk which was adopted by El-Sayegh (2008) and Li et al. (2005). With the principle that the party best capable to manage the risk should bear such risk, the interpretations of findings are illustrated in Table 5.8 as follows:

Table 5.8. Interpretation of Survey Findings

Case	**Result**	**Perceived party best capable to manage the risk**
Case 1	Total percentage of Choice 1 and Choice 2 > 50%	Client
Case 2	Total percentage of Choice 4 and Choice 5 > 50%	Contractor
Case 3	Percentage of Choice 3 > 50%	Shared
Case 4	None of Cases 1 to 3	Negotiated

5.5.1 Results of Cronbach's Alpha Reliability Test

Similar to the previous section on risk assessment, the Cronbach's alpha reliability test is adopted to measure the internal consistency of the responses. It is found that the value of Cronbach's alpha is 0.885, which is much higher than the acceptance threshold of 0.70 as suggested by Hair et al. (1998). It can be concluded that the measurement scale adopted is statistically reliable.

5.5.2 Agreement of respondents within experienced group and informed group

Some of the survey respondents (frequency = 39) did not have direct hands-on experience in TCC/GMP projects (but have obtained basic understanding of the underlying principles of TCC/GMP scheme via conferences, seminars, workshops, journals and internal sharing from their counterparts) and they were classified as the informed group. Experienced group were those who have participated in TCC/GMP projects before. A statistical test on the difference of opinions amongst the respondents within each of the two survey groups (i.e. within experienced group and within informed group) should be first conducted. As Ke *et al.* (2010) suggested, a Kendall's concordance test is performed to gauge the agreement of different respondents on their preferences of risk allocation within a particular survey group. This statistical analysis aims to ascertain whether the respondents within an individual group respond in a consistent manner or not.

However, the Kendall's coefficient of concordance (W) is only suitable when the number of attributes does not exceed 7 (Siegel and Castellan, 1988). Chi-square should be used as a near approximation instead if the number of attributes is greater than 7. The critical values of chi-square are referred to the table found in Siegel and Castellan (1988). The actual calculated chi-square values within the experienced group and non-experienced group are 661.186 and 408.221 respectively, and they are both higher than 67.985 (i.e. the critical value of chi-square derived from the table with a degree of freedom of 33) at the 5 % significance level. This statistical result implies that the assessment by various respondents on their risk allocation preferences within each of the two survey groups is found to be consistent and they are essentially applying the same standard in allocating the respective risk factors.

5.5.3 Agreement of Respondents between Experienced Group and Informed group

Independent two-sample t-test was applied to test the agreement on the preference of allocation of each listed risk factor between the experienced group and informed group as adopted by Ke *et al.* (2010). Rahman and Kumaraswamy (2008) employed this technique to test if there is any statistical difference in perceptions on factors facilitating relational contracting in client-contractor, contractor-consultant and consultant-client two group comparisons in their study. Independent two-sample t-test was also employed in a recent study by Xie et al. (2010) on barriers to innovation in small and medium sized enterprises (SMEs) in China. In their study, a questionnaire survey with a five-point Likert scale was adopted and independent two-sample t-test was used to detect if there was any statistical difference in perception on policy environment of innovation for SMEs in China between two groups of respondents. The application of independent two-sample t-test is justified by the fact that the same method was used in previous research work with similar nature (i.e. comparing the views of different groups in a questionnaire survey with a Likert scale of measurement).

The results of the statistical test shown in Table 5.9 indicated that there are no statistically significant differences on the preference of risk allocation in TCC/GMP projects between the experienced group and informed group (all of the actual calculated significance levels larger than the critical value of 5%). It was concluded that the two sets of opinion data can be lumped together for further analysis and the survey findings are regarded as consistent, reliable and representative.

Risks to be allocated to client

Eight risks to be allocated to client as depicted in Table 5.9 include:

- Change in scope of work;
- Errors and omissions in tender document;
- Inaccurate topographical data at tender stage;
- Insufficient design completion during tender invitation;
- Poor buildability / constructability of project design;
- Lack of involvement of main contractor in design development process;
- Unforeseeable design development risks at tender stage; and
- Consequence of delayed payment to contractor.

After a careful observation, such eight risks may be classified into three groups, i.e. contractual risks, design risks, together with economic and financial risks.

"Change in scope of work", "Errors and omissions in tender document" and "Inaccurate topographical data at tender stage" could be considered as contractual risks encountered with TCC/GMP construction projects. "Change in scope of work" is regarded as a significant risk in TCC/GMP projects. According to a study by Cox *et al*. (1999) in the United Kingdom, it was revealed that change in employer's requirements was one of the most frequently cited reasons for design changes in their cases explored. This risk was perceived as better taken by client. The finding is consistent with another study on risk allocation by Ojo and Ogunsemi (2009) that the risk "change in work" was perceived to be allocated to client. Another two risks are both related to tender preparation. The respondents considered that the risks should be allocated to client. One of the possible reasons for this finding is that these three risks are under control on the client's side. Some case studies launched in the United Kingdom by Laryea (2011) concluded that client impatience, reluctance to invest more in good quality tender documents, ignorance and incompetence were four main reasons for decreased quality of tender documents. Similarly, inaccurate topographical data at tender stage is often provided by the client to contractor. The client has full control of this risk, although the client does not guarantee the accuracy of such data in most cases.

"Insufficient design completion during tender invitation", "Poor buildability / constructability of project design", "Little involvement of main contractor in design development process" and "Unforeseeable design development risks at tender stage" are all design risks and all of them are preferred to be taken by client. This finding is understandable and in line with those observations from previous research studies (e.g. Kartam and Kartam, 2001; Andi, 2006) as the entire design work is usually carried out by an independent team of design consultants (e.g. architects, structural engineers, building services engineers, etc) due to their inherent expertise and professional training, who represent the clients' intent and interests, while the contractor is passive in design changes under the traditional construction practices in Hong Kong. The clients would be in a more advantageous position to manage these design risks.

The last risk which should be allocated to client was "Consequence of delayed payment to contractor". Again, the finding echoes the previous study on risk allocation in the construction industry (Andi, 2006) and standard form of contracts such as the NEC3 Option C stating that interest is paid on late payment if a certified payment is late or a payment is late because the Project Manager does not issue a certificate which he should issue.

By observation, it is not difficult to see that there is a common point on the risks perceived to be better allocated to client – they are all under the control of client (e.g. change in scope of works, errors and omissions in tender document, delayed payment on contracts and the like.) The findings appear to match with the fault standard and management standard as suggested by Grove (2000). According to the fault standard, the time and cost impacts of those risks caused through the faults of a party should be borne by that party. Obviously, the faults of client cause those risks mentioned above, and thus the survey result matches the fault standard. On the other hand, the philosophy of the management standard states that a risk should belong to the party who is best able to evaluate and control it (Grove, 2000). The client can exercise full control of all of the risks mentioned in this part (e.g. insufficient design completion during tender invitation, change in scope of work, etc). The survey result is therefore considered to be reasonable and reflective of the real-life situations.

Table 5.9. Preferred Allocation of Risk Factors in TCC/GMP Construction Projects in Hong Kong

Risk factors		Risk allocation				Independent 2-sample t-test	
		Client	Shared	Contractor	Allocated to	t-value	Sig. level
5	Change in scope of work	80.9%	13.8%	5.3%	Client	0.356	0.723
6	Errors and omissions in tender document	64.5%	15.1%	20.4%	Client	-1.721	0.089
8	Inaccurate topographical data at tender stage	61.3%	22.6%	16.1%	Client	-0.750	0.455
17	Insufficient design completion during tender invitation	79.6%	16.1%	4.3%	Client	0.041	0.967
18	Poor buildability / constructability of project design	50.5%	22.6%	26.9%	Client	0.570	0.570
19	Lack of involvement of main contractor in design development process	68.8%	12.9%	18.3%	Client	-0.250	0.803
20	Unforeseeable design development risks at tender stage	65.6%	24.7%	9.7%	Client	0.612	0.542
25	Consequence of delayed payment to contractor	73.4%	18.1%	8.5%	Client	0.925	0.359
7	Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors	8.7%	13.0%	78.3%	Contractor	1.335	0.185
12	Poor quality of work	6.5%	17.2%	76.3%	Contractor	0.916	0.364
13	Delay in availability of labour, materials and equipment	2.1%	17.0%	80.9%	Contractor	0.719	0.474
14	Low productivity of labour and equipment	1.1%	10.6%	88.3%	Contractor	0.175	0.862
15	Selection of subcontractors with unsatisfactory performance	4.3%	23.4%	72.3%	Contractor	-1.239	0.218
24	Change in interest rate on main contractor's working capital	5.4%	24.7%	69.9%	Contractor	-0.015	0.988
2	Delay in resolving contractual disputes	25.8%	64.5%	9.7%	Shared	-1.251	0.214
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor	26.9%	57.0%	16.1%	Shared	-0.058	0.954
10	Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage	16.1%	77.4%	6.5%	Shared	-0.756	0.451
22	Inflation beyond expectation	19.1%	51.1%	30.9%	Shared	-1.332	0.186
26	Global financial crisis	11.8%	83.9%	4.3%	Shared	-1.977	0.061
27	Force Majeure (Acts of God)	10.8%	78.5%	10.7%	Shared	-0.027	0.979
28	Inclement weather	7.5%	57.0%	35.5%	Shared	0.534	0.594
30	Change in relevant government regulations	35.5%	60.2%	4.3%	Shared	-1.787	0.077
32	Lack of experience of contracting parties throughout TCC/GMP process	20.4%	59.1%	20.5%	Shared	1.276	0.205
1	Actual quantities of work required far exceeding estimate	41.3%	32.6%	26.1%	Negotiated	0.029	0.977
3	Unrealistic maximum price or target cost agreed in the contract	38.3%	41.5%	20.2%	Negotiated	1.482	0.142
9	Loss incurred by main contractor due to unclear scope of work	45.2%	29.0%	25.8%	Negotiated	-0.218	0.828
11	Technical complexity and design innovations requiring new construction methods and materials from main contractor	12.8%	41.5%	45.7%	Negotiated	0.466	0.643
16	Delay in work due to third party	23.4%	44.7%	31.9%	Negotiated	-1.879	0.063
21	Exchange rate variations	18.1%	42.6%	39.3%	Negotiated	-1.320	0.190
23	Market risk due to the mismatch of prevailing demand of real estate	45.7%	41.5%	12.8%	Negotiated	-1.209	0.230
29	Unforeseeable ground conditions	32.6%	42.4%	25.0%	Negotiated	-1.177	0.242
31	Difficult to obtain statutory approval for alternative cost saving designs	29.8%	37.2%	33.0%	Negotiated	0.081	0.936
33	Impact of construction project on surrounding environment	17.2%	44.1%	38.7%	Negotiated	1.496	0.138
34	Environmental hazards of constructed facilities towards the community	24.5%	44.7%	30.8%	Negotiated	1.386	0.169

Risks to be allocated to contractor

As revealed from Table 5.9, six risks were discerned to be better managed by contractor, namely:

- Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors;
- Responsibility for quality;
- Delay in availability of labour, materials and equipment;
- Low productivity of labour and equipment;
- Selection of subcontractors with unsatisfactory performance; and
- Change in interest rate on main contractor's working capital.

Four of these six risks to be better allocated to contractor (i.e. "Responsibility for quality", "Delay in availability of labour, materials and equipment", "Low productivity of labour and equipment", and "Selection of subcontractors with unsatisfactory performance") are related to site operation. More than 70% of the respondents believed that these four risks should lie on the contractor side in TCC/GMP projects as observed from Table 5.9.

This finding is reasonable since contractors are the actual constructors by nature, they would be better positioned to manage the construction risks encountered during site operation. Based on the results obtained from their fuzzy risk allocation model by Lam *et al*. (2007), the risk of subcontractor failure in controlling the quality of work should be allocated to contractor. Another study by Andi (2006), suggesting that poor quality of work, delay in availability of labour, materials and equipment and selection of subcontractors with unsatisfactory performance should be allocated to contractor, supports the current findings reported in this paper.

More than 75% of the respondents perceived that "Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors" was better managed by contractor. About 70% of the respondents considered "Change in interest rate on main contractor's working capital" should be allocated to contractor. These findings are congruent again with the management standard of risk allocation suggested by Grove (2000). The main contractor is the sole party who can exercise control over the contractual issues with the subcontractors. Regarding the change in interest rate on main contractor's working capital, the contractor is the party who suffers the loss in the first instance if the risk does materialise. This is in line with one of the Abrahamson's principles which form the classic risk allocation approach (Abrahamson, 1984).

Risks to be shared between client and contractor

Nine risks were perceived to be better shared between client and contractor. Through a closer examination, these nine risks may be sub-divided into two types: (1) risks out of control of both parties; and (2) risks which both parties have potential to incur. Risks out of control of both parties include:

- Inflation beyond expectation;
- Global financial crisis;
- Force Majeure (Act of God)
- Inclement weather; and

- Change in relevant government regulations.

When compared with the risk/obligation allocation model mentioned in the "No Dispute Report" (National Building and Construction Council, 1989) published in Australia, the findings for "Inflation beyond expectation", Force Majeure (Act of God)", "Inclement weather" and "Change in relevant government regulations" match well with the model, indicating that the findings are sensible and logical in general. The fuzzy risk allocation model proposed by Lam *et al.* (2007) suggested that risks on inflation and inclement weather should be shared between client and contractor as well. In practice, inclement weather is a ground for granting extension of time in most construction contracts in Hong Kong, while the contractors have to absorb any cost implications for such risk. Inflation risk is shared when a fluctuation clause is applied in the TCC/GMP projects. Perhaps, the rationale behind such contractual clause is that both parties cannot control the level of severity and likelihood of occurrence of such risks. As it is unfair to ask either party to take these risks, they ought to be shared between the two parties under the contract.

"Delay in resolving contractual disputes", "Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor", and "Lack of experience of contracting parties throughout TCC/GMP process" were risks which both client and contractor have contribution to their occurrence. For example, "delay in resolving contractual disputes", the delay can be caused by both parties in the process of preparation of claims and/or assessment of claims. This risk was perceived as a shared risk in the study of Andi (2008).

Regarding the risk factor "Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage", the issues on the sharing fraction are subject to negotiation between the two parties in case of negotiated tendering employed in the TCC/GMP projects. Chan et al. (2007b) opined that inexperienced clients and contractors may jeopardise the TCC/GMP process. This risk appears to be inevitable in Hong Kong, since the number of TCC/GMP projects completed is rather scarce in the local construction market. A previous research study conducted by Chan et al (2007a) reflected that there have been a limited number of TCC/GMP construction projects in Hong Kong, and it seems that both clients and contractors are still learning how to adopt such new kind of alternative procurement strategies.

5.6 Results of Questionnaire Survey on Risk Mitigation Measures in Hong Kong

5.6.1 Overall Rankings of the Risk Mitigation Measures of TCC/GMP Projects

The respondents were asked to rate the effectiveness of 18 risk mitigation measures on TCC/GMP projects with a five-point Likert scale where 1 denoted "Least effective" and 5 denoted "Most effective". The results of the Cronbach's alpha reliability test shows that the value of Cronbach's alpha is 0.814, which is well above the acceptance threshold of 0.70 (Nunnally and Berstein, 1994), indicating that the scale of reliability is achieved. The mean scores of each of the 18 risk mitigation measures for all respondents were computed and ranked in descending order in Table 5.10. The respondents in general believe the suggested risk mitigation measures were effective. They perceived that "Right selection of project team" was the most effective risk mitigation measure for TCC/GMP construction projects. Chan et al. (2002) suggested that selection of project team is essential for a project in the construction industry, since inexperienced or claim-conscious contractors may jeopardise the implementation of the TCC/GMP process. Gander and Hemsley (1997) shared a similar perception that recruitment of an experienced project team was crucial to the success of a TCC/GMP project as an inexperienced one could be lacking in fulfilling his obligations.

Table 5.10. Overall Ranking of Risk Mitigation Measures for TCC/GMP Construction Projects

ID	Risk Mitigation Measures	N	Mean	S.D
16	Right selection of project team	94	3.90	0.843
12	Mutual trust between the parties to the contract	94	3.73	1.109
2	Clearly defined scope of work in client's project brief	94	3.67	1.010
8	Early involvement of the main contractor in design development process	94	3.64	0.960
14	Proactive participation by the main contractor throughout the TCC/GMP process	94	3.61	0.895
4	Prompt valuation and agreement on any variations as they are introduced	94	3.60	0.872
15	Reasonable sharing mechanism of cost saving / overrun of budget between client and contractor	94	3.59	0.999
6	Confirming a contract GMP value or target cost after design documents are substantially completed	94	3.56	0.887
11	Sufficient time given to interested contractors to submit their bids for consideration	94	3.54	0.991
17	Tender interviews and tender briefings to ensure tenderers gain a clear understanding of scope of work involved and necessary obligations to be taken in the project	94	3.48	0.864
2	Clearly stated circumstances in which agreed GMP value or target cost can be adjusted in contracts	94	3.46	0.980
18	Establishment of adjudication committee and meetings to resolve potential disputed issues	93	3.27	0.946
13	Open-book accounting regime provided by main contractors in support of their tender pricing	93	3.24	1.136
5	Proper risk register with responsible parties assigned and agreed	94	3.23	0.977
10	Implementation of relational contracting within project team	92	3.14	1.033
7	Development of standard contract clauses in connection with TCC/GMP schemes or methodology	94	3.04	1.004
1	Application of price fluctuation clause in the contract	94	2.90	0.928
9	Employing a third party to review the project design in compliance with prevailing building regulations and buildability at tender stage	94	2.64	0.937

S.D: standard deviation

The second most effective risk mitigation measure perceived by the respondents was "Mutual trust between the parties to the contract". It is found that partnering concept was applied in parallel in a number of TCC/GMP projects in Hong Kong (Chan et al., 2007a). The concept of TCC is usually applied in projects with high risks (Wong, 2006), so mutual trust between the employer and the contractor would be necessary to cope with the risks associated with the projects.

"Clearly defined scope of work in client's project brief" was considered as the third most effective risk mitigation measures by the respondents. Since "change in scope of works" was regarded as the most significant risk in the same survey (Chan et al., 2010a), it is not surprising that respondents believed that clearly defining the scope of work could effectively mitigate risks in TCC/GMP projects. This finding is consistent with that in a recent study in the United Kingdom (Olawale and Sun, 2010), suggesting that clear distinction between design change and a design development at the outset of a construction project could mitigate the risk on design changes.

"Early involvement of the main contractor in design development process" is regarded as the fourth most effective measure to mitigate risks associated with TCC/GMP schemes in construction in this survey. Song et al. (2009) documented a case study of early contractor involvement in the United States. Their study revealed that the observed benefits of early contractor involvement include improved drawing quality, material supply and information flow. It was also concluded that early involvement of contractor led to reduction of project duration, due to the improved design and capitalisation of contractor's knowledge and experience. The finding is similar to that of this study in risk mitigation in TCC/GMP projects, since the contractor's knowledge on buildability could be applied in the projects procured by TCC/GMP schemes in Hong Kong.

"Proactive participation by the main contractor throughout the TCC/GMP process" was perceived as the fifth most effective risk mitigation measures in this study. Proactive participation of the main contractor is definitely beneficial to the project delivery of TCC/GMP construction projects. In fact, the early warning clause in the NEC3 (New Engineering Contract Version 3) Options C and D is a contractual clause to encourage the proactive participation of the contractor and project manager to give early warning to the project team for matters which could increase in the total price; delay completion; delay meeting a key date and/or impair the performance of the works. The project team would attend a risk mitigation meeting to seek solutions to reduce the risks. Such a mechanism is considered to be an effective means for risk mitigation built in the NEC3.

5.6.2 Factor Analysis of Risk Mitigation Measures for TCC/GMP Projects

Factor analysis is considered as a statistical technique to identify a relatively small number of individual factors which can be used to represent the relationships among sets of many interrelated variables (Norusis, 1993). On top of the descriptive statistics in the previous section, factor analysis was conducted to reduce the 18 risk mitigation measures into a more manageable number of "underlying" grouped factors.

Two analytical techniques, which are Principal Components Analysis (PCA) and Promax rotation, were employed in factor analysis in this study. PCA was used to identify the underlying factors and determining the interdependence of variables due to its simplicity and distinctive characteristic of data-reduction capacity for factor extraction. PCA can generate a linear combination of variables which account for as much of the variance present in the data as possible. The 18 risk mitigation measures were consolidated to 7 underlying factors in the factor analysis. The total percentage of variances explained by each factor is examined to determine how many factors would be required to represent the set of data. The results of the factor analysis are indicated in Table 5.11.

Table 5.11. Results of Factor Analysis for Risk Mitigation Measures for TCC/GMP Construction Projects

No.	Item	Factor loading	Eigenvalue	Percent of variance explained	Cumulative percent of variance explained
Factor 1 – Relational Contracting and Mutual Trust					
10	Implementation of relational contracting within project team	0.828	4.661	25.893	25.893
13	Open-book accounting regime provided by main contractors in support of their tender pricing	0.725			
11	Sufficient time given to interested contractors to submit their bids for consideration	0.662			
12	Mutual trust between the parties to the contract	0.591			
Factor 2 – Clear Contract Provisions and Well-defined Scope of Works					
2	Clearly stated circumstances in which agreed GMP value or target cost can be adjusted in contracts	0.771	2.003	11.127	37.020
1	Application of price fluctuation clause in the contract	0.671			
3	Clearly defined scope of work in client's project brief	0.662			
6	Confirming a contract GMP value or target cost after design documents are substantially completed	0.661			
Factor 3 – Involvement of Contractor in Decision Making Process					
18	Establishment of adjudication committee and meetings to resolve potential disputed issues	0.754	1.449	8.047	45.067
15	Reasonable sharing mechanism of cost saving / overrun of budget between client and contractor	0.730			
8	Early involvement of the main contractor in design development process	0.709			
Factor 4 – Right Selection of Project Team					
16	Right selection of project team	0.853	1.337	7.430	52.497
14	Proactive participation by the main contractor throughout the GMP/TCC process	0.808			
5	Proper risk register with responsible parties assigned and agreed	0.556			
Factor 5 – Third Party Review of Project Design at Tender Stage					
9	Employing a third party to review the project design in compliance with prevailing building regulations and buildability at tender stage	0.801	1.132	6.290	58.786
Factor 6 – Standard Contract Clauses for GMP/TCC Schemes					
7	Development of standard contract clauses in connection with GMP/TCC schemes or methodology	0.701	1.054	5.853	64.639
Factor 7 – Fair Dealing with Contractor					
4	Prompt valuation and agreement on any variations as they are introduced	0.833	1.002	5.569	70.208
17	Tender interviews and tender briefings to ensure tenderers gain a clear understanding of scope of work involved and necessary obligations to be taken in the project	0.653			

KMO Measure of Sampling Adequacy		0.732
Barlett's Test of Sphericity:	Approx Chi-square	478.547
Degree of Freedom		153
Significance Level		0.0000
Cronbach's Alpha Reliability Coefficient		0.816

The appropriateness of employing the factor analysis is assessed in this study. The sample size is considered as sufficient to conduct factor analysis as it complies with the ratio of 1:5 for variables to sample size as suggested by Lingard and Rowlinson (2006), i.e. 18 risk mitigation measures x 5 samples required for each factor = at least 90 samples for assuring sufficient sample size to proceed with factor analysis. Various statistical tests are also undertaken to examine the appropriateness of factor analysis for factor extraction. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Barlett's test of sphericity for the extraction factors can be used. The KMO value ranges from 0 to 1, where 0 implies that the sum of partial correlations is large relative to the sum of correlation, in which case factor analysis would not be appropriate (Norusis, 1993). A value close to 1 indicates that the patterns of correlations are relatively compact and factor analysis would generate individual factors. According to Norusis (1993), the KMO value should be greater than 0.50 for a satisfactory factor analysis to proceed. The KMO value of the factor analysis in this study is 0.732 which is higher than the acceptable threshold of 0.50.

The Barlett's test for sphericity is used to test the hypothesis that the correlation matrix is an identity matrix, which indicates that there is no relationship amongst the items (Pett et al., 2003). The value of the test statistic for Barlett's sphericity is large (chi-square value = 478.547) and the associated significance level is small (p-value = 0.000), implying that the population correlation matrix is not an identity matrix. The Cronbach's alpha reliability coefficient was used for checking internal consistency (reliability) between 0 and 1, based on the average inter-item correlation. The usual rule is that if the alpha value is larger than 0.70, according to Nunnally (1978), it can be concluded that the adopted measurement scale is reliable. In this study, the overall alpha value for the 18 risk mitigation measures was found to be 0.816, implying that there is good internal consistency (reliability) in terms of the correlations amongst the 18 factors, and the adopted measurement scale is reliable. Due to the fact that the requirements of KMO value and the Barlett's test of sphericity are both achieved, it can be therefore concluded that factor analysis was appropriate for this research and it can proceed with confidence on reliability.

Seven underlying factors were extracted in this study, representing 70.2% of the total variances in the responses, which is higher than the minimum requirement of 60% as advocated by Malhotra (1996). All loadings of the 18 individual risk mitigation measures were higher than 0.50 as suggested by Holt (1997). The higher the absolute value of the factor loading, the more a particular individual factor contributes to the underlying grouped factor (Proverbs et al., 1997). It is observed that the factor loadings and the interpretation of the individual factors extracted were reasonably consistent.

5.6.3 Interpretation of the Underlying Grouped Risk Mitigation Measures

Factor 1 – Relational Contracting and Mutual Trust

Factor 1 comprises four items primarily focusing on mutual trust between the two contracting parties. As may be seen from Table 5.11, the factor loading of this factor is relatively large. They include "Implementation of relational contracting within project team"; "Open-book accounting regime provided by main contractors in support of their tender pricing"; "Sufficient time given to interested contractors to submit their bids for consideration" and "Mutual trust between the parties to the contract". All of these items are in common that they are all related to the relationship between the employer and contractor. Zaghloul and Hartman (2003) considered that trust and contracting method are related and this relationship is of paramount importance to effective project management and contract administration. As Tay et al. (2000) suggest, a close relationship between all the contracting parties is one of the most important factors for project success for TCC. Another study by Chan et al. (2007b) concluded that partnering could be implemented with GMP/TCC to make the project successful. Partnering could improve communication flow, enhance mutual trust, help resolve disputes and improve working relationship between project participants (Chan et al., 2004). It is therefore considered that the mutual trust between client and contractor could help to mitigate risks in GMP/TCC projects which are usually related to design changes and scope of works due to the improved information flow and working relationship between different parties involved.

Factor 2 – Clear Contract Provisions and Well-defined Scope of Works

Factor 2 includes four items which are all tender and contract related. A recent study by Chan et al. (2010a) shows that change in scope of works, nature of variations, clarity of tender documents were key risk factors of GMP/TCC schemes in construction in Hong Kong. Corresponding to such risks, having clear provisions in the contract and scope of works would probably reduce the amount of contractual disputes due to nature of variations and scope of works. As Fan and Greenwood (2004) point out, it is advisable for employers to specify circumstances under which agreed GMP value or target cost can be adjusted in contracts, in order to minimise the disputes at the post-contract stage.

Factor 3 – Involvement of Contractor in Decision Making Process

Three items comprise elements of Factor 3 regarding involvement of contractor in decision making. The items concerned include "Establishment of adjudication committee and meetings to resolve potential disputed issues"; "Reasonable sharing mechanism of cost saving / overrun of budget between client and contractor" and "Early involvement of the main contractor in design development process". This finding is in line with those in a recent study about financial incentive mechanisms in Australia (Rose and Manley, 2010). It is found by Rose and Manley (2010) that contractor involvement in design could improve the integration of design and construction due to the contribution of contractor's expertise in buildability. Another earlier study indicates that early involvement of contractor in projects could improve the certainty of construction outcomes (Sidwell and Kennedy, 2004).

Factor 4 – Right Selection of Project Team

Factor 4 is made up of three items namely "Right selection of project team"; "Proactive participation by the main contractor throughout the GMP/TCC process" and "Proper risk register with responsible parties assigned and agreed". Chan et al. (2010c) launched a case study of an underground railway modification works in Hong Kong. It is found that right selection of project team is an essential element to facilitate trust and effective communications between project stakeholders. Strong leadership and proactive contractor are significant in to deal with unexpected issues and potential disputes, the choice made by all involved would possibly break or make the strategy and processes which are crucial for project success (Avery, 2006). The risks on inexperienced project stakeholder jeopardising the GMP/TCC process could be therefore considerably reduced with the right selection of project team.

Factor 5 – Third Party Review of Project Design at Tender Stage

Factor 5 only comprises one item (i.e. Third Party Review of Design at Tender Stage). This measure could offer a chance for the employer to review the project design before tender documentation and hence reduce the likelihood of occurrence of errors and omissions in tender (and likewise contract) documents. This risk mitigation measure is similar to that suggested in a research by Olewale and Sun (2010). One of the risk mitigation measures for design change in construction projects is to have a design manager to manage design changes and review related information as it comes in. Chan et al. (2010a) launched several interviews with industrial practitioners with hands-on experience in GMP/TCC construction projects, indicating that third party review at tender stage is advocated by their interviewees.

Factor 6 – Standard Contract Clauses for GMP/TCC Schemes

Similar to Factor 5, Factor 6 is only made up of one item. The launch of standard contract clauses for GMP/TCC schemes is considered as a significant element of successful project delivery for GMP/TCC projects (Chan et al, 2007a). Despite the fact that the NEC3 engineering and construction contracts have been established for a number of years (including Option C Target Cost with Activity Schedule and Option D Target Cost with Bills of Quantities), its application is rather limited in Hong Kong. Up to the moment when this thesis was written in April of 2011, only one case of using the NEC3 Option C was reported (Cheung, 2008). In the cases of GMP projects, it is found that developers tend to employ their in-house contracts with amendments to accommodate the GMP mechanisms (Chan et al, 2007a). Ting

(2006) recommended that developing a standard form of contract for GMP schemes in Hong Kong would enhance the receptivity of such procurement scheme.

Factor 7 – Fair Dealing with Contractor

Factor 7 comprises two items focusing on fair dealing with contractor namely "Prompt valuation and agreement on any variations as they are introduced" and "Tender interviews and tender briefings to ensure tenderers gain a clear understanding of scope of work involved and necessary obligations to be taken in the project". Bower et al. (2002) opined that incentivisation of a contract requires a clear understanding of what to be achieved at the outset of project. It is thus important to hold a tender interview and a tender briefing to make sure tenderers acquire a clear understanding of scope of works and the GMP/TCC mechanism for the project concerned. Prompt valuation of variations could probably mitigate the potential disputes about quantum and nature of variations. In case of disagreement of such valuation, the contracting parties could refer to the dispute resolution mechanism in contract as soon as possible to avoid affecting other construction works at the construction stage. The above two items appear to be fair to the both sides and hopefully can keep the number of disputes to a minimum.

5.7 Chapter Summary

This chapter has reported on the findings of an empirical questionnaire survey on risk identification and assessment, preference of risk allocation and effectiveness of risk mitigation measures of TCC/GMP in Hong Kong. A five-level data analysis framework was applied in data analysis on risk assessment of TCC/GMP, the research findings showed that the client group, contractor group and consultant group are in general agreement on the impact of individual risks. The top five perceived risk factors are (1) "change in scope of works"; (2) "insufficient design completion during tender invitation"; (3) "unforeseeable design development risks at tender stage"; (4) "errors and omissions in tender document" and (5) "exchange rate variations".

The Kendall's concordance analysis revealed that the client group and contractor group held a significant agreement on the ranking exercise. The Spearman's rank correlation test indicated that all of the three respondent groups (i.e. client group, contractor group and consultant group) shared a general association on the rankings of the 34 risks identified from the questionnaire survey. The Mann-Whitney U tests reflected that there were statistically significant differences in perceptions of 8 risks out of 34 risks. Such differences in perceptions may be due to the roles played by different contracting parties under the construction development. This view is also supported by a recent study by Lam and Wong (2011) regarding comparison between the views of clients and contractors towards buildability of project design. Lam and Wong (2011) concluded that the different roles played by clients and contractors within the project team of a construction project contribute to the differences in perceptions on buildability between the two groups.

The identification of the key risk factors and their relative significance are important in the risk management of target cost contracts and guaranteed maximum price projects, which, if properly done, would enhance the value for money throughout the whole procurement process.

The findings on risk allocation shows that the respondents considered that risks on tender documentation and project design are better borne by clients, while construction related risks are perceived to be taken by contractors. The research findings are consistent with other similar studies on risk allocation in construction projects in general.

Regarding the findings on effectiveness of risk mitigation measures, the results of factor analysis revealed that the 18 individual risk mitigation strategies can be consolidated into 7 underlying grouped factors: (1) Relational contracting and mutual trust; (2) Clear contract provisions and well-defined scope of works; (3) Involvement of contractor in decision making process; (4) Right selection of project team; (5) Third party review of project design at tender stage; (6) Standard contract clauses for TCC/GMP schemes; and (7) Fair dealing with contractor. The development of a Fuzzy Risk Assessment Model will be introduced in the next chapter.

6.0

DEVELOPMENT OF A FUZZY RISK ASSESSMENT MODEL (FRAM)

CHAPTER 6 – DEVELOPMENT OF A FUZZY RISK ASSESSMENT MODEL (FRAM)

6.1 Introduction

There have been plenty of research studies on TCC and GMP which align the benefits of owners and those of contractors together. However, not many of them have focused on the risk identification and assessment of projects procured with such kinds of contractual arrangements. This chapter reports on the development of a risk assessment model associated with TCC and GMP construction projects by means of factor analysis and fuzzy synthetic evaluation method on the opinions gleaned from the previous questionnaire survey, to enable a more objective risk assessment. An overall risk index (ORI) of a project and risk indices of individual principal risk groups (PRGs) can be generated from the model. The development of this model enhances the understanding of the project team for implementing a successful TCC/GMP project. It also provides a platform for measuring the risk level of the projects based on objective evidence instead of subjective judgments. The findings discussed in this chapter have been included in a published journal article of Chan et al. (2011b).

6.2 Overall Research Framework

6.2.1 Literature Review

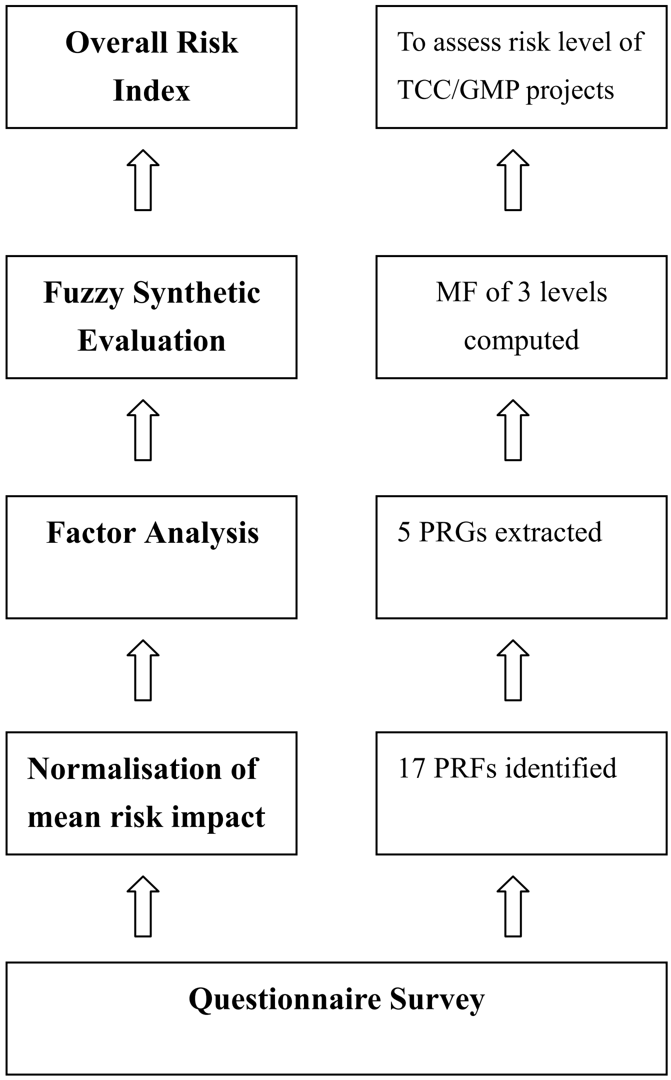
Figure 6.1 illustrates the overall research framework for developing the fuzzy risk assessment model. Risk management is a key element of procuring TCC/GMP projects and risk identification is the first step towards risk management. A total of 34 individual key risk factors associated with TCC/GMP contracts were identified through a comprehensive literature review of the relevant textbooks, refereed journals, conference proceedings, research reports, company newsletters, previous dissertations, online resources, etc. Therefore, the list of 34 key risk factors in relation to TCC/GMP contracts was considered to be sufficient, relevant and representative.

6.2.2 Structured Interviews

Seven structured interviews with experienced industrial practitioners with adequate hands-on practical experience in the TCC/GMP procurement approach (the results already reported in ***Chapter 4***). The interviewees suggested that the "nature of variations", "change in scope of works", "quality and clarity of tender documents", "unforeseen ground conditions", "fluctuation of material prices", and "approval from regulatory bodies for alternative cost saving designs", were the common key risk factors associated with TCC/GMP construction projects in Hong Kong (Chan *et al.*, 2010c). The result of the interviews enabled the fine-tuning of the empirical research questionnaire.

6.2.3 Empirical Questionnaire Survey

As mentioned in Chapter 5, the empirical questionnaire survey was launched in March 2009 after the pilot test. A total of 300 self-administered blank survey forms were distributed to construction professionals associated with the Hong Kong construction industry. The completed forms were collected through postal mails, electronic mails, faxes as well as personal networking. The respondents were requested to rate the level of severity and likelihood of occurrence of the 34 key risks elicited on the survey form, with a Likert Scale from 1 to 5 (where 1 = very low and 5 = very high) for severity and from 1 to 7 (where 1 = very very low and 7 = very very high) for likelihood. They were welcome to add any extra risk factors not yet mentioned on the survey form based on their personal discretion and actual experience, but no additional risk was ultimately suggested by them. A total of 141 valid and duly completed forms were returned, yielding a response rate of 47%. Among these 141 respondents, 47 of them declared that they had "No hands-on experience in procuring TCC/GMP construction projects" and they were advised not to complete the survey forms and return the forms for record. The remaining 94 respondents either had acquired hands-on experience in procuring TCC/GMP projects or they declared to have a basic understanding of the underlying principles of TCC/GMP schemes via conferences, seminars, workshops, journals and internal sharing from their counterparts even though without the direct exposure to TCC/GMP contracts before. Such screening enabled the researcher to make sure that the respondents have gained a basic understanding of TCC/GMP underlying principles so as to improve the creditability of survey results. Therefore, only the data and opinions obtained from these 94 responses were used for further statistical analysis. The profiles of survey respondents are depicted in ***Chapter 5***.



*Note: * Refer to Figure 5.2 in Section 5.6*

Figure 6.1 Overall Research Framework Adopted in Developing the Fuzzy Risk Assessment Model (FRAM)

Factor Analysis

The purpose of factor analysis (FA) is to reduce a large number of observed variables to a smaller number of factors with a minimum loss of information and reveal the inter-relationship between variables (Hair *et al.*, 1998). Principal components analysis was performed for factor analysis and the equamax rotation method with Kaiser Normalisation was conducted. The aim of principal components analysis is to derive a smaller number of variables in order to convey as much information in the 17 risk factors crystallised by normalisation of the combined mean scores as possible. The underlying principles and details of factor analysis have been introduced in Chapter 5.

Fuzzy Synthetic Evaluation Method

It is commonly accepted that risk assessment is a typical multi-objective problem because it is affected by many uncertainties and variations. In order to facilitate the decision-making process for these problems, fuzzy set theory and fuzzy synthetic evaluation model were employed to develop the risk assessment model in this study. (Zhang et al, 2004)

Fuzzy Synthetic Evaluation was applied to this study to derive the Risk Index of each Principal Risk Group (PRG) and also the Overall Risk Index (ORI) of TCC/GMP projects in Hong Kong.

A fuzzy synthetic evaluation model requires three basic elements:

1. A set of basic criteria/factors $\pi = \{f_1, f_2, ..., f_m\}$;
2. A set of grade alternatives $E = \{e_1, e_2, ...e_n\}$;
3. For every object $u \notin U$, there is an evaluation matrix $R = (r_{ij})_{m \times n}$. In the fuzzy environment, r_{ij} is the degree to which alternative e_j satisfies the

criterion f_j. It is presented by the fuzzy membership function of grade alternative e_j with respect to the criterion f_j.

With the preceding three elements, for a given $u \notin U$, its evaluation result can be derived.

The risk assessment of TCC/GMP projects involves a considerable number of PRFs and PRGs. All PRFs and PRGs should be taken into consideration to enable an effective risk assessment. It is therefore desirable if the synthetic evaluation method in this study can tackle problems with multi-attributes and multi-levels. Fuzzy Synthetic Evaluation, which is one of the applications of fuzzy set theory, was applied in this study to develop a fuzzy risk assessment model for TCC/GMP projects in Hong Kong.

According to Tah and Carr (2000), fuzzy sets can be used to quantify the linguistic variables and severity for risk assessment of construction projects. Zhang *et al*. (2004) suggested that it is always problematic to define uncertain information input for construction-oriented discrete-event simulation. Thus, they proposed incorporating Fuzzy Set Theory with discrete-event simulation to handle the vagueness, imprecision and subjectivity in the estimation of activity durations, particularly when insufficient or no sample data are available. Moreover, Baloi and Price (2003) applied the Fuzzy Set Theory in their study in which a model was developed as a decision framework for contractors to handle global risk factors affecting cost performance.

It is also recommended that fuzzy set theory can be employed to model construction issues where the process was only available in the mind of experienced practitioners (Knight and Fayek, 2002). Both Chen and Cheng (2009) and Zeng and Smith (2007) held a similar view that fuzzy set theory should be applied when handling vague information because of its ability to use natural language in terms of linguistic variables. Since the risk assessment in construction is mainly based on the individual intuition and experience (Flanagan and Norman, 1993), the method of fuzzy synthetic evaluation can be applied in this study to cope with the use of linguistic variables such as "high" and "very high" and to allow for ranking or subjective rating of various risk factors (Knight and Fayek, 2002; Singh et al., 2008).

This method was also applied in research in fields other than construction management. For example, Lu *et al.* (1999) applied fuzzy synthetic evaluation in the analysis of water quality in Taiwan and found that change in water quality was expressed in such evaluation. Singh *et al*. (2008) employed the same method for the assessment of physico-chemical quality of groundwater for drinking purpose in India. Subjective judgments of evaluators are involved in the risk assessment of TCC/GMP projects. Fuzzy synthetic evaluation is thus considered to be a suitable tool to develop the risk assessment model for TCC/GMP contracts due to the nature of risk assessment which is usually multi-layered (Sadiq et al., 2004), fuzzy in nature and involving subjective judgments.

6.3 Selection of Principal Risk Factors by Normalisation of Mean Combined Scores

It is generally accepted that the impact of a risk is computed by multiplying its level of severity and likelihood of occurrence (Cox and Townsend, 1998; Garlick, 2007). The risk impact of the 34 risks in the survey was computed by this approach. The combined scores of the 34 risks are presented in Table 6.1. The normalised value of each risk factor is derived by the formula below:

Normalised value of impact =
(Average actual value – Average minimum value) / (Average maximum value – Average minimum value)

Muller and Turner (2010) examined the leadership competency profiles of successful project managers in different kinds of projects via a questionnaire survey. The mean of normalised scores of competencies was used as a demarcation point in catagorising the profiles of project managers in their survey. The same logic was adopted in this study and the mean of all of the 34 normalised values was found to be 0.49. Hence, the value of 0.49 was used as the demarcation point for normalisation to select only those upper half "more important" risk factors with normalised values equal to or larger than 0.49 for conducting the subsequent factor analysis. Table 6.1 reveals that there are 17 risk factors with normalised values equal to or greater than 0.49 and they were selected for performing factor analysis.

The main reason for conducting such normalisation of mean scores is that a more manageable number of risk factors can be extracted through this process, considering the fact that industrial practitioners would prefer a model which is more user-friendly and requires fewer inputs for application (Yeung et al, 2007). Such selection also complies with the prerequisite of the factor analysis technique, which requires a ratio of 1: 5 for variables under study to sample size (Gorsuch, 1983; Lingard and Rowlinson, 2006).

Another reason for conducting such normalisation is that one of the important objectives of developing the model was practicality/user-friendliness. It would be more desirable to reduce the number of risk factors involved in the model, since the users would be required to input their perceived severity and likelihood of each risk factor included in the model, in order to generate the Overall Risk Index and identify the most critical Principal Risk Group. If all the risk factors are included, the users have to enter 68 inputs (34 risk factors in total x 2 entities for each risk factor) in the model to obtain the results. It would be too demanding for the industrial practitioners to input such a huge amount of data in the model. It is thus necessary to conduct normalisation to strike a balance between the comprehensiveness of risk factors included in the model and practicality/user-friendliness of the model.

As observed from Table 6.1, the eliminated risk factors seem not very critical in the construction industry. For example, it seems to be reasonable that Item 25 "Delayed payment on contracts" was eliminated after normalisation. The contractors are well protected by commonly applied standard forms of contracts in both building and civil engineering works in Hong Kong (referring to Clause 79(4)(a) in the General Conditions of Contract for Building Works of the

HKSAR Government and Clause 51.2 in NEC3 Option C: Target Cost with Activity Schedule) from their payments being delayed by the employers. The respondents may not consider this to be a severe risk for TCC/GMP projects, since if non-payment situations do occur, they would affect all types of contracts given a defaulting client. Similar findings were obtained by El-Sayegh (2008) and Ahmed et al. (1999).

Furthermore, Item 13 "Delay in availability of labour, materials and equipment" was eliminated after the normalisation exercise. This result matches with the findings by Tam et al. (2007) in which the same factor was ranked as the 17th out of 24 risk factors by the Architect respondent group and as the 14th by the Engineer respondent group in their questionnaire survey on risks in public foundation projects in Hong Kong. On the other hand, Item 30 "Change in relevant government regulations" was dropped out after normalisation which echoes the findings by Tam et al (2007) that "change in statutory requirements" was only ranked as the 20th out of 24 risk factors by both Architect group and Engineer group. Thus, the survey results of this study are consistent with previous research studies and regarded as logical and reasonable.

6.4 Identification of 5 Principal Risk Groups (PRGs) for TCC/GMP Projects in Hong Kong

The impact of a single risk factor (RF) was measured by the product of the level of severity and likelihood of occurrence. Based on the results of the normalisation, a taxonomy was developed with factor analysis which explored the structure of inter-relationship amongst data by defining a set of common underlying constructs known as factors (Roshe, 1988). The appropriateness of applying factor analysis was examined by the KMO test and the Barlett's test of sphericity. The KMO value of factor analysis on the 17 risks was 0.810 which was higher than the threshold requirement of 0.50 (Norusis, 1993). The value of test statistic for sphericity was large (chi-square = 681.79) and the associated significance level was small (p-value < 0.001), implying that the population matrix was not an identity matrix. Moreover, the internal consistency of factor analysis was tested by examining the value of Cronbach's alpha for both "severity" and "likelihood". The overall alpha values for severity and likelihood were 0.924 and 0.936 respectively, which are much higher than 0.50 as applied in Lu and Yan (2007)'s questionnaire survey, indicating a high degree of internal consistency between the 5 PRGs. As the requirements of KMO value and Barlett's test of sphericity were both fulfilled, factor analysis could be conducted with confidence in this study.

Equamax rotation method with Kaiser normalisation being conducted through the SPSS FACTOR program. The method of Equamax rotation gives the highest individual factor loadings for the same set of individual factors and more interpretable overall results as applied and recommended by both Abraham *et al.* (1994) and Emsley *et al.* (2003). The aim of principal components analysis is to derive a smaller number of variables in order to convey as much information about the top 17 key risk factors crystallised by normalisation of combined mean scores as possible out of a total of 34. Factor loadings of each factor are shown in Table 6.2 to explain the correlation between the risks and the PRGs. These loadings give an indication of the extent to which the risks are influential in forming the PRGs. As seen in Table 6.2, five PRGs were extracted in this case, totally accounted for 69% of the variance in responses. They include: (1) Third party delay and tender inadequacy; (2) Post-contract risks; (3) Lack of experience in TCC/GMP process; (4) Design documentation risks; and (5) Economic and financial risks.

Table 6.1 Result of Normalisation of Risk Factors by Mean Combined Scores

ID	Risk factors	Severity	Likelihood	Impact	Rank	Normalised Value
5	**Change in scope of work**	**3.53**	**4.48**	**15.84**	**1**	**1.00**
17	**Insufficient design completion during tender invitation**	**3.47**	**4.30**	**14.93**	**2**	**0.88**
20	**Unforeseeable design development risks at tender stage**	**3.38**	**4.13**	**13.98**	**3**	**0.74**
6	**Errors and omissions in tender document**	**3.44**	**4.05**	**13.97**	**4**	**0.74**
21	**Exchange rate variations**	**3.31**	**4.19**	**13.86**	**5**	**0.73**
29	**Unforeseeable ground conditions**	**3.50**	**3.93**	**13.76**	**6**	**0.71**
3	**Unrealistic maximum price or target cost agreed in the contract**	**3.66**	**3.64**	**13.30**	**7**	**0.65**
1	**Actual quantities of work required far exceeding estimate**	**3.46**	**3.83**	**13.27**	**8**	**0.65**
22	**Inflation beyond expectation**	**3.34**	**3.91**	**13.08**	**9**	**0.62**
32	**Lack of experience of contracting parties throughout GMP/TCC process**	**3.30**	**3.93**	**12.99**	**10**	**0.61**
26	**Global financial crisis**	**3.70**	**3.50**	**12.94**	**11**	**0.60**
4	**Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor**	**3.21**	**4.02**	**12.93**	**12**	**0.60**
18	**Poor buildability / constructability of project design**	**3.40**	**3.77**	**12.82**	**13**	**0.59**
2	**Delay in resolving contractual disputes**	**3.28**	**3.88**	**12.72**	**14**	**0.57**
9	**Loss incurred by main contractor due to unclear scope of work**	**3.46**	**3.62**	**12.54**	**15**	**0.55**
7	**Difficult for main contractor to have back-to-back GMP/TCC contract terms with nominated or domestic subcontractors**	**2.97**	**4.21**	**12.49**	**16**	**0.54**
16	**Delay in work due to third party**	**3.24**	**3.81**	**12.37**	**17**	**0.52**
28	Inclement weather	2.92	4.11	12.01	18	0.47
8	Inaccurate topographical data at tender stage	3.24	3.65	11.84	19	0.45
15	Selection of subcontractors with unsatisfactory performance	3.34	3.52	11.76	20	0.44
19	Little involvement of main contractor in design development process	2.98	3.92	11.68	21	0.43
31	Difficult to obtain statutory approval for alternative cost saving designs	3.16	3.69	11.65	22	0.42
33	Impact of construction project on surrounding environment	3.11	3.69	11.48	23	0.40
11	Technical complexity and design innovations requiring new construction methods and materials	3.18	3.57	11.35	24	0.38

	from main contractor					
12	Poor quality of work	3.19	3.53	11.25	25	0.37
23	Market risk due to the mismatch of prevailing demand of real estate	3.06	3.64	11.14	26	0.35
24	Change in interest rate on main contractor's working capital	2.97	3.54	10.50	27	0.27
13	Delay in availability of labour, materials and equipment	3.10	3.37	10.46	28	0.26
34	Environmental hazards of constructed facilities towards the community	3.04	3.40	10.34	29	0.24
10	Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage	3.06	3.37	10.29	30	0.24
30	Change in relevant government regulations	3.00	3.42	10.27	31	0.23
25	Delayed payment on contracts	3.07	3.31	10.14	32	0.22
14	Low productivity of labour and equipment	3.02	3.19	9.63	33	0.15
27	Force Majeure (Acts of God)	3.24	2.64	8.56	34	0.00

Normalised value = (average actual value – average minimum value)/
(average maximum value – average minimum value)

Table 6.2 Principal Risk Groups of TCC/GMP projects extracted by Factor Analysis

No.	Item	Factor loading	Eigenvalue	Percent of variance explained	Cumulative percent of variance explained
PRG 1 – Third party delay and tender inadequacy					
16	Delay in work due to third party	0.670	6.857	40.338	40.338
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor	0.645			
3	Unrealistic maximum price or target cost agreed in the contract	0.577			
20	Unforeseeable design development risks at tender stage	0.575			
18	Poor buildability / constructability of project design	0.554			
17	Insufficient design completion during tender invitation	0.498			
PRG 2 – Post-contract risks					
7	Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors	0.849	1.500	8.822	49.159
1	Actual quantities of work required far exceeding estimate	0.718			
2	Delay in resolving contractual disputes	0.634			
9	Loss incurred by main contractor due to unclear scope of work	0.501			
PRG 3 – Lack of experience in TCC/GMP process					
32	Lack of experience of contracting parties throughout TCC/GMP process	0.878	1.217	7.157	56.316
PRG 4 – Design documentation risks					
5	Change in scope of work	0.821	1.119	6.581	62.897
29	Unforeseeable ground conditions	0.557			
6	Errors and omissions in tender document	0.483			

PRG 5 – Economic and financial risks					
26	Global financial crisis	0.783	1.046	6.154	69.051
21	Exchange rate variations	0.727			
22	Inflation beyond expectation	0.606			

6.5 Development of Weightings of the 17 PRFs and 5 PRGs for TCC/GMP projects in Hong Kong

The next step of developing the fuzzy risk assessment model for TCC/GMP projects is to derive the weightings of each PRF and each PRG. The weightings for each of the 17 PRFs and 5 PRGs were derived by the formula below (Chow, 2005; Yeung *et al*, 2007):

$$W_i = \frac{M_i}{\sum_{i=1}^{5} M_i}$$

where: W_i represents the weighting of a particular PRF/PRG;
M_i represents the mean ratings of a particular PRF/PRG;

$\sum M_i$ represents the summation of mean ratings of all the PRFs/PRGs.

The approach employed in this study is supported by previous researchers (Chow, 2005; Menches et al., 2006; Yeung et al., 2007; Yeung et al., 2009). Since the formula of calculating the weightings was supported by a number of previous research studies, the researcher applied the same approach and computed the M_i based on ordinal scale of measurement in this thesis.

Within the research demain of construction management, it is common for scholars to calculate the means (averages) based on an ordinal scale. For example, Li et al. (2005) computed the means of risks in public-private partnership (PPP) in Mainland China and ranked their importance with descending order of the mean score. Ng et al. (2005) also employed the same approach to determine the importance of factors of safety performance evaluation in their research. In addition, in a recent study by Cheung and Chan (2011), the attractive factors and negative factors of adopting PPP were ranked in descending order of mean scores, in order to determine their levels of importance.

The weightings of each PRF and PRG are presented in Table 6.3.

Table 6.3 Weightings of PRFs and PRGs

ID	CRF	Severity				Likelihood			
		Mean of Severity (A)	Weighting for each PRF (B)	Total Mean for each PRG (D)	Weighting of each PRG (E)	Mean of Likelihood	Weighting for each PRF	Total Mean for each PRG	Weighting of each PRG
16	Delay in work due to third party	3.24	0.16			3.81	0.16		
4	Disagreement ove r e valuating the revised contract pric e after submitting an alternative design by main contractor	3.21	0.16			4.02	0.17		
3	Unrealistic maximum price or target cost agreed in the contract	3.66	0.18			3.64	0.15		
20	Unforeseeable design development risks at tender stage	3.38	0.17			4.13	0.17		
18	Poor buildability / constructability of project design	3.40	0.16			3.77	0.16		
17	Insufficient design completion during tender invitation	3.47	0.17			4.30	0.19		
	Third Party Delay and Tender Inadequacy			**20.36**	**0.35**			**23.67**	**0.35**
7	Difficult fo r main cont ractor t o have ba ck-to-back TCC/GMP contract terms with nominated or domestic subcontractors	2.97	0.23			4.21	0.27		
1	Actual quantities of work required far exceeding estimate	3.45	0.26			3.83	0.25		
2	Delay in resolving contractual disputes	3.28	0.25			3.88	0.25		
9	Loss incurred by main contractor due to unclear scope of work	3.46	0.26			3.62	0.23		
	Pos t-contract Risks			**13.16**	**0.23**			**15.54**	**0.23**
32	Lack o f experience of c ontracting parties t hroughout TC C/GMP process	3.30	1.00			3.93	1.00		
	Lack of Experience in TCC/GMP Process			**3.30**	**0.06**			**3.93**	**0.06**
5	Change in scope of work	3.53	0.34			4.47	0.36		
29	Unforeseeable ground conditio	3.50	0.33			3.93	0.32		
6	Errors and omissions in tender document	3.44	0.33			4.05	0.33		
	Design Documentation Risks			**10.47**	**0.18**			**12.45**	**0.19**
26	Global financial crisis	3.70	0.36			3.50	0.30		
21	Exchange rate variations	3.31	0.32			4.19	0.36		
22	Inflation beyond expectatio	3.34	0.32			3.91	0.34		
	Economic and Financial Risks			**10.35**	**0.18**			**11.60**	**0.17**
	Total			57.64				67.19	

Notes: D = Sum of A of each PRG, B =A/D and E = D of each PRG/Sum of D

6.6 Computation of Membership Function of each PRF and PRG

A total of 17 PRFs of TCC/GMP projects were identified from normalisation of combined mean scores. Suppose that the set of basic criteria in fuzzy risk assessment model to be $\pi = \{f_1, f_2, ..., f_{16}\};$ and the grades for selection are defined as $E = \{1,2,3,4,5\}$ where 1 = very low; 2 = low; 3 = moderate; 4 = high; and 5 = very high. For each particular CRF, the membership function can be formed by the evaluation of respondents from the survey. For example, the survey results on the "Actual quantities of work required far exceeding estimate" indicated that 2% of the respondents opined this risk as very low, 17% as low; 33% as moderate; 33% as high and 18% as very high, therefore the membership function of this risk is:

$$C1 = \frac{0.02}{verylow} + \frac{0.17}{low} + \frac{0.33}{moderate} + \frac{0.33}{high} + \frac{0.18}{veryhigh}$$

$$C1 = \frac{0.02}{1} + \frac{0.17}{2} + \frac{0.33}{3} + \frac{0.30}{4} + \frac{0.18}{5}$$

The membership function can also be expressed as (0.02, 0.17, 0.33, 0.30, 0.18). The process of calculation of membership functions and Overall Risk Index are illustrated in Figure 6.2 . The membership functions of other PRFs and the 5 PRGs for both severity and likelihood are computed in Table 6.4 and Table 6.5 respectively.

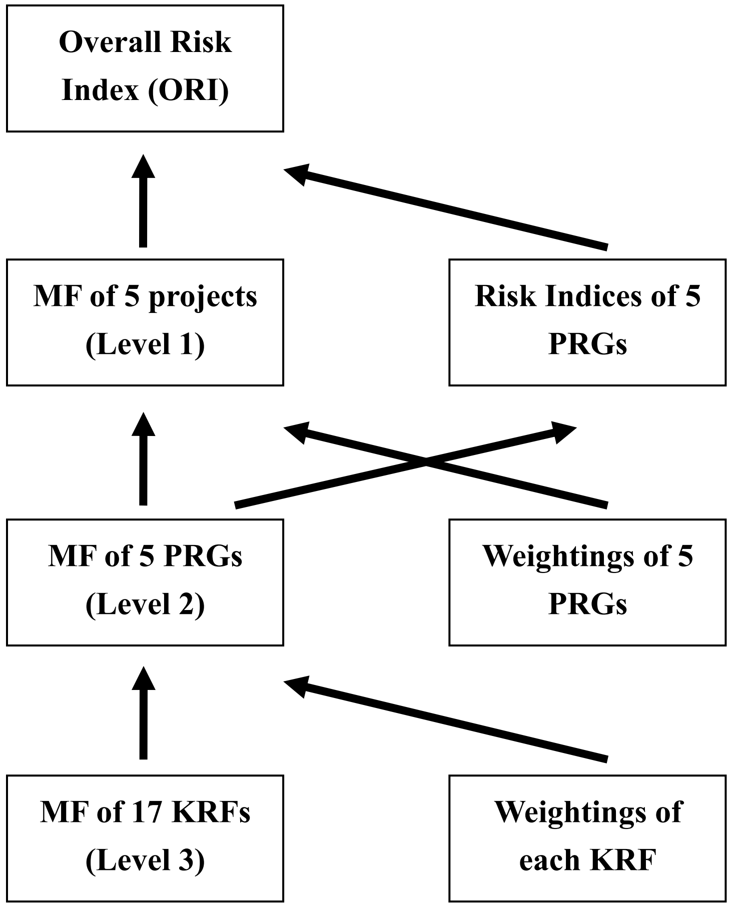


Figure 6.2 Computation of Membership Functions and Overall Risk Index

Table 6.4. Membership Functions of all PRFs for TCC/GMP projects in Hong Kong (Risk Severity)

ID	Principal Risk Factors	W	Membership Function of Level 3	Membership Function of Level 2
16	Delay in work due to third party	0.16	(0.01,0.21,0.38,0.32,0.08)	**(0.03,0.16,0.34,0.35,0.12)**
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor	0.16	(0.05,0.17,0.40,0.29,0.09)	
3	Unrealistic maximum price or target cost agreed in the contract	0.18	(0.01,0.12,0.28,0.38,0.21)	
20	Unforeseeable design development risks at tender stage	0.17	(0.03,0.15,0.33,0.39,0.10)	
18	Poor buildability / constructability of project design	0.16	(0.03,0.16,0.35,0.29,0.17)	
17	Insufficient design completion during tender invitation	0.17	(0.04,0.13,0.30,0.40,0.13)	
7	Difficult for main contractor to have back-to-back GMP/TCC contract terms with nominated or domestic subcontractors	0.23	(0.10,0.19,0.43,0.20,0.08)	**(0.04,0.17,0.36,0.30,0.13)**

1	Actual quantities of work required far exceeding estimate	0.26	(0.02,0.17,0.33,0.30,0.18)	
2	Delay in resolving contractual disputes	0.25	(0.02,0.18,0.38,0.33,0.09)	
9	Loss incurred by main contractor due to unclear scope of work	0.26	(0.04,0.13,0.30,0.37,0.16)	
32	Lack of experience of contracting parties throughout TCC/ GMP process	1.00	(0.08,0.16,0.27,0.37,0.12)	**(0.08,0.16,0.27,0.37,0.12)**
5	Change in scope of work	0.34	(0.03,0.10,0.37,0.30,0.20)	**(0.02,0.12,0.35,0.35,0.16)**
29	Unforeseeable ground conditions	0.33	(0.02,0.14,0.30,0.39,0.15)	
6	Errors and omissions in tender document	0.33	(0.02,0.12,0.37,0.37,0.12)	
26	Global financial crisis	0.36	(0.07,0.09,0.26,0.25,0.33)	**(0.06,0.13,0.32,0.31,0.18)**
21	Exchange rate variations	0.32	(0.03,0.18,0.33,0.36,0.10)	
22	Inflation beyond expectation	0.32	(0.07,0.11,0.37,0.32,0.13)	

W: Weightings

Table 6.5 Membership Functions of all PRFs for TCC/GMP projects in Hong Kong (Risk Likelihood)

ID	Principal Risk Factors	W	Membership Function of Level 3	Membership Function of Level 2
16	Delay in work due to third party	0.16	(0.01,0.13,0.27,0.34,0.14,0.09,0.02)	**(0.04,0.11,0.22,0.32, 0.16,0.11,0.04)**
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor	0.16	(0.03,0.11,0.21,0.33,0.14,0.12,0.06)	
3	Unrealistic maximum price or target cost agreed in the contract	0.18	(0.09,0.16,0.19,0.30,0.15,0.07,0.04)	
20	Unforeseeable design development risks at tender stage	0.17	(0.04,0.08,0.19,0.33,0.17,0.12,0.07)	
18	Poor buildability / constructability of project design	0.16	(0.04,0.12,0.24,0.33,0.17,0.12,0.07)	
17	Insufficient design completion during tender invitation	0.17	(0.02,0.07,0.20,0.29,0.19,0.19,0.04)	
7	Difficult for main contractor to have back-to-back GMP/TCC contract terms with nominated or domestic subcontractors	0.23	(0.07,0.14,0.12,0.20,0.22,0.17,0.08)	**(0.07,0.14,0.19,0.26, 0.20,0.10,0.04)**
1	Actual quantities of work required far exceeding estimate	0.26	(0.07,0.14,0.12,0.20,0.22,0.17,0.08)	
2	Delay in resolving contractual disputes	0.25	(0.03,0.14,0.16,0.36,0.23,0.04,0.04)	
9	Loss incurred by main contractor due to unclear scope of work	0.26	(0.09,0.10,0.29,0.28,0.13,0.09,0.02)	

32	Lack of experience of contracting parties throughout TCC/GMP process	1.00	(0.03,0.11,0.26,0.24,0.24,0.10,0.02)	**(0.03,0.11,0.26,0.24, 0.24,0.10,0.02)**
5	Change in scope of work	0.34	(0.03,0.11,0.26,0.24,0.24,0.10,0.02)	**(0.03,0.14,0.14,0.28, 0.22,0.13,0.06)**
29	Unforeseeable ground conditions	0.33	(0.03,0.17,0.12,0.34,0.23,0.07,0.04)	
6	Errors and omissions in tender document	0.33	(0.02,0.16,0.18,0.25,0.21,0.11,0.07)	
26	Global financial crisis	0.36	(0.09,0.20,0.22,0.28,0.10,0.04,0.07)	**(0.05,0.13,0.21,0.33, 0.15,0.07,0.06)**
21	Exchange rate variations	0.32	(0.02,0.11,0.18,0.20,0.19,0.13,0.07)	
22	Inflation beyond expectation	0.32	(0.03,0.07,0.23,0.41,0.19,0.04,0.03)	

W: Weighting

6.7 Development of a Fuzzy Synthetic Evaluation Model for TCC/GMP Projects in Hong Kong

After developing appropriate weightings for the PRFs and the PRGs for TCC/GMP projects in Hong Kong, together with the fuzzy membership functions for each PRF, a total of 4 models were considered to determine the results of the evaluation (Lo, 1999).

Model 1: M (∧, ∨),

$$bj = \bigvee_{i=1}^{m}(wi \wedge rij) \qquad \forall bj \in B$$

$$bj = \bigvee_{i=1}^{m}(wi \times rij) \qquad \forall bj \in B$$

Model 2: M (•,∨),

Both Model 1 and Model 2 are suitable for single-item problems because only the major criteria are considered; other minor criteria are ignored (Lo, 1999). However, the calculation of the ORI involves multi-criteria, each PRF should have its influence to the overall risk level. Models 1 and 2 are therefore considered not suitable for this study.

Model 3: M (•,⊕), $$bj = \min(1, \sum_{i=1}^{m} wi \times rij) \qquad \forall bj \in B$$

Model 4: M (∧, +), $$bj = \sum_{i=1}^{m} (wi \wedge rij) \qquad \forall bj \in B$$

The symbol ⊕ in Model 3 represents the summation of product of weighting and membership function. Model 3 is suitable when many criteria are considered and the difference in the weighting of each criterion is not great. Model 4 will miss some information with smaller weightings. Therefore, it yields similar results to those derived from Models 1 and 2. To conclude, Model 3 is suitable for calculating the ORI for TCC/GMP projects amongst the four models, since the differences of weightings for PRFs are not great and calculation of ORI involves many criteria (PRFs).

It should be noted that there are three levels of membership function. Level 3 refers to each of 17 PRFs. Level 2 refers to each of the 5 PRGs and Level 1 refers to the ORI. Let ORI_A denote the ORI of TCC/GMP projects in Hong Kong. W and R denote the weighting and membership function of each PRF (Level 2). The results of fuzzy synthetic evaluation are presented in Table 6.6.

After deriving the membership function of Level 1, the ORI can be calculated using the following equation:

$$ORI_A = \sum_{k=1}^{5} (W \times R_k) \times L$$

where ORI_A is the Overall Risk Index;

W is the weighting of each PRF;

R is the degree of membership function of each PRF;

L is the linguistic variable where 1 = very low; 2 = low; 3 = moderate, 4 = high; and 5 = very high (for severity) and 1 = very very low; 2 = very low; 3 = low; 4 = moderate; 5 = high; 6 = very high and 7 = very very high (for likelihood)

Table 6.6 Results of Fuzzy Synthetic Evaluation for all PRGs of TCC/GMP projects in Hong Kong

	Principal Risk Group	Weighting	Membership Function for Level 2	Membership Function for Level 1
Risk Severity (from Level 2 to Level 1)	Third Party Delay and Tender Inadequacy	0.35	(0.03,0.16,0.34,0.35,0.12)	(0.04,0.15,0.34,0.33,0.14)
	Post-contract Risks	0.23	(0.04,0.17,0.36,0.30,0.13)	
	Lack of Experience in TCC/GMP Process	0.06	(0.08,0.16,0.27,0.37,0.12)	
	Design Documentation Risks	0.18	(0.02,0.12,0.35,0.35,0.16)	
	Economic and Financial Risks	0.18	(0.06,0.13,0.32,0.31,0.18)	
Risk Likelihood (from Level 2 to Level 1)	Third Party Delay and Tender Inadequacy	0.35	(0.04,0.11,0.22,0.31,0.16,0.11,0.04)	(0.05,0.13,0.20,0.30,0.18, 0.11,0.05)
	Post-contract Risks	0.23	(0.07,0.14,0.19,0.26,0.20,0.10,0.04)	
	Lack of Experience in TCC/GMP Process	0.06	(0.03,0.11,0.26,0.24,0.24,0.10,0.02)	
	Design Documentation Risks	0.18	(0.03,0.14,0.14,0.28,0.22,0.13,0.06)	
	Economic and Financial Risks	0.18	(0.05,0.13,0.21,0.33,0.15,0.07,0.06)	

Notes: Membership Function (MF) of Level 1 = sum-product of weighting and MF of Level 2

The Overall Risk Index (ORI) of TCC/GMP projects in Hong Kong

= (0.04 x 1 + 0.15 x 2 + 0.34 x 3 + 0.33 x 4 + 0.14 x 5) x
(0.05 x 1 + 0.13 x 2 + 0.20 x 3 + 0.30 x 4 + 0.18 x 5 + 0.11 x 6 + 0.05 x 7)

= 3.38 x 4.02

= 13.59

The results generated by the Fuzzy Synthetic Evaluation indicates that the ORI of TCC/GMP projects is 13.59 which is considered as higher than "moderate" since it is higher than the value of 12 (severity = 3 x likelihood = 4). Furthermore, to have an in-depth analysis, the Risk Index of a particular PRG can also be calculated in the same way. The results are presented in Table 6.7.

Table 6.7 Risk Indices of Principal Risk Groups of TCC/GMP Projects in Hong Kong

Principal Risk Groups	**Severity**	**Likelihood**	**Risk Index**
1. Third Party Delay and Tender Inadequacy	3.37	3.94	13.28
2. Post-contract Risks	3.31	3.84	12.71
3. Lack of Experience in TCC/GMP Process	3.29	3.93	12.93
4. Design Documentation Risks	***3.51***	***4.15***	***14.57***
5. Economic and Financial Risks	3.42	3.85	13.17

According to Table 6.7, Design Documentation Risks were perceived as the most critical risk group with a risk index of 14.57, followed by Third party Delay and Tender Inadequacy with a risk index of 13.28. Economic and Financial Risks was ranked as the third with a risk index of 13.17, Lack of Experience in TCC/GMP Process being the fourth and Post-contract Risks the last. The above findings indicated that the nature of variations can be a significant risk in projects procured with TCC/GMP. Disputes may arise due to the changes in scope of work in such kind of procurement approach (Tang and Lam, 2003). The construction projects are dynamic with the external environment such as changes in market demand and economic situations.. The employers may change their mind due to such ever-changing environment and thus initiating more design changes at the post-contract stage of a development project. Since those unexpected changes in scope of work may generate a considerable number of GMP/TCC variations (Fan and Greenwood, 2004), it would prolong the overall development programme as well as incur significant cost to the projects concerned. Moreover, the extent of design development changes would also be difficult to define. Improper handling on these issues may provoke adversarial disputes and thus diminish the mutual trust and partnering relationship developed within the project team (Sadler, 2004).

6.8 Potential Applications of FRAM

At the pre-contract stage, the client/developer may input the assessment of the 17 KRFs into the Model to generate a risk index for using TCC and GMP scheme separately, then to determine whether applying TCC or GMP or none of them in the forthcoming construction projects. Another possible application of the FRAM is that the contractor may assess the risk level of the project if procured by a TCC/GMP contract during the peer-review process in bidding at tender stage and then decide to bid or not. The Overall Risk Index may also help the contractor to quantify the risk exposure of the projects and help in pricing in the bidding exercise.

At the post-contract stage, the project team members can input their assessment of the 17 KRFs to generate an Overall Risk Index to assess the risk level periodically in every monthly meeting for risk monitoring purpose. They can identify the most critical PRG so that they can pay more attention to managing the constituent component risks of such PRG and thus reducing the overall risk level subsequently.

Moreover, they may prioritise the risk groups to be dealt with according to their respective risk indices. For example, the project team would deal with design risks if the risk index of such risk group is the highest amongst the 5 PRGs. The model helps to indicate the priority of risk mitigation/management in this way.

Another possible application of the Model is that this model has established a norm of TCC/GMP projects in Hong Kong. If there are adequate numbers of samples/projects procured with TCC/GMP, a benchmarking model can be built up to help the industrial practitioners to benchmark the risk level of their own TCC/GMP projects, say the Overall Risk Index is 80% of the norm (i.e. lower than the norm) or 120% of the norm (i.e. higher than the norm).

The methodology of this model building is universal to every geographical region and hence the same research methodology can be applied to other regions using TCC/GMP forms of procurement to enable international comparisons of risk levels of TCC/GMP projects across different countries/regions. Alternatively, the same methodology can be adopted to measure and compare the risk level of construction projects procured with the traditional approach with the risk level of TCC/GMP projects.

6.9 Validation of the Risk Assessment Model

6.9.1 Purpose of the Validation Exercise

According to Chow (2005), verification and validation is an evaluation procedure to examine whether the research procedures are suitable and free of errors, and the new theories/framework/guidelines established from the research could meet the aim and objectives of the research or not. In general, it is a justification for its usefulness, practicality and appropriateness of the research.

The validation exercise, in the form of face-to-face interviews, was conducted in October 2010. Seven experts with direct hands-on experience in TCC/GMP construction projects in Hong Kong were invited to assess the: (1) Degree of Comprehensiveness of Risks included in the Model; (2) Degree of Clarity of the Model; (3) Degree of Objectivity of the Model; (4) Degree of Practicality of the Model; and (5) Overall Reliability of the Model.

The selection of experts was based on the following criteria to ensure the objectivity of the validation exercise:

1. Having hands-on experience in TCC/GMP construction project in Hong Kong
2. Having a wealth of working experience of at least 10 years in the construction industry in Hong Kong
3. Not yet participated in the questionnaire survey

The above selection criteria are in line with similar validation of models in construction management research. For example, Ng et al. (2010) developed a model for feasibility evaluation and project success for public-private partnerships (PPP) in Hong Kong. A total of eight interviews were launched for validating their model. Five interviewees were construction practitioners with experience of at least five years in the construction industry and with direct hands-on experience in PPP projects in Hong Kong. The remaining three interviewees were academics with experience of at least five years in research on PPP. Yeung et al. (2009) generated a computerised model for measuring the partnering performance of construction projects in Hong Kong. Seven experts were interviewed to validate their computerised model. All of the seven interviewees were construction practitioners in Hong Kong, with hands-on experience in partnering projects.

The fuzzy risk assessment model for TCC/GMP contracts was tailor-made for those projects based in Hong Kong. According to the lessons learned from previous research, it is logical to validate the model via some face-to-face interviews with industrial practitioners in Hong Kong who have obtained extensive knowledge and experience about the local practices of TCC/ GMP schemes. It should also be noted that the surveyed group and validation group were composed of separate and independent groups of experts to avoid possible bias on the validation results.

Individual invitations (see ***Appendix 6***) through electronic mails were sent to the target experts in early October 2010 and followed up by phone calls. The email message clearly explained the purpose of the validation exercise and the flow of the exercise which was as follows:

1. A short verbal presentation by the research student (about 15 minutes)
2. Question and Answer Session between the expert and student (about 10 minutes)
3. Completion of a validation questionnaire by the expert as attached in ***Appendix 7*** (about 5 minutes)

The Model was presented to the expert to make sure that they understand the background of this study, the process of how this Model was developed and the potential application of the Model during the face-to-face interviews. A Question and Answer Session was organised to offer them an opportunity to raise questions if they were in doubt about the contents of the presentation. Finally, the expert was requested to fill in a validation form with five multiple choice questions with a five-point Likert scale where 1 denoted "poor" and 5 denoted "excellent".

6.9.2 Results of Validation Exercise

The details of the validation experts were tabulated in Table 6.8. All of the seven experts have acquired a wealth of working experience in the construction industry of at least 20 years and they were all directly involved with at least one TCC/GMP construction project in Hong Kong. In addition, they took different roles in the projects concerned (client, consultant or contractor) and derived from the public and private sectors. Thus, the results of validation exercise are considered to be representative and reliable.

Table 6.8 Profile of Experts Participated in the Validation Exercise for Risk Assessment Model

GMP or TCC	GMP	GMP	GMP	GMP	TCC	TCC	TCC
Role of Experts	Client 1	Client 2	Con 1	Ctr 1	Client 3	Con 2	Ctr 2
Position	Senior Quantity Surveyor	Quantity Surveyor	Technical Director of Consultant QS Firm	Quantity Surveying Manager	Project Manager	Quantity Surveyor	Estimating Manager
Sector	Public	Public	Private	Private	Public	Private	Private
Years of Experience in construction industry	26	24	21	23	24	27	21
Number of GMP/TCC projects involved in	1	1	1	2	1	1	1

Notes: Con = Consultant; Ctr = Contractor

Table 6.9 Results of Validation Exercise for Risk Assessment Model

Validation Criteria	Scores rated by Experts							Average Scores
1. Degree of Comprehensiveness of Risks included in the Model	5	5	5	4	5	5	5	**4.86**
2. Degree of Clarity of the Model	4	5	4	4	3	4	4	**4.00**
3. Degree of Objectivity of the Model	5	4	4	5	5	5	4	**4.57**
4. Degree of Practicality of the Model	5	4	4	3	3	4	4	**3.86**
5. Overall Reliability of the Model	5	5	4	4	3	4	4	**4.14**

The average scores of all of the five criteria are well above 3.50 (Yeung, 2007), so the result confirmed that the Model is considered to be comprehensive, clear, objective, practical and reliable by the experts in the validation exercise.

However, three of the seven experts expressed that the naming of the Principal Risk Group 1 (PRG1) (initially named as "Pre-contract Risks") may not be the best one and may somewhat overlap with the PRG3 "Design Documentation Risks". Indeed, the naming of factors under Factor Analysis may be different due to the perceptions of different researchers (Norusis, 1993). In view of the comments received from the interviewees during the validation exercise, the labelling of the PRG1 was changed from "Pre-contract Risks" to "Third Party Delay and Tender Inadequacy" which may better reflect the nature of the risks categorised under this principal risk group after consulting the researcher's chief supervisor. Follow up phone calls were made to the three experts expressing their concerns about the naming, and they all found that the revised naming of the principal risk group was acceptable to reflect the nature of the risks in that group.

6.10 Chapter Summary

The development of an objective and comprehensive risk assessment model for TCC and GMP projects, with the concept of fuzzy synthetic evaluation model, is reported in this chapter. The development of this model enhances the understanding of project team members about implementing a successful TCC/GMP project. It also provides a platform to measure the risk level of the projects based on objective evidence instead of subjective judgments. The research findings show that Design Risk is the most critical risk group associated with TCC/GMP construction projects. This may be due to the grey areas in determining whether a variation is classified as a design development item or a contract variation which has cost implication to the projects concerned.

After the development of the Model, a validation exercise was conducted in the form of face-to-face interviews in October 2010. Seven experts with direct hands-on experience in TCC/GMP construction projects in Hong Kong were involved in the validation exercise and were requested to rate the comprehensiveness of the risks included in the Model, the clarity, objectivity, practicality and overall reliability of the Model. It is found that the ratings in all aspects were satisfactory in the validation exercise. Hence, the Model could be regarded as comprehensive, clear, objective, practical and reliable by the experts during the validation process.

The main contribution of this study is that it provides a holistic framework for assessing various key risks associated with TCC/GMP projects. The model may serve as a tool for risk assessment in the peer-review process of such kind of projects on the contractor's side, to help the contractors to assess the relative risk levels amongst several TCC/GMP projects in hand. On the other hand, the owners may apply the same tool to assess the risk level of projects and decide to adopt TCC/GMP in construction projects under planning or not. Further research can be launched to adopt the same methodology to assess the risk levels in general of TCC/GMP projects in the United Kingdom and Australia where the development of TCC/GMP is more mature in order to draw an international comparison.

7.0

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 7 - CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

Several research studies on the benefits, difficulties, critical success factors, sharing ratios, control mechanisms and the like of TCC/GMP construction projects have been undertaken within the construction management discipline over the last decade. However, it is found from the literature review that little comprehensive and systematic research on developing a risk assessment model for TCC/GMP construction projects has been conducted. This research study has provided an in-depth investigation into the risk management of TCC/GMP projects in Hong Kong, with a view to developing an objective, practical and reliable risk assessment model for projects procured with this kind of contractual arrangement. The underlying objectives of this study will first be reviewed in this chapter. The conclusions derived from the research findings will then be presented. The contribution of theoretical knowledge and the application of research outcomes into practice will also be highlighted and recommendations are made for further research.

7.2 Review of Research Objectives

The aim of this study is to develop an objective, reliable and practical risk assessment model for TCC/GMP construction projects in Hong Kong. In order to develop this model, five objectives were set out below.

1) To determine the Key Risk Factors (KRFs) inherent with TCC/GMP projects and analyse their importance;
2) To solicit and compare the opinions of various project stakeholders on risk assessment of TCC/GMP projects in Hong Kong;
3) To explore and compare the preferences of various project stakeholders on risk allocation of TCC/GMP projects in Hong Kong;
4) To develop and validate an overall risk assessment model for TCC/GMP projects in Hong Kong; and
5) To recommend effective guidelines or measures for managing the potential risks associated with TCC/GMP projects.

7.2.1 To Determine the Key Risk Factors (KRFs) Inherent with TCC/GMP Projects and Analyse their Importance

A comprehensive literature review on TCC/GMP was first launched to identify a basket of risk factors associated with construction projects in general and those inherent with TCC/GMP construction projects in particular. Afterwards, a series of structured face-to-face interviews were undertaken with industrial practitioners having direct hands-on experiences in TCC/GMP construction projects in Hong Kong. Based on the interview findings, the key risk factors inherent with TCC/GMP construction projects were identified as: (1) Nature of variations; (2) Quality and clarity of tender documents; (3) Change in scope of work; (4) Unforeseen ground conditions; (5) Fluctuation of materials price; and (6) Approval from regulatory bodies for alternative cost saving designs (Chan et al., 2010c).

An empirical questionnaire survey was then conducted by means of a self-administered survey form developed based on the results of the structured interviews and literature review in 2009. It was found after summarising the rankings given by the respondents that the top 10 risk factors encountered in TCC/GMP construction projects included:

1. Change in scope of work
2. Insufficient design completion during tender invitation
3. Unforeseeable design development risks at tender stage
4. Errors and omissions in tender document
5. Exchange rate variations
6. Unforeseeable ground conditions
7. Actual quantities of work required far exceeding estimate
8. Lack of experience of contracting parties throughout TCC/GMP process
9. Inflation beyond expectation
10. Unrealistic maximum price or target cost agreed in the contract

The findings from the interviews were generally consistent with those from the questionnaire survey.

7.2.2 To Solicit and Compare the Opinions of Various Project Stakeholders on Risk Assessment of TCC/GMP Projects in Hong Kong

A five-level data analysis framework, including the Cronbach's alpha reliability test, descriptive statistics, the Kendall's concordance test, the Spearman's rank correlation test and the Mann-Whitney U Test, was employed in data analysis for the questionnaire survey. The research findings manifested that the client group, contractor group and consultant group are in general agreement on the impact of individual risks (i.e. level of severity of each risk multiplied by its likelihood of occurrence). The identification of the key risk factors and their relative significance are important in the risk management of TCC/GMP construction projects, which, if properly done, would enhance the value for money throughout the whole procurement process. The Kendall's concordance analysis revealed that the client group and contractor group held a significant agreement on the ranking exercise within their individual groups. The Spearman's rank correlation test indicated that all of the three respondent groups (i.e. client group, contractor group and consultant group) exhibited associated rankings of the 34 key risk factors identified from the questionnaire survey. The Mann-Whitney U tests reflected that there were statistically significant differences in the perceptions on 8 risk factors out of the 34 key risk factors. The inference which can be drawn is that such differences in perceptions are attributable to the roles played by different contracting parties under the project development process (e.g. the contractor group rated a higher score on the severity of exchange rate variations, since the contractor is the party responsible for procuring materials throughout the entire construction process).

7.2.3 To Explore and Compare the Preferences of Various Project Stakeholders on Risk Allocation of TCC/GMP Projects in Hong Kong

On top of risk assessment, a further attempt was made to identify the party most preferred or capable to take the risks associated with TCC/GMP projects in Hong Kong. The research findings indicated that risks on tender documentation and project design are better borne by clients, while construction-related risks are perceived to be taken by contractors. The research findings are consistent with other similar studies on risk allocation in construction projects in general. The findings are expected to benefit both academic researchers and industrial practitioners in generating an equitable risk sharing mechanism for future TCC/GMP projects. It has provided sufficient empirical evidence, added to the growing body of knowledge and laid a solid foundation for further research such as an international comparison of various risk allocation schemes associated with this kind of contractual arrangement.

7.2.4 To Develop and Validate an Overall Risk Assessment Model for TCC/GMP Projects in Hong Kong

Based on the results of the questionnaire survey, the most important 17 Principal Risk Factors (PRFs) after the calculation of normalised values were selected for undertaking factor analysis. Five Principal Risk Groups (PRGs) were then generated in descending order of importance as: (1) Third party delay and tender inadequacy; (2) Post-contract risks; (3) Lack of experience in TCC/GMP procurement process; (4) Design documentation risks; and (5) Economic and financial risks. A Fuzzy Risk Assessment Model (FRAM) for TCC/GMP construction projects in Hong Kong was subsequently developed based on the results of factor analysis and fuzzy synthetic evaluation method. An overall risk index can thus be computed for TCC/GMP construction projects in Hong Kong.

The model was then validated with seven experienced industrial practitioners having direct hands-on experience in TCC/GMP projects in Hong Kong via a series of face-to-face interviews. It was found that the model was considered as reliable, objective and practical by the experts. The development of this model has enhanced the understanding of project team members on implementing a successful TCC/GMP construction project. It has also provided a strong platform for industrial practitioners to measure, evaluate and mitigate the risk level of the projects based on objective evidence instead of subjective judgments. The research findings reflected that "Design documentation risks" are the most critical risk group associated with TCC/GMP schemes that would constitute significant barriers for TCC/GMP projects to succeed in real practice. This may be attributed to the grey areas in determining whether a post-contract change is classified as a design development item or a contract variation, which has cost implications to the projects concerned.

7.2.5 To Recommend Effective Guidelines or Measures for Managing the Potential Risks Associated with TCC/GMP Projects

The last objective of this research is to recommend effective guidelines or measures for managing the potential risks associated with TCC/GMP projects in the construction industry of Hong Kong. According to the results of structured interviews, a multitude of key risk factors identified were related to design variations. Not surprisingly, the risk mitigation measures suggested by the interviewees were about the tendering process and applying partnering concepts to improve the working relationship between clients and contractors.

In the follow-up questionnaire survey, the five most effective individual risk mitigation measures as perceived by those industrial practitioners encompass: (1)

Right selection of project team; (2) Mutual trust between the parties to the contract; (3) Clearly defined scope of works in client's project brief; (4) Early involvement of the main contractor in the design development process; and (5) Proactive participation by the main contractor throughout the GMP/TCC process. Following the descriptive analysis of the survey results, factor analysis was employed to crystallise seven underlying grouped risk mitigation measures. It was found that these underlying grouped risk mitigation measures mainly focus on relationship management (e.g. "Relational contracting and mutual trust" and "Involvement of contractor in decision making process") and tendering process (e.g. "Clear contract provisions and well-defined scope of works", "Third party review of project design at tender stage" and "Standard contract clauses for GMP/TCC schemes"). This finding is logical since the success of implementing GMP/TCC forms of contractual arrangement is heavily dependent on the partnering spirit and a well-defined scope of works at the outset of a project (Chan *et al.*, 2010c).

7.3 Value of the Research

The research has initiated a comprehensive investigation into risk management of TCC/GMP projects within the construction industry of Hong Kong. It has provided a review of previous research studies on risk factors associated with construction projects in general and TCC/GMP projects in particular. To identify the key risk factors of TCC/GMP projects, a series of structured face-to-face interviews were conducted with industrial practitioners with extensive hands-on experience in such kind of projects. An empirical questionnaire survey was subsequently launched to glean information and solicit personal perceptions on risk management from industrial practitioners, and the research findings including the development of a Fuzzy Risk Assessment Model have been confirmed to be influential to knowledge development and applicable to project management of TCC/GMP construction projects.

7.4 Contributions to Existing Knowledge

This research study has adopted an innovative approach to the overall risk management of TCC/GMP construction projects in Hong Kong in terms of risk identification, risk assessment, risk allocation and risk mitigation. Firstly, the identification of key risk factors associated with TCC/GMP and the analyses on internal consistency and correlations enable both industrial practitioners and construction academics to equip with better knowledge and understanding of TCC/GMP schemes by paying close attention to those high-risk factors identified from this research.

Secondly, an in-depth understanding of the significant risks is imperative in project delivery with TCC/GMP contractual arrangements. Inadequate consideration of risk allocation may result in failure in achieving the stated project objectives upon completion. The literature review indicated that previous research studies on risk management of TCC/GMP scheme are rather limited in depth. Another contribution of this research is that it has attempted to fill up the knowledge gap of risk management of TCC/GMP construction projects. This study adopted an empirical questionnaire survey to examine the preferred risk allocation of TCC/GMP projects, concluding that the risks under client's control such as risks on tender documentation and project design would better be borne by clients and construction risks are perceived to be better taken by contractors. Such findings are in line with previous similar research studies on risk allocation in construction projects in general and are consistent with the management standard and fault standard of risk allocation as advocated in the Grove (2000)'s report in particular.

The findings derived from this study could also serve as a useful reference for desirable risk allocation for future TCC/GMP contracts in construction. Given the fact that TCC/GMP schemes are extensively applied in infrastructure projects worldwide including Hong Kong (Walker et al., 2002; Rojas and Kell, 2008; Chan et al., 2008; Bogus et al., 2010; Chan et al., 2010a), the research findings should be relevant and essential to both academics and construction practitioners in the field of infrastructure development and management. This research study has engendered a strong research interest to capture the lessons learned from previous TCC/GMP construction projects for generating best practice guidelines for equitable (preferred) risk allocation in future target cost-based projects especially in those infrastructure developments often associated with high risks, both locally and overseas.

Thirdly, this research study has applied an innovative approach to establishing an objective, reliable and comprehensive risk assessment model for TCC/GMP construction projects by using factor analysis and a fuzzy synthetic evaluation method. The development of this model has enhanced the understanding of project team members on implementing a successful TCC/GMP construction project. It has also provided a good platform for industrial practitioners to measure, evaluate and mitigate the risk level of the projects based on objective evidence instead of subjective judgments. The research findings indicated that "Design risks" are the most critical risk group associated with TCC/GMP schemes that would constitute significant barriers for TCC/GMP projects to succeed in real practice. This may be attributed to the grey areas in determining whether a post-contract change is classified as a design development item or a contract variation, which has cost implications to the projects concerned.

The main contribution of this study is that it has built up a solid framework for assessing the key risks associated with TCC/GMP contracts. The Fuzzy Risk Assessment Model derived may be used as an effective tool for risk assessment during the peer-review process for TCC/GMP projects on the contractor's side (i.e. to help the contractors to assess the relative overall risk levels among their several TCC/GMP projects in hand or to decide whether to bid for a project based on the TCC/GMP form of contract during tender stage). On the other hand, the clients can apply the same model to evaluate the overall risk levels of various TCC/GMP projects and decide whether to adopt TCC/GMP contractual arrangement in their construction projects under planning. The project team can also evaluate the risk level on a regular basis at any time during the construction stage with the model.

Fourthly, a number of effective risk mitigation measures for TCC/GMP projects have been suggested in this study. With the identified risk mitigation measures for TCC/GMP methodology in mind, industry leaders and decision makers are provided with sufficient evidence and useful pointers to determine whether to adopt TCC/GMP contracts in future projects and they can use a set of corresponding useful practical strategies for the reduction of possible risks arisen.

A wider application of TCC/GMP across a broad spectrum of the entire construction industry is anticipated with the purpose of achieving more favourable project outcomes with some effective risk mitigation strategies in place. It is hoped that this research study has serve as a first step towards developing plausible solutions for mitigating potential risks associated with the TCC/GMP contractual arrangements, which should be suitable for projects with high risks (Wong, 2006).

7.5 Practical Applications of the Research

The study has presented the application of TCC/GMP contractual arrangements in Hong Kong with the responses of project participants so that industrial practitioners and construction academics can better understand the local practice of this special kind of construction projects. The identification of key risk factors can provide project participants with those risks meriting more attention in order to achieve the success of their projects. An evaluation of key risk factors is likely to lead to a better appreciation of TCC/GMP benefits and problems. Such an improvement of understanding should generate essential strategies to alleviate the root causes of poor project performance. The identification of effective risk mitigation measures may help the development of effective strategies in preparing project procedure manuals or other documents for project control to mitigate the risks and hence enhance project performance.

The computation of the Overall Risk Index for TCC/GMP projects using the Fuzzy Risk Assessment Model can assess the risk level of the projects. In addition, since the most critical principal risk group can be identified, corrective measures can then be taken before major problems occur. As stated in the previous sections, the model may help the contractor in assessing the risk of projects at tendering stage to decide whether to bid for the jobs involving TCC/GMP schemes. The project team may also apply the same model to assess the risk level of the project during pre-contract stage and/or post-contract stage. The clients can apply the same model to evaluate the overall risk levels of various TCC/GMP projects and decide whether to adopt TCC/GMP contractual arrangement in their projects under planning. Furthermore, this research forms a strong foundation on developing risk assessment model for TCC/GMP projects with fuzzy synthetic evaluation and factor analysis. The same research methodology can be replicated in TCC/GMP construction projects in other jurisdictions where the pace of development of TCC/GMP is more mature such as Australia, Sweden, the United Kingdom (e.g. Chan et al., 2011a), the United States, and the like, provided that sufficient data from those jurisdictions are available for analysis. An international comparison on overall risk levels of TCC/GMP projects can then be drawn between the East and the West wherever deemed appropriate.

7.6 Limitations of the Study

The research findings are particularly useful in the field of risk management in construction, considering that a scarcity of research has been conducted on the risk aspects in implementing TCC/GMP contracts. However, the scope of study is limited to Hong Kong, which nevertheless has an internationalised construction market. It would be more ideal to collect data from other jurisdictions with more mature development of TCC/GMP such as Australia, Sweden, the United Kingdom and the United States. In addition, the distribution of client group, contractor group and consultant group are not exactly balanced (the number of respondents of client group: 33; the number of respondents in contractor group: 27 and the number of respondents in consultant group: 34), it would be more representative to have more samples from contractors in the survey, although statistical tests indicated that the three respondent groups were in general agreement in major issues such as risk assessment and ratings of the effectiveness of risk mitigation measures.

7.7 Recommendations for Future Research

Both TCC and GMP are at a geminating stage of development within the construction market of Hong Kong. The Works Branch under the Development Bureau of the HKSAR Government is now implementing the New Engineering Contract Version 3 (NEC3) including Option C – Target Cost with Activity Schedule, in their pilot projects on a trial basis. For example, an open nullah improvement works project in Sai Kung was launched by the Drainage Services Department in August 2009 (Cheung, 2008). When more TCC/GMP projects are launched in the near future, further research studies may be carried out to measure their risk levels against the norm generated by the fuzzy risk assessment model developed in this study. Moreover, a longitudinal study can be launched to investigate the process of risk management in real-life cases in Hong Kong to further enrich the knowledge base of TCC/GMP schemes. Further research studies may focus on developing similar risk assessment models for projects procured by traditional fixed-price lump-sum contracts in order to compare and contrast the risk levels of projects procured with different kinds of contractual arrangements. However, it should be noted that the key risk factors inherent with TCC/GMP contracts may not be universal or totally applicable to other procurement strategies. For example, the two risk factors: “Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage” and “Unrealistic maximum price or target cost agreed in the contract” would not be applicable to the traditional procurement method due to different operational mechanisms.

The same research technique may also be applied in different geographical locations to allow an international comparison between the East and the West for risk management of TCC/GMP construction projects.

7.8 Recommendations for Industry Practice

A fuzzy risk assessment model for TCC/ GMP construction projects in Hong Kong has been developed in this research. The model has also been validated by a number of experienced experts and proved to be practical and reliable for use. Yet, the model has not been made known to the construction industry at large and the local government.

A further step can be taken forward to promote the developed model in various relevant professional institutions such as the Hong Kong Institute of Surveyors (HKIS), the Royal Institution of Chartered Surveyors (RICS) and the Hong Kong Institute of Architects (HKIA), and those Works Department under the Development Bureau of the HKSAR Government. According to Conner (2011), the HKSAR Government has launched a number of pilot study projects for application of NEC3 contracts including Option C – target cost with activity schedule. The government, being both the regulator and one of the largest clients in the construction market, can consider applying such a risk assessment model to her new TCC/GMP projects. If the results are satisfactory and significant, the private sector may also follow this practice. As such, further efforts can be placed to develop a computerised system based on the fuzzy risk assessment model to enhance the user-friendliness of the system. Computerisation of the system is thus regarded as another possible direction for future study.

7.9 Chapter Summary

In this chapter, the achievement of the research objectives was reviewed. The main conclusions and the value of the research were summarised. Core directions for further studies were suggested based on the major research findings from this study. It is believed that the current research can serve as a concrete foundation for future research on TCC/GMP schemes and provide useful insights beyond the existing knowledge of risk management of TCC/GMP, which is scarce in currently available literature.

8.0

APPENDICES

1 June 2008

Dear Sir/Madam,

Request for an Interview

The Department of Building and Real Estate of The Hong Kong Polytechnic University is now conducting a research on the application of Guaranteed Maximum Price (GMP) and Target Cost Contracts (TCC) in construction.

The topic of the research project is "An Investigation of the Risk Factors and Risk Allocation for Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) Schemes in Hong Kong". The aim of my research is to investigate the risk factors, risk analysis, risk allocation and risk mitigation of GMP/TCC projects in Hong Kong. I believe that your experience is of great importance to my research and it would be my honour and privilege if you could offer an interview to me. The interview questions are provided on the attached page for preview.

It would be much appreciated if you could reply to me at your earliest convenience. Should you have any enquiries about my research, please feel free to contact me at my mobile phone number 9162 or e-mail at joseph.chan.

Thank you very much for your assistance with my research. I am looking forward to receiving your early reply.

Yours faithfully, Endorsed by

Chan Hing Lun Joseph (Student)
Student No: 0890
Department of Building and Real Estate
The Hong Kong Polytechnic University

Dr. Daniel W.M. Chan (Supervisor)
Assistant Professor
Department of Building and Real Estate
The Hong Kong Polytechnic University

List of Questions for Structured Interview

A. Case History of GMP/TCC

1. How many GMP/TCC construction projects have you been involved in? Please briefly describe the scope of work of a GMP/TCC project in which you were engaged (e.g. project nature, project duration, contract sum, GMP/TCC implementation mechanism, gain-share/pain-share arrangement, etc)

B. Risk Factors and Risk Allocation

2. Can you name some risk factors associated with those GMP/TCC contracts that you had encountered? (e.g. errors and omissions in tender documents, difficult to set a genuine maximum price or target cost, unforeseen ground conditions, change in scope of work, unforeseen design development risk, etc)

3. Amongst those risk factors mentioned in Q 2, which are the three most important ones?

4. Were there any mitigation measures to deal with these risk factors? If so, please illustrate how they were treated.

5. How were these 3 most important risk factors allocated amongst various contracting parties in this project? Who took up each of these risks?

C. Risk Sharing Mechanisms

6. How did you develop a proper risk allocation (sharing) mechanism to deal with risks inherent in GMP/TCC projects? (e.g. use of risk register, risk management workshop, etc)

7. How were you satisfied with the performance / effectiveness / appropriateness of the existing risk allocation mechanisms for those projects? What aspects would need for further improvement?

D. Risk Mitigation Measures

8. Can you provide some strategies or guidelines to mitigate the risks involved in GMP/TCC projects?

9. Can you provide some strategies or guidelines for better risk allocation in GMP/TCC projects?

<u>Interview Report 1</u>

Date: 11 June 2008 (Wed)

Time: 10:00am – 11:50am

Interviewee: Contractor 1

Interviewers: Dr. Daniel Chan and Mr. Joseph Chan of PolyU

Project: Three Pacific Place (3PP)

A. Case History of GMP/TCC

1. How many GMP/TCC construction projects have you been involved in? Please briefly describe the scope of work of a GMP/TCC project in which you were engaged (e.g. project nature, project duration, contract sum, GMP/TCC implementation mechanism, gain-share/pain-share arrangement, etc)
   2 projects: Three Pacific Place and One Island East

Project duration: From 6 May 2002 to July 2004 for main office building block. The construction of pedestrian tunnel link in this project was completed in January 2007.

Contract Sum: Around HK$1,000M to HK$1,100M

Client: Swire Properties Limited

Architect: Wong & Ouyang (HK) Limited

Quantity Surveyor: Davis Langdon and Seah (Hong Kong) Limited

Method of Tendering: Selective tendering for main contract

Gain share ratio: 50:50 (employer: main contractor)

Pain share ratio: 0: 100 (employer: main contractor)

Scope of work: It was a Grade A private office development project with GMP contractual arrangement including the construction of a 34-storey high office tower for a typical floor gross floor area of about 1,700 m^2, a 3-level podium, three basement car parking floors, and an underground pedestrian tunnel link. At the basement B3 level, the development was connected to the MTR Admiralty Station and other parts of Pacific Place via an air-conditioned, travelator-equipped underground pedestrian link which was an optional item in this project. The construction of the pedestrian tunnel link commenced after the main building had been completed. The external façade of the tower was a combination of glass walls and curtain walls. There was no specific item for the contractor to price for design development, and the price of design development was reflected in BQ rates and preliminaries. There was no open-book accounting arrangement as well in this project.

The GMP Contract leaded to efficient contractual arrangements and reduces disputes. The partnering working relationship with the main contractor and subcontractors facilitates an more effective and efficient dispute prevention and resolution.

B. Risk Factors and Risk Allocation

2. Can you name some risk factors associated with those GMP/TCC contracts that you had encountered? (e.g. errors and omissions in tender documents, difficult to set a genuine maximum price or target cost, unforeseen ground conditions, change in scope of work, unforeseen design development risk, etc)

The first risk factor was related to unforeseen ground conditions. For instance, there was soft ground condition for the tunnel construction. More grouting and lateral supports were required to cope with this weak soil condition, so the progress of soil excavation was affected in this project.

Inaccuracy of materials quantities in Bills of Quantities (BQ) was the second risk factor encountered with this project. All of the quantities including those for steel reinforcement bars in the BQ under this contract were firm. (i.e. no provisional quantities in the BQ). The changes in the quantity of steel bars for the whole building structural frame were at risk of main contractor. For example, the increase in reinforcement bars in structural elements was regarded as an item of Design Development. If the actual quantity for steel reinforcement bars used was more than the BQ quantities, then the extra expenditure had to be solely borne by the main contractor.

Another risk factor would be the different interpretations of nature of variation order (VO). The architect might believe that some variation orders were adjudicated as Design Development Instructions (DDI) which would not be allowed to adjust the value of GMP. For example, the Architect instructed the main contractor to core holes in walls and installed more reinforcement bars inside structural walls. However, the main contractor held an opposite view and believed that the variation orders should be GMP Variations which would be allowed to change the value of GMP.

The fourth one was the compliance of prevailing building regulations from time to time. Some drawings issued by the Architect did not comply with prevailing building regulations. For example, the headroom and height of risers in stairs did not meet the requirements stipulated by the contemporary building regulations. The contractor had to spot out those errors himself and rectify the errors in drawings. Otherwise, many abortive works would be required with main contractor's own expenditure in terms of time and money.

The last risk factor would be the lack of involvement of contractor in issuing variation orders. There were fewer chances for the main contractor to contribute his expertise and innovative ideas to the project design to improve the buildability and main contractor did not always know the rationale behind issuing those variation orders.

3. Amongst those risk factors mentioned in Q 2, which are the three most important ones?

They include: (1) unforeseen ground conditions; (2) different interpretations of nature of VO; and (3) inaccuracy of materials quantities in BQ.

4. Were there any mitigation measures to deal with these risk factors? If so, please illustrate how they were treated.

More site investigations could be conducted by the main contractor in order to gain better understanding about soil conditions on site.

Better communication between the Architect and main contractor before issuing VO would be a preferred way to deal with potential variations. The main contractor could be given a chance to advise the Architect on economical and efficient construction methods, thus abortive works and delay of projects could be mitigated.

Support from top management to project management team was important. The instructions and blessing from top management would make the project team more pro-active in problem solving.

5. How were these 3 most important risk factors allocated amongst various contracting parties in this project? Who took up each of these risks?

Unforeseen ground conditions: This risk was taken up by the main contractor in this project. In my opinion, this risk should be borne by the employer.

Inaccuracy of materials quantities in BQ: The risk of inaccuracy of BQ quantities for steel reinforcement bars should be taken up by the employer, but it was taken up by main contractor in this project. This kind of risk could be taken up by main contractor for quantities other than reinforcement bars.

The risk of different interpretations of nature of VO was shared by both contracting parties (employer and main contractor).

C. Risk Sharing Mechanisms

6. How did you develop a proper risk allocation (sharing) mechanism to deal with risks inherent in GMP/TCC projects? (e.g. use of risk register, risk management workshop, etc)

There was a 'risk opportunity register' for every project in my company, but it was for in-house use only. The risk factors emerged at different stages of a project are categorized and then listed in the register. For example, key risks on commercial areas, safety risks, technical risks, etc are listed in this register. Risk mitigation measures and contingency plans are also incorporated in this document.

7. How were you satisfied with the performance / effectiveness / appropriateness of the existing risk allocation mechanisms for those projects? What aspects would need for further improvement?

I was satisfied with the effectiveness of the existing risk allocation mechanism in this project.

All of the potential risk items were listed in the 'risk opportunity register' clearly at the beginning of the project. Their frequency of occurrence and level of impact were then evaluated throughout the whole project duration.

The project team could know that they should pay more attention to which risks. Corresponding contingency plans and mitigation measures could be developed to reduce the frequency of occurrence and level of impact of those key risk factors.

D. Risk Mitigation Measures

8. Can you provide some strategies or guidelines to mitigate the risks involved in GMP/TCC projects?

The magnitude of risk really depends on the extent of design complete when issuing tenders. In general, the more the design is completed, the lower the risk for contractor.

At the pre-contract stage, the contractor should carefully check whether the BQ quantities for cost significant items were under-measured (e.g. steel reinforcement bars). Moreover, the contractor should also check whether the design was mature. If the design was immature, it has to allow more risk premium to cover any uncertainties in subsequent design development.

At the post-contract stage, the contractor could be more proactive to communicate with the Architect before issuing VO, so the reasons behind the variations could be made more transparent. The contractor's expertise could then be tapped in for both design and construction, and thus more efficient and economical solutions could be generated together.

9. Can you provide some strategies or guidelines for better risk allocation in GMP/TCC projects?

The main contractor should monitor the Architect's Instructions for nominated subcontractors which may affect main contractor's builder works. In addition, as mentioned in Question 8, it is advisable for the contractor to play a more proactive role in communicating with the Architect before issuing VO, so the rationale behind the variations could be clearly conveyed. The contractor's expertise can be tapped in for both design and construction, and hence more efficient and economical solutions could be jointly developed. The nature of VO can also be more easily identified with this synergy approach. The underlying principles of GMP should be fully conveyed and understood by all the contracting parties before implementing this kind of projects.

Interview Report 2

Date: 11 June 2008 (Wed)

Time: 3:40pm – 5:00pm

Interviewees: Cons ultant 1

Interviewers: Dr. Daniel Chan and Mr. Joseph Chan of PolyU

Project: Public Housing Development at Eastern Harbour Crossing Site Phase 4

(near MTR Yau Tong Station)

A. Case History of GMP/TCC

1. How many GMP/TCC construction projects have you been involved in? Please briefly describe the scope of work of a GMP/TCC project in which you were engaged (e.g. pr oject na ture, pr oject durat ion, c ontract sum , GM P/TCC implementation mechanism, gain-share/pain-share arrangement, etc)

Project duration: From June 2006 to May 2009 (combined foundation and bu ilding contract period = 36 months)

Contract Sum: Around HK$435M

Client: Hong Kong Housing Authority (HKHA)

Architect: H ousing Department

Quantity Surveyor: WT Partnership (HK) Limited

Main Contractor: Shui On Building Contractors Co Ltd

Subcontractors: Piling, Lift and GMP Subcontractors

Method of Tendering: Two-envelope tendering method (technical proposal together with price proposal)

Six tenderers were shortlisted by HKHA and then invited to submit tenders with base design and alternative proposals which were evaluated to formulate their individual technical scores. At the same time, their price scores were formulated based on their tender sums. The contract was awarded to the tenderer with highest overall score which was the sum of technical score and price score.

Gain share ratio: 50:50 (employer: main contractor)

Pain share ratio: 0: 100 (employer: main contractor)

Scope of work: EHC Phase 4 being a pilot project adopting a Modified GMP Contracting Model (MGMP) was a public rental domestic building project including the construction of: (1) three 41-storey Non-standard Domestic Blocks providing total 2,369 flats including foundations; (2) a lift tower and footbridge connected to Yau Tong Estate; (3) one Neighbourhood Elderly Centre; (4) an at grade bus stop; (5) a double-deck walkway connected to EHC Phase 4; (6) site formation and retaining walls; (7) a drainage reserve; and (8) external works.

The combined foundation and building Contract was commenced in June 2006. Contract period is 36 months, with phased completion allowed for completion of bus stop and two of the domestic blocks (Blocks P and Q) in 24 and 31 months respectively after commencement of works.

The domestic blocks in EHC Phase 4 offer potential to set aside portions of the construction works for Modified Guaranteed Maximum Price (MGMP) packages and this amounted to approximately 31% of the overall contract sum (approximately $135.4M). This MGMP Works packages were -

(a) Specialist External Works including a footbridge and lift tower, and a double-deck walkway linking the blocks;

(b) Enclosure to drainage reserve and the associated backfilling works;

(c) Plumbing and drainage installations;

(d) Fire services and water pump installations;

(e) Electrical installations; and

(f) Prefabrication of concrete elements other than the main structural frame.

It provides an opportunity for the contractor to add value to the contract by setting aside a portion of the work (~31% of the overall contract sum) for the contractor's alternative design and construction solutions.

Tenders were required to submit Alternative Proposals for five of the packages where Base Designs were provided (Packages b-f), and their own designs for the other packages where only design intent was provided (Package a).

B. Risk Factors and Risk Allocation

2. Can you name some risk factors associated with those GMP/TCC contracts that you had encountered? (e.g. errors and omissions in tender documents, difficult to set a genuine maximum price or target cost, unforeseen ground conditions, change in scope of work, unforeseen design development risk, etc)

One of the risk factors encountered was the site constraints. The site was located near a substation for towngas. However, the tenderers were reminded about this issue during tender briefing.

Another risk factor was the selection of a competent main contractor for the project. Since this procurement approach required expertise input and more innovations from main contractor to continue developing the base design and propose alternative design and construction solutions, the selection of a right contractor was very important to the success of this kind of project. It was encouraging that the main contractor engaged in this project was very co-operative and proactive in problem solving, and it also provided innovative ideas to improve the buildability and efficiency of the project.

Unfamiliarity with the practice and operation of Independent Checking Unit (ICU) of Housing Department, which was a unit whose function was similar to the Buildings Department responsible for checking and approving designs of projects developed by Hong Kong Housing Authority (HKHA), was the third risk factor associated with this project. When the main contractor comes up with an alternative proposal, it has to submit its design proposal to ICU for verification and approval. If the contractor is not familiar with the practice of ICU, this certainly increases the difficulty to obtain approval from the unit.

Change in scope of work was also a risk factor of this project. The standard of HKHA projects changes from time to time, and thus the standard of this project also changed accordingly. For example, when the brightness of electrical lights under the standard of HKHA projects alters, the standard of all electrical lights in this project must change accordingly. Moreover, there was not too much space for the main contractor to continue developing the base designs of those GMP Works Packages as the design was about 90% completed at tendering stage, so design risk was not very significant in this case.

Moreover, fluctuation in price of materials was also a risk factor of this project. However, this risk was shared with the fluctuation clause in contract.

In addition, the unforeseen ground conditions was also a significant risk factor associated with this project.

3. Amongst those risk factors mentioned in Q 2, which are the three most important ones?

They were: (1) selection of a competent main contractor; (2) unfamiliarity with practice and operation of Independent Checking Unit; and (3) fluctuation in price of materials.

4. Were there any mitigation measures to deal with these risk factors? If so, please illustrate how they were treated.

The risk of selection of competent contractor was mitigated by prequalification exercise of contractors at tendering stage. Their previous working experiences with HKHA projects and track record of past project performance were evaluated under the technical assessment which formed one part of technical score in tender assessment.

5. How were these 3 most important risk factors allocated amongst various contracting parties in this project? Who took up each of these risks?

(a) Unforeseen ground conditions:

The lengths of bored concrete piles in this project were measured in provisional quantities which were subject to re-measurement. This risk was borne by the employer.

(b) Unfamiliarity with practice of Independent Checking Unit of HKHA:

The first design approval was obtained by the employer (HKHA) in this project. The drawings for base design were approved by the ICU at the pre-contract stage before the commencement of site works. This risk was borne by the contractor himself.

(c) Fluctuation in price of materials:

This risk was shared by both major contracting parties (employer and contractor) in this project with reference to the fluctuation clause in contract.

(d) Regarding the selection of competent main contractor, this risk was solely borne by the employer with the mechanism of prequalification exercise of contractors.

C. Risk Sharing Mechanisms

6. How did you develop a proper risk allocation (sharing) mechanism to deal with risks inherent in GMP/TCC projects? (e.g. use of risk register, risk management workshop, etc)

Regarding time management, the employer, who was more familiar with practice of ICU, accepted the risk for obtaining design approval for the base design which was the most significant risk in this project.

In terms of quality of design, the design was 90% completed at the tendering stage, so the design risk was not significant in this project.

As regards the cost control, fluctuation clause was included in this contract, so the contractor was treated fairly for the fluctuation in price of materials. However, the contractor proposed a special design (a green roof over main contractor's site office) in the technical proposal to increase its technical score during tender assessment, but it did not fully know the cost of the green roof incurred at the tendering stage, this would be a risk on the contractor side.

The opinions from HKCA (Hong Kong Construction Association) were solicited before initiating this project with MGMP contractual arrangement. There was a tender briefing for interested tenderers to let them have a better understanding about the scope of work, site constraints (e.g. the site located near MTR Yau Tong Station) and methodology of MGMP and the like. Moreover, tenderers were interviewed during tender assessment stage to clarify their irregularities in tender pricing (e.g. high/low rates) and they would be asked to abide by the tender sums for those irregularities.

The specialist subcontractors were chosen from an approved list provided by the HKHA. This could ensure the quality and performance of those subcontractors. On the other hand, the main contractor was given some degree of freedom to select his specialist subcontractors who could work well with him.

At the post-contract stage, there were partnering workshops to improve communication flows between the project team members and the main contractor and to facilitate exchange of innovative ideas between project participants.

In addition, there was an adjudication committee to resolve potential disputes. However, no meeting was called for this committee because all problems had been resolved at site level.

7. How were you satisfied with the performance / effectiveness / appropriateness of the existing risk allocation mechanisms for those projects? What aspects would need for further improvement?

The performance of existing risk allocation mechanism for the project was satisfactory and the risk allocation was fair from contractual side. For example, the risk of price fluctuation in materials was shared by both contracting parties with the provision of the fluctuation clause in contract. Moreover, the contractor's expertise was tapped in to the project. For example, there had been 8 different kinds of precast concrete elements at the beginning and 6 more kinds of precast elements were subsequently introduced by the main contractor to improve the efficiency of workflow and reduce the generation of construction waste. This joint effort had achieved a win-win situation for both parties in this case.

The risk of unforeseen ground conditions was accepted by the employer and the quantities for bored concrete piles were subject to re-measurement.

The overall project performance would be improved if the main contractor could be more familiar with the practice of ICU. And the design approval could be expedited and the site progress would not have been delayed.

D. Risk Mitigation Measures

8. Can you provide some strategies or guidelines to mitigate the risks involved in GMP/TCC projects?

Strategies to mitigate the risks associated with this project were proposed as follows:

1. Design intent should be clearly spelt out in tender documents.
2. Scope of work should be clearly stated in tender documents.
3. Definition of Design Development should be made clear in contract documents to avoid potential disputes at post-contract stage.
4. Definition of GMP variations should be clearly stated in contract without ambiguity.
5. Early involvement of main contractor in design development.
6. More communications between main contractor and project team members (e.g. regular meeting to facilitate exchange of innovative ideas within the project team).

9. Can you provide some strategies or guidelines for better risk allocation in GMP/TCC projects?

Suggested guidelines for better risk allocation for GMP projects were summarized as follows:

1. Conduct tender briefing and tender interview at pre-contract stage to let tenderers have a deeper understanding about the scope of work and methodology of GMP. The main contractor would know how much time, cost and resources need to be allocated to this project after the tender briefing and interview.

2. Technical assessment of tenders was conducted on top of comparison of tender sums to ensure a fair and thorough assessment of tenders for selecting a competent main contractor.
3. Partnering approach could be implemented to foster an environment of mutual trust and effective communication between the employer and the main contractor.

The overall project performance so far was good in this case and there were fewer variations compared with traditional fixed-price lump-sum approach. The number of contractual claims and disputes was also lower than those projects procured with traditional approach.

<u>Interview Report 3</u>

Date: 18 June 2008 (Wed)

Time: 4:15 pm – 5:40 pm

Interviewee: Client 1

Interviewers: Dr. Daniel Chan and Mr. Joseph Chan of PolyU

Project: MTRC Tsim Sha Tsui Railway Station Modification Works

A. Case History of GMP/TCC

1. How many GMP/TCC construction projects have you been involved in? Please briefly describe the scope of work of a GMP/TCC project in which you were engaged (e. g. project nature, project duration, contract sum, GMP/TCC implementation mechanism, gain-share/pain-share arrangement, etc)

Personally, the interviewee has been involved in 3 TCC projects in Hong Kong including (1) MTR Quarry Bay Station Modification Works (from lump sum to target cost); (2) TST Railway Station Modification Works; and (3) Tung Chung Cable Car Project. He has also gained experience with this kind of procurement approach in both Europe and Australia.

Project duration: April 2002 – September 2005

(Contract duration: 36 months)

(completed 7 months ahead of schedule)

Contract sum: HK$300M (achievement of 5% cost saving)

Client: Mass Transit Railway Corporation Limited (MTRC)

Main Contractor: Kumagai Gumi Company Limited

E&M Engineer: Balfour Beatty Group Limited

Instrumentation Subcontractor: Fugro Geotechnical Services (HK) Limited

Cladding/Architectural Steelwork: Inka Limited

Ceilings Subcontractor: Litecraft Electrical and Metal Manufacturing Limited

Method of Tendering: Two-stage tendering method

Gain share ratio: 50:50 (employer: main contractor)

Pain share ratio: 50:50 (employer: main contractor)

Scope of work: This project was the first fully "open-book" Target Cost Contract (TCC) from Day 1 of the project in Hong Kong. It was an attempt to place priority to innovations and value engineering, backed by the gain-share/pain-share formula of TCC. The contract involved the connection of the pedestrian subway links of the new Kowloon-Canton Railway Corporation (KCRC) East Tsim Sha Tsui Station to the existing Mass Transit Railway Corporation (MTRC) Tsim Sha Tsui Station at the south end, and to improve passenger access and egress at the north end. The station modification required a single level extension to one end of the existing underground structure.

This extension was constructed beneath the Nathan Road, in one of the busiest districts of Hong Kong, within a cut and cover cofferdam. Other station modifications required significant alterations to the existing station structure whilst maintaining passenger flows at all times.

B. Risk Factors and Risk Allocation

2. Can you name some risk factors associated with those GMP/TCC contracts that you had encountered? (e.g. errors and omissions in tender documents, difficult to set a genuine maximum price or target cost, unforeseen ground conditions, change in scope of work, unforeseen design development risk, etc)

One of the risk factors encountered was unforeseen ground conditions. The groundwater table was high at the site and hence increasing the difficulty in construction. Moreover, there were many existing underground utilities such as water pipes, electrical cables and towngas pipes underneath the site. In general, the types of risks would depend on the methods of construction used.

Another risk factor was the impact of construction process on surrounding environment. Since the site was located within a congested area in Tsim Sha Tsui, there were many shops and an operating underground railway. The construction process could not affect the operation of these shops and, more importantly, the operation of existing railway service. The access problem also posed a major challenge in this project.

Unfamiliarity with the methodology of TCC by project team members was also perceived to be a risk factor. Some team members left the project mid-way because they did not really have a sound understanding about the spirit of TCC methodology.

Fluctuation in price of materials could also be considered as a significant risk factor in this project, but this was solely borne by the main contractor.

3. Amongst those risk factors mentioned in Q 2, which are the three most important ones ?

They included: (1) unforeseen ground conditions (e.g. high groundwater table); (2) impact of construction process on surrounding environment (e.g. proceeding of construction without interference with the existing railway service); and (3) unfamiliarity with the methodology of TCC by project team members.

4. Were there any mitigation measures to deal with these risk factors? If so, please illustrate how they were treated.

(1) Unforeseen ground conditions:

A considerable number of ground site investigations were conducted. As-built drawings were referred to have a better idea on the actual locations and sizes of underground utilities. A proper dewatering surveillance system was devised to look after the impact of groundwater table on underground construction to mitigate the risk.

(2) Impact of construction process on surrounding environment:

The main contractor set up an effective monitoring system to observe the impact of construction process on underground railway service to ensure its smooth and safe operation.

Many value engineering activities took place throughout the construction period of this project. Staff members who could create innovative ideas to reduce the time and/ or cost of construction were rewarded to encourage them to generate innovations beneficial to the project. These innovations also reduced the impact of construction process to surrounding environment apart from saving time and/or cost in this case.

(3) Unfamiliarity with the methodology of TCC by project team members:

Partnering approach was adopted in this project. The project teams from MTRC and Kumagai Gumi shared the same site office to facilitate prompt idea exchange and more effective formal/ informal communications. The two teams worked with a harmonious relationship and their working attitudes were less adversarial than those projects procured by traditional approach.

5. How were these 3 most important risk factors allocated amongst various contracting parties in this project? Who took up each of these risks?

(1) Unforeseen ground conditions:

It could be discerned that this risk was shared between employer and contractor in this case. The risk sharing mechanism of this particular risk varied with the location/portion around the site. The risk of unforeseen ground conditions was borne by the Employer in one area whereas the same risk was taken by the main contractor in other areas.

(2) Impact of construction process on surrounding environment:

This risk was solely borne by the main contractor in this case.

(3) Unfamiliarity with the methodology of TCC by project team members:

This risk was shared between employer and contractor. The team of consultants was not liable for any cost savings from this contract.

Here are some examples of risk sharing in this project:

<u>Examples of Risk Sharing in MTRC TST Railway Station Modification Works</u>

Employer's Risks	Shared Risks	Contractor's Risks
Change in scope of work classified as total employer's risk due to engineer's design	Unforeseen ground conditions around the site	Price fluctuation of materials due to the effect of inflation
Engineer's Instructions	Inclement weather	
	Approval by Buildings Department	

C. Risk Sharing Mechanisms

6. How did you develop a proper risk allocation (sharing) mechanism to deal with risks inherent in GMP/TCC projects? (e.g. use of risk register, risk management workshop, etc)

The fundamental principle of risk sharing is that the risk should be borne by a party who can best manage it. Which risks did the contractor take the best? Which they couldn't take? Which risks would be shared?

Both the value of agreed target cost and valuation of any possible risks were audited by an independent external auditing team to ensure that the target cost would not be too high which would expose the Employer to an unreasonable level of risk.

A risk register was used to identify potential risk factors associated with this project, and their levels of impact and probabilities of occurrence would be assessed. Then, a set of effective contingency plans and risk mitigation measures would be developed to manage those risk factors identified.

The contract itself served the purpose of risk allocation. The risks were properly allocated in the tender documents and the contractor priced the risks involved. The basic principle of risk allocation in tender document was illustrated below:

<u>Risk transfer at tender stage</u>

Tender Documents		
Employer's Risks	**Shared Risks**	**Contractor's Risks**
Risk 1	Risk A	Risk X
~~Risk 2~~ →	Risk2	Risk Y
Risk 3	Risk B	Risk Z
~~Risk 4~~ →	→	Risk 4
	Contractor priced responsible risks in their submitted tenders	Contractor priced responsible risks in their submitted tenders

The tender document can be regarded as a tool of risk allocation. In this case, the Employer should initially bear the Risk 1, Risk 2, Risk 3 and Risk 4. The contractor would bear Risk X, Risk Y and Risk Z. At the tender stage, the Employer shifted Risk 2 to "Shared Risks" and Risk 4 to "Contractor's Risks" to reduce his risk level. The contractor priced the responsible risks in his tender. The risk transfer is one-way only (from Employer to Contractor but not vice versa).

7. How were you satisfied with the performance / effectiveness / appropriateness of the existing risk allocation mechanisms for those projects? What aspects would need for further improvement?

The performance of existing risk allocation mechanism for the project was found satisfactory and it was logical to do things in principle.

There were regular meetings to monitor the risks involved in this project. The meeting attendees included project managers and construction managers from both employer and main contractor, the programme managers, the consultant engineers, together with commercial managers from main contractor. The actual out-turn cost was closely monitored by the project team through the whole delivery process.

The interfaces between various phases of construction could be better co-ordinated in this project via partnering with teamwork approach. MTRC would consider using TCC for other upcoming railway development projects like West Island Line, Shatin to Central Link and Kwun Tong Line Extension.

D. Risk Mitigation Measures

8. Can you provide some strategies or guidelines to mitigate the risks involved in GMP/TCC projects?

Strategies to mitigate the risks associated with this project were proposed as follows:

1. Right selection of project team

2. More site investigations could be conducted by the employer before the commencement of site construction. Always think about advanced works prior to construction!

3. Dividing the whole project into different stages of packages to save overall delivery time

4. Price fluctuation clause could be included in the contract document to share the risk of price fluctuation of materials with main contractor as the

inflation rate of materials has surged significantly over the recent months worldwide.

9. Can you provide some strategies or guidelines for better risk allocation in GMP/TCC projects?

Suggested guidelines for better risk allocation for TCC projects were summarized as follows:

1. Use of a proper risk register to have a clearer picture of risks inherent with the project during early stage of project implementation with responsible/ capable parties assigned to deal with those risks.

2. In-house standard form of contract with amendments for TCC methodology.

3. Partnering approach could be introduced to foster an environment of mutual trust and effective communication between employer and main contractor.

4. Use of 'open-book' accounting regime enabled quantification of the costs of risks and prevented the project risks from causing adverse effect on overall project performance in terms of time and cost.

Interview Report 4

Date: 23 June 2008 (Mon)

Time: 10:00 am – 12:00 noon

Interviewee: Client 2

Interviewers: Dr Daniel Chan and Mr. Joseph Chan of PolyU

Project: Chater House

A. Case History of GMP/TCC

1. How many GMP/TCC construction projects have you been involved in? Please briefly describe the scope of work of a GMP/TCC project in which you were engaged (e.g. project nature, project duration, contract sum, GMP/TCC implementation mechanism, gain-share/pain-share arrangement, etc)

Apart from Chater House Project in Hong Kong, the interviewee was also involved in One Raffles Link which was a GMP building project in Singapore.

Project duration: From October 2000 to July 2002 (641 days)
Final project duration (635 days)

Contract Sum: HK$1.2 billion and final project cost HK$1.5 billion with 15% cost saving

Client: Hongkong Land Limited

Project Manager: Hongkong Land (Project Management) Limited

Main Contractor: Gammon Skanska Limited

Design Architect: Kohn Pederson Fox Associates

Project Architect: Aedas LPT Limited

Structural Engineer: Ove Arup and Partners (HK) Limited

E&M Engineer: WSP Hong Kong Limited

Quantity Surveyor: WT Partnership (HK) Limited

Method of Tendering: Negotiated tendering with preferred contractor

The project was procured by a "negotiated" Guaranteed Maximum Price (GMP) contract. The mechanism of the GMP contract was envisaged and required the major project stakeholders to work as a team in determining the construction methods, programmes, pricing details, preliminaries and conditions of contract. The initial GMP was set when the basic schematic design was completed, which was the stage of submitting general building plans to the government regulatory body. A lump sum was given for the building concrete frame but the other works packages were let on an open-book competitive basis.

The Main Contractor submitted a tender based on the information included in tender documents and the Employer's team of consultants subsequently negotiated the GMP with the Main Contractor. When the GMP was agreed, the main contractor submitted a new tender based on the latest tender documents to the Employer with the agreed GMP, for acceptance by the Client. During the negotiation process, the Main Contractor was required to provide on an 'open-book' basis all information used in support of his tender pricing.

Gain share ratio: 60: 40 (Employer: main contractor)

Pain share ratio: 0: 100 (Employer: main contractor)

Scope of work: The scope of works in this project comprised a 29-storey high commercial building in the hub of Central District in Hong Kong, accommodating high-end retail areas on lower floors with Grade A standard. This project consisted of a 3-storey basement, a 3-storey podium and a 23-storey commercial tower.

The site of Chater House had been occupied by Swire House owned by Hongkong Land Limited. The construction of the building was undertaken under three separate contracts including demolition of the existing building, construction of foundation and construction of superstructure elements. The overall GFA was around 74,000 m^2. The GMP contract with a cost saving sharing mechanism was adopted as an incentive formula under a negotiated tendering method. (Gain share ratio was 60:40 for Employer and main contractor respectively.)

B. Risk Factors and Risk Allocation

2. Can you name some risk factors associated with those GMP/TCC contracts that you had encountered? (e.g. errors and omissions in tender documents, difficult to set a genuine maximum price or target cost, unforeseen ground conditions, change in scope of work, unforeseen design development risk, etc)

The first risk factor was the quality of tender documents at tender stage. If there had been errors or omissions in tender documents at the outset of the project, there would be a huge number of disputes during the post-contract stage.

The second risk factor was the nature of variations. That is, whether a variation should be classified either as GMP variation which would be liable to adjust the agreed GMP value in contract or as design development change.

Setting a genuine maximum price was also regarded as a key risk inherent with this kind of project. If the GMP was set too high, there would be less incentive for the main contractor to propose cost saving proposals. If it was set at an unreasonably low level, the contractor would probably suffer a loss and would then become more claim-conscious, this would jeopardize the whole project delivery process.

In addition, change in scope of work posed a risk in this project. One extra office floor of the building was added in this case, and this was certainly classified as GMP variation which raised the contract GMP value.

Moreover, unforeseen ground conditions and unforeseen design development items were also perceived to be major risks associated with this project.

3. Amongst those risk factors mentioned in Q 2, which are the three most important ones?

They included: (1) quality of tender documents at tender stage and (2) nature of variations.

4. Were there any mitigation measures to deal with these risk factors? If so, please illustrate how they were treated.

(1) Quality of tender documents at tender stage:

The upfront preparation work of tender documentation was important. A clear client's project brief should be given to the QS consultant for perusal before the commencement of tender documentation.

(2) Nature of variations:

An adjudication committee which comprised senior management of both contracting parties (i.e. employer and main contractor) and the representative of consultant QS was set up in this project. This adjudication committee chaired by a senior representative of consultant QS (i.e. Mr Arthur Shia, Director of WTP) served as an effective means to resolve potential disputes, in particular regarding nature of variations in this case.

The seniority of representatives to serve on the adjudication committee was essential to the success of dispute resolution. If the representatives were senior enough, they could make prompt, reasonable decisions on behalf of their working companies in a more effective and efficient manner.

Moreover, the ability and experience of the consultant QS was vital to the success of the adjudication process. He should be impartial, senior enough and well experienced. Every party could query about the rationale behind making decisions in the meeting. He should also be able to stand up against possible questions raised. In addition, he should be courageous enough and not to be shy to tell the client that a certain variation was assessed as a GMP variation and able to accept responsibility. The consultant QS did a very good job in this project, contributing to the overall success in this project.

5. How were these 3 most important risk factors allocated amongst various contracting parties in this project? Who took up each of these risks?

(1) Quality of tender documents at tender stage:

This risk was taken by the employer.

(2) Nature of variations:

This risk was borne by the main contractor in this case.

In my opinion, all the risks including unforeseen ground conditions, unforeseen design development changes and the like at the post-contract stage should be taken by the main contractor himself. This is in fact one of the purposes of introducing GMP contracts to ensure a cost certainty at the outset of a project by avoiding the occurrence of any variations as far as possible.

C. Risk Sharing Mechanisms

6. How did you develop a proper risk allocation (sharing) mechanism to deal with risks inherent in GMP/TCC projects? (e.g. use of risk register, risk management workshop, etc)

Potential risks were identified and analyzed during the negotiated tender stage together with the main contractor.

Moreover, as mentioned in Question 4, risks were dealt with at the adjudication meetings during the course of construction stage. It was flexible and useful to determine disputed items by involving the three parties in the project (i.e. employer, main contractor and team of consultants).

7. How were you satisfied with the performance / effectiveness / appropriateness of the existing risk allocation mechanisms for those projects? What aspects would need for further improvement?

The performance of risk allocation mechanism adopted in this project was satisfactory.

At the pre-contract stage, due diligence was conducted by the team of consultants via prequalification exercise to ensure a proper selection of competent main contractor to partner with. This also helped in risk mitigation in this case. The same was as well undertaken in selection of qualified trade subcontractors. The performance of subcontractors was very good in this project.

At the post-contract stage, the independent adjudication committee was a key element of success in this project. Most intractable disputes between various contracting parties were resolved via this process. There were no arbitration and mediation necessary to this project.

There were also monthly Directors Meetings which involved senior executives such as executive director, senior project manager, contracts manager of the main contractor, directors of various consulting practices and senior project manager of the employer and representatives from subcontractors (e.g. curtain walling) to identify potential risk factors or areas. These meetings initially took place once in every 6 weeks or 2 months but later changed to once per month. The meetings facilitated more effective communications and prompt idea exchange between project participants.

Partnering was adopted in this project as well. This was critical to the success of the Chater House. The working relationship between the employer and main contractor was less adversarial but more harmonious in this case.

Perhaps, the adjudication process could be further improved in terms of frequency of meetings, how the disputed items were presented and discussed and what each party should bring to discussion with substantiated evidence or reasoning.

D. Risk Mitigation Measures

8. Can you provide some strategies or guidelines to mitigate the risks involved in GMP/TCC projects?

Strategies to mitigate the risks associated with this project were proposed as follows:

1. Right selection of project team. For example, due diligence could be conducted during the prequalification exercise. Main contractor was required to select subcontractors for some works packages from a list provided by the employer to let the main contractor have some freedom to choose and, at the same time, the employer would be assured a quality subcontractor with a past track record of good performance to carry out the necessary works. Try to constitute a dream team!

2. Open, frank discussion with consultants after tender interviews. The amount of tender sum was an important selection criterion of tenderers, but it was not the unique one. Other factors such as previous track record and reputation of tenderers should also be taken into consideration during tender assessment.

3. Clearly defined and comprehensive scope of work in client's project brief to let the consultants and tenderers secure a better understanding of the scope of work involved and the underlying philosophy of GMP contractual arrangement.

4. High quality of tender documents at tender stage

5. Early involvement of main contractor in design development.

6. Productive attitude of working team.

7. Design review workshops to review the building design frequently with the main contractor and tap in his expertise to improve the buildability.

8. Representatives of sufficient seniority to participate in the adjudication meetings.

9. Be fair to contractors in valuation of variations and interim payments.

10. Partnering initiative + Adjudication committee + Directors meeting

9. Can you provide some strategies or guidelines for better risk allocation in GMP/TCC projects?

Suggested guidelines for better risk allocation for GMP projects were summarized as follows:

1. Use of 'open-book' accounting regime also enabled quantification of the costs of risks and prevented the project risks from causing adverse effects on overall project performance in terms of time and cost.

2. Partnering approach could be implemented to foster an environment of mutual trust and effective communication between employer and main contractor.

3. Reasonable share of cost saving between employer and main contractor. The gain-share ratio introduced in this project was 60:40 for employer to main contractor. The share ratio would be computed based on historical data of previous GMP projects within employer's organization.

4. Effective adjudication process at post-contract stage to resolve any potential disputes.

5. Standard form of contract for GMP scheme may not be necessary, and standard form of building contract with GMP cross amendments can do!

Interview Report 5

Date: 23 June 2008 (Mon)

Time: 2:00 pm – 3:50 pm

Interviewee: Contr actor 2

Interviewer: Mr . Joseph Chan of PolyU

Project: Public Housing Development at Eastern Harbour Crossing Site Phase 4

(near MTR Yau Tong Station)

A. Case History of GMP/TCC

1. How many GMP/TCC construction projects have you been involved in? Please briefly describe the scope of work of a GMP/TCC project in which you were engaged (e.g. pr oject na ture, pr oject durat ion, c ontract sum , GM P/TCC implementation mechanism, gain-share/pain-share arrangement, etc)

Project duration: From June 2006 to May 2009

(combined foundation and building contract period = 36 months)

Contract Sum: Around HK$434M

Client: Hong Kong Housing Authority (HKHA)

Architect: H ousing Department

Quantity Surveyor: WT Partnership (HK) Limited

Main Contractor: Shui On Building Contractors Co Ltd

Subcontractors: Piling and GMP Subcontractors

Method of Tendering: Two-envelope tendering method (technical proposal together with price proposal)

Six tenderers were shortlisted by HKHA and then invited to submit tenders with base design and alternative proposals which were evaluated to formulate their individual technical scores, as well as the tender price which their price scores were formulated based on their tender sums. The contract was awarded to the tenderer with highest overall score which was the sum of technical score and price score.

Gain share ratio: 50:50 (employer: main contractor)

Pain share ratio: 0: 100 (employer: main contractor)

Scope of work: EHC Phase 4 being a pilot project adopting a Modified GMP Contracting Model (MGMP) was a public rental domestic building project including the construction of: (1) three 41-storey Non-standard Domestic Blocks providing total 2, 469 flats including foundations; (2) a lift tower and footbridge connected to Yau Tong Estate;

(3) one Neighbourhood Elderly Centre; (4) an at grade bus stop; (5) a double-deck walkway connected to EHC Phase 3; (6) site formation and retaining walls; (7) a drainage reserve; and (8) external works.

The combined foundation and building Contract was commenced in June 2006. Contract period is 36 months, with phased completion allowed for completion of bus stop and two of the domestic blocks (Blocks P and Q) in 24 and 31 months respectively after commencement of works.

The domestic blocks in EHC Phase 4 offer potential to set aside portions of the construction works for Modified Guaranteed Maximum Price (MGMP) packages and this amounted to approximately 31% of the overall contract sum (approximately HK$136 M). This MGMP Works packages were -

(a) Specialist External Works including a footbridge and lift tower, and a double-deck walkway linking the blocks;

(b) Enclosure to drainage reserve and the associated backfilling works;

(c) Plumbing and drainage installations;

(d) Fire services and water pump installations;

(e) Electrical installations; and

(f) Prefabrication of concrete elements other than the main structural frame.

It provides an opportunity for the contractor to add value to the contract by setting aside a portion of the work

(~31% of the overall contract sum) for the contractor's alternative design and construction solutions.

Tenders were required to submit Alternative Proposals for five of the packages where Base Designs were provided (Packages b-f), and their own designs for the other packages where only design intent was provided (Package a).

B. Risk Factors and Risk Allocation

2. Can you name some risk factors associated with those GMP/TCC contracts that you had encountered? (e.g. errors and omissions in tender documents, difficult to set a genuine maximum price or target cost, unforeseen ground conditions, change in scope of work, unforeseen design development risk, etc)

Difficulty in obtaining design approval from the Independent Checking Unit (ICU) of Housing Department, which was a unit whose function was similar to the Buildings Department responsible for checking and approving designs of projects developed by Hong Kong Housing Authority (HKHA). When the main contractor comes up with some alternative innovative ideas, it has to submit its alternative design proposal to ICU for verification and approval. If the contractor is not familiar with the practice of ICU, this certainly increases the difficulty in obtaining design approval from the unit on time to suit site progress.

Interface between GMP components and non-GMP components was also perceived to be a risk factor in this case. It would be difficult to classify a design change is "Design Development" or "Requested Variation" in GMP packages, especially when the scope of GMP works was not clearly spelt out in the contract.

Change in scope of work also appeared to be a risk factor associated with this project. The standard of HKHA projects changes from time to time, and thus the standard of this project also changed accordingly. For example, when the brightness of electrical lights under the standard of HK HA projects alters, the standard of all electrical lights in this project must change accordingly. The design change due to policy change of HK HA was the third risk factor encountered in this project.

The nature of variations was the fourth one. If a variation was evaluated as Design Development Instruction (DDI), the main contractor had to bear the time and cost implications of such instruction.

Moreover, fluctuation in price of materials was also considered a risk factor of this project. This risk was shared between employer and main contractor with the fluctuation clause in contract to some extent. However, the main contractor still suffered a loss due to recent sharp increase in materials price in this project although this may be encountered in both traditional and MGMP contracts.

The last one was the inaccurate information about underground conditions in tender documents. This kind of information was provided in good faith (i.e. the accuracy of information was not guaranteed.) The underground conditions were found to be different from what was stated in the tender documents provided at tender stage, so the main contractor had to do extra work on ground site investigation. This extra work was classified as Design Development change, and thus the main contractor had to bear all time and cost implications concerned.

3. Amongst those risk factors mentioned in Q 2, which are the three most important ones?

They were: (1) difficulty in obtaining design approval of ICU of Housing Department; (2) nature of variations; and (3) errors and omissions in tender documents.

4. Were there any mitigation measures to deal with these risk factors? If so, please illustrate how they were treated.

(1) Difficulty in obtaining design approval of ICU of Housing Department:

Several design review workshops were undertaken with the representatives from HKHA and a team of design consultants. The design proposed by the main contractor were reviewed and discussed. These workshop meetings were held once in every 2 weeks during the peak period. Moreover, partnering was adopted in this project to expedite the design approval procedures of ICU.

(2) Errors and omissions in tender documents:

Contingency plans for various risk factors identified were developed at the outset of the project and the risky tasks were determined at earlier stage to lower the level of impact of risks on project success.

5. How were these 3 most important risk factors allocated amongst various contracting parties in this project? Who took up each of these risks?

(1) Difficulty in obtaining design approval of ICU of Housing Department:

This risk was borne by the main contractor. It was added that the design cost of alternative proposals was borne by the main contractor and the time impact of design approval was also on his side. However, the saving was shared by both main contractor and employer. This arrangement would offer less incentive for main contractor to propose innovative ideas on design and construction.

Furthermore, the main contractor had introduced all innovations in the technical submission at tender stage to enhance his chance of winning the contract. The room for further innovations at post-contract stage was rather limited.

The outcome (usually cost saving) for alternative proposals could be borne solely by main contractor in pure design-and-build procurement approach. On the other hand, under the traditional approach, any cost saving because of alternative proposals was totally absorbed by the employer, but the additional cost incurred due to those proposals under design & build was solely paid by main contractor. GMP and TCC would be midway between the traditional approach and design-and-build in terms of financial incentive for main contractor to submit alternative proposals.

The incentive for main contractor to initiate innovative designs to achieve cost saving can be illustrated below:

Least incentive → ***Most incentive***

Traditional approach GMP TCC Design-and-Build

GMP: Guaranteed Maximum Price

TCC: Target Cost Contracting

(2) Errors and omissions in tender documents:

This risk was also borne by the main contractor.

(3) Nature of variations:

This risk was shared by both major contracting parties (i.e. employer and main contractor) in this project.

C. Risk Sharing Mechanisms

6. How did you develop a proper risk allocation (sharing) mechanism to deal with risks inherent in GMP/TCC projects? (e.g. use of risk register, risk management workshop, etc)

A risk register was compiled to identify the potential risk factors inherent with this project at tender stage. Then, the risks were evaluated and their consequences were foreseen. Following on this, a set of proper mitigation measures would be established and a risk estimate would be accompanied by each risk within the tender documents.

There was a "cost build up" system by a database to price the preliminaries. For example, when the project manager enters the number of site agents and site QS into the system, the allowance will be placed in the tender to facilitate the pricing of preliminaries.

Design control schedules were used as a tool to monitor the design progress of the 6 GMP works packages in this project. The latest dates of shop drawing submissions were established to monitor the design progress of subcontractors.

As mentioned in Question 3, design review meetings were held on a regular basis to review the designs proposed by the main contractor and the team of consultants to improve the buildability of project design.

Partnering was also adopted to facilitate a better working relationship between the employer and main contractor. This helped improve communication flows and problem solving.

Short-term programme was used to monitor the design and construction of this project. Amount of float time can be estimated and thus the site progress can be properly monitored. Corresponding contingency plans were established for unexpected delays.

7. How were you satisfied with the performance / effectiveness / appropriateness of the existing risk allocation mechanisms for those projects? What aspects would need for further improvement?

The performance of existing risk allocation mechanism for the project was satisfactory, considering that this was the first MGMP project in Hong Kong.

Only 31% of the total contract sum in this project was subject to GMP contractual arrangement. The extent of main contractor in participating in building designs was rather limited, and thus the flexibility of design change for contractor was relatively lower in this case.

The risk allocation would be improved if:

(1) GMP arrangement was applied to the whole project, rather than only 31% of total contract sum to enhance contractor's flexibility of design change and avoid the problem of interfacing between GMP components and non-GMP components.

(2) The Employer shared both gain and pain with the main contractor. In other words, applying Target Cost Contracting (TCC) in this project.

D. Risk Mitigation Measures

8. Can you provide some strategies or guidelines to mitigate the risks involved in GMP/TCC projects?

Strategies to mitigate the risks associated with this project were proposed as follows:

1. Use of risk register at tender stage for risk identification, analysis and mitigation.

2. Relaxation of contract specifications by HKHA. Since the alternative designs proposed by the main contractor have to comply with the contract specifications, relaxation of such specifications would encourage more innovations from contractor. For example, if there were more choices of acceptable materials specified in the specifications, the contractor would be more flexible in selecting materials for their alternative design proposals.

3. Risky tasks or items should be sought at earlier stage of the project via the risk register.

4. More effective communications between main contractor and project team members to streamline the design approval process of ICU of Housing Department (e.g. regular meetings to facilitate prompt exchange of innovative ideas within the project team).

5. Application of short-term programme and design control schedule for better time management.

9. Can you provide some strategies or guidelines for better risk allocation in GMP/TCC projects?

Suggested guidelines for better risk allocation for GMP projects were summarized as follows:

1. Partnering approach could be implemented to foster an environment of mutual trust and effective communication between the employer and the main contractor.

2. Application of TCC to share gain as well as pain between the employer and main contractor.

3. More reasonable share of gain between employer and main contractor (e.g. 30:70 for employer to main contractor rather than 50:50).

4. The gain-share ratio between main contractor and subcontractors was assessed case by case in this project. This arrangement could be improved by stating the gain-share ratio between main contractor and subcontractors in subcontracts for better risk allocation.

<u>Interview Report 6</u>

Date: 30 June 2008 (Mon)

Time: 2:30 pm – 4:00 pm

Interviewee: Client 3

Interviewers: Dr Daniel Chan and Mr Joseph Chan of PolyU

Project: Three Pacific Place (3PP)

A. Case History of GMP/TCC

1. How many GMP/TCC construction projects have you been involved in? Please briefly describe the scope of work of a GMP/TCC project in which you were engaged (e.g. project nature, project duration, contract sum, GMP/TCC implementation mechanism, gain-share/pain-share arrangement, etc)

Client 3 has been involved in 2 GMP building projects in Hong Kong including Three Pacific Place and One Island East. He has also taken a leading role in producing draft standard form of building contract with GMP methodology on behalf of Swire Properties, in particular the first pilot GMP scheme applied to the project of “The Orchards (逸樺園)”.

Project duration: From 6 May 2002 to July 2004 for main office building block. The construction of pedestrian tunnel link in this project was completed in January 2007.

Contract Sum: Around HK$1,000M to HK$1,100M

Client: Swire Properties Limited

Architect:	Wong & Ouyang (HK) Limited
Quantity Surveyor:	Davis Langdon and Seah (Hong Kong) Limited
Method of Tendering:	Selective tendering for main contract
Gain share ratio:	50:50 (employer: main contractor)
Pain share ratio:	0: 100 (employer: main contractor)
Scope of work:	It was a Grade A private office development project with GMP contractual arrangement including the construction of a 34-storey high office tower for a typical floor gross floor area of about 1,700 m^2, a 3-level podium, three basement car parking floors, and an underground pedestrian tunnel link. At the basement B3 level, the development was connected to the MTR Admiralty Station and other parts of Pacific Place via an air-conditioned, travelator-equipped underground pedestrian link which was an optional item in this project. The construction of the pedestrian tunnel link commenced after the main building had been completed. The external façade of the tower was a combination of glass walls and curtain walls. There was no specific item for the contractor to price for design development, and the price of design development was reflected in BQ rates and preliminaries. There was no open-book accounting arrangement as well in this project.

The GMP Contract leaded to efficient contractual arrangements and reduces disputes. The partnering working relationship with the main contractor and subcontractors facilitates a more effective and efficient dispute prevention and resolution.

B. Risk Factors and Risk Allocation

2. Can you name some risk factors associated with those GMP/TCC contracts that you had encountered? (e.g. errors and omissions in tender documents, difficult to set a genuine maximum price or target cost, unforeseen ground conditions, change in scope of work, unforeseen design development risk, etc)

The first risk factor was the unforeseen ground conditions which was shifted to the foundation contractor. If the lengths of piles actually required were longer than those specified in the Bills of Quantities, the contractor would be compensated in terms of money but no extension of time would be granted.

The second risk factor was the nature of variations. That is, whether a variation should be classified either as GMP variation which would be liable to adjust the agreed GMP value in contract or as design development change.

In addition, unclear scope of work was a risk factor in this project. In fact, this risk was related to the clarity of tender documents. The tender documents should be drafted as clear as possible to avoid ambiguity.

The last one was the selection of subcontractors.

3. Amongst those risk factors mentioned in Q 2, which are the three most important ones?

They included: (1) quality and clarity of tender documents; (2) nature of variations; and (3) selection of right project team.

4. Were there any mitigation measures to deal with these risk factors? If so, please illustrate how they were treated.

(1) Quality and clarity of tender documents:

The upfront preparation work of tender documentation was important in risk mitigation. A well-defined client's project brief should be given to the consultant QS for perusal before the commencement of tender documentation. Moreover, tender briefings and tender interviews enabled the tenderers to really understand and recognize the potential risks involved in the project before contract award.

(2) Nature of variations:

Proactive communications between both contracting parties (i.e. employer and main contractor) would help mitigate this risk. It was also important that the representatives from both parties have an open mind to solve problems. Moreover, partnering approach was also an essential vehicle to facilitate effective communications and harmonious working relationship in this project.

(3) Selection of right project team:

Named (approved) subcontractors were used rather than nominated subcontractors in this case. The main contractor was involved in the selection of those named subcontractors which were already registered on an approved list provided by the client. This approach could offer some flexibility to main contractor in selecting subcontractors with whom he is willing or preferable to partner. On the other hand, the client had exercised more stringent control on the quality of subcontractors because those subcontractors recommended by main contractor needed to be approved and agreed by the client for appointment as well. The subcontractors submitting lowest bids might not necessarily be awarded the subcontracts. Other factors such as previous track record, technical competence, market reputation and the like would be taken into consideration as well.

5. How were these 3 most important risk factors allocated amongst various contracting parties in this project? Who took up each of these risks?

(1) Quality and clarity of tender documents:

This risk was taken by the main contractor.

(2) Nature of variations:

This risk was borne by the main contractor.

C. Risk Sharing Mechanisms

6. How did you develop a proper risk allocation (sharing) mechanism to deal with risks inherent in GMP/TCC projects? (e.g. use of risk register, risk management workshop, etc)

At the pre-contract stage, the tender documents should be drafted as clear as possible as mentioned in Q4. If the main contractor had not made sufficient allowance in the tender to cover his risks, he would probably become claim-conscious later and this would jeopardize the whole project delivery process and overall performance.

Problems arisen from the project were analyzed and discussed as early as possible through partnering workshops at post-contract stage.

7. How were you satisfied with the performance / effectiveness / appropriateness of the existing risk allocation mechanisms for those projects? What aspects would need for further improvement?

The effectiveness of the existing risk allocation mechanism was satisfactory in this case.

The project manager should take initiative to solve the problems occurred in the project.

Partnering approach helped facilitate harmonious working relationship between both contracting parties (i.e. employer and main contractor).

D. Risk Mitigation Measures

8. Can you provide some strategies or guidelines to mitigate the risks involved in GMP/TCC projects?

Strategies to mitigate the risks associated with this project were proposed as follows:

1. Right selection of project team.

2. Clearly-defined and comprehensive scope of work in client's project brief to let the team of consultants and tenderers have a better understanding of scope of work involved and the philosophy of GMP contractual arrangements.

3. High quality and clarity of tender documents

4. Productive attitude of working team.

5. Engagement of an independent external construction advisor to advise on the buildability of project design at pre-contract stage.

9. Can you provide some strategies or guidelines for better risk allocation in GMP/TCC projects?

Suggested guidelines for better risk allocation for GMP projects were summarized as follows:

1. Introduction of bonus clause for early completion by the main contractor.

2. Partnering approach could be adopted to foster an environment of mutual trust and effective communication between employer and main contractor.

3. Reasonable share of cost saving between employer and main contractor to stimulate contractor's interest in improving both design and construction.

Interview Report 7

Date: 3 July 2008 (Thu)

Time: 10:00 am – 12:00 noon

Interviewee: Consultant 2

Interviewers: Dr Daniel Chan and Mr. Joseph Chan of PolyU

Project: Chater House

A. Case History of GMP/TCC

1. How many GMP/TCC construction projects have you been involved in? Please briefly describe the scope of work of a GMP/TCC project in which you were engaged (e.g. project nature, project duration, contract sum, GMP/TCC implementation mechanism, gain-share/pain-share arrangement, etc)

Consultant 2 was personally involved in 4 GMP building projects including Chater House, 1064 King's Road, York House in Hong Kong and One Raffles Link in Singapore which were all developed by the client "Hongkong Land".

Project duration: From October 2000 to July 2002 (641 days)
Final project duration (635 days)

Contract Sum: HK$1.2 billion and final project cost HK$1.5 billion with 15% cost saving

Client: Hongkong Land Limited

Project Manager: Hongkong Land (Project Management) Limited

Main Contractor: Gammon Skanska Limited

Design Architect: Kohn Pederson Fox Associates

Project Architect: Aedas LPT Limited

Structural Engineer: Ove Arup and Partners (HK) Limited

E&M Engineer: WSP Hong Kong Limited

Quantity Surveyor: WT Partnership (HK) Limited

Method of Tendering: Negotiated tendering with preferred contractor

The project was procured by a "negotiated" Guaranteed Maximum Price (GMP) contract. The mechanism of the GMP contract was envisaged and required the major project stakeholders to work as a team in determining the construction methods, programmes, pricing details, preliminaries and conditions of contract. The initial GMP was set when the basic schematic design was completed, which was the stage of submitting general building plans to the government regulatory body. A lump sum was given for the building concrete frame but the other works packages were let on an open-book competitive basis.

The Main Contractor submitted a tender based on the information included in tender documents and the Employer's team of consultants subsequently negotiated the GMP with the Main Contractor. When the GMP was agreed, the main contractor submitted a new tender based on the latest tender documents to the Employer with the agreed GMP, for acceptance by the Client. During the negotiation process, the Main Contractor was required to provide on an 'open-book' basis all information used in support of his tender pricing.

Gain share ratio: 60: 40 (Employer: main contractor)

Pain share ratio: 0: 100 (Employer: main contractor)

Scope of work: The scope of works in this project comprised a 29-storey high commercial building in the hub of Central District in Hong Kong, accommodating high-end retail areas on lower floors with Grade A standard. This project consisted of a 3-storey basement, a 3-storey podium and a 23-storey commercial tower.

The site of Chater House had been occupied by Swire House owned by Hongkong Land Limited. The construction of the building was undertaken under three separate contracts including demolition of the existing building, construction of foundation and construction of superstructure elements. The overall GFA was around 74,000 m^2. The GMP contract with a cost saving sharing mechanism was adopted as an incentive formula under a negotiated tendering method. (Gain share ratio was 60:40 for Employer and main contractor respectively.)

B. Risk Factors and Risk Allocation

2. Can you name some risk factors associated with those GMP/TCC contracts that you had encountered? (e.g. errors and omissions in tender documents, difficult to set a genuine maximum price or target cost, unforeseen ground conditions, change in scope of work, unforeseen design development risk, etc)

Market trend in building design was the first risk factor encountered. The building itself was a product, and whether this product could fits or respond to the market demand was a risk for production.

The second one was the quality of tender documents at tender stage. If there had been errors and omissions in tender documents at the outset of the project, there might be a plethora of intractable disputes at the post-contract stage due to incomplete tender documentation.

Nature of variations was considered to be another risk factor inherent with this project. That is, whether a variation should be classified either as GMP variation which would be liable to adjust the agreed GMP value in contract or as design development change. The changes in building services installation and structural building frame erection were usually classified as design development items which would not be allowed to alter the GMP contract value. Taking the example of York House, the call for tender was issued at about 70-80% design complete and the GMP arrangement was also applied between main contractor and E&M nominated subcontractor. This might reduce the extent of variations as far as possible. Generally, a change would be categorized as a GMP variation under six possible conditions (e.g. change in floor area or volume, function of an area, quality of an area, adjustment of provisional quantities or provisional sums, etc).

In addition, unfamiliarity with GMP methodology by contractor was perceived as a risk factor associated with this form of project procurement. If the traditional mindset of contractor did not change, the GMP projects would probably be difficult to proceed.

Price fluctuation of materials was also regarded as a risk factor in this GMP project. Other risk factors included inclement weather and unforeseen ground conditions.

It was interesting to compare the final project cost under traditional form of contract (i.e. lump-sum contract price + alleged variations) with the agreed contract GMP value (i.e. construction cost + expected profit + design development changes) to see whether final project cost is higher or lower than the contract GMP value. Generally speaking, GMP seeks "reasonable" price to complete a project with satisfactory quality but usually not the "lowest" price of the project.

3. Amongst those risk factors mentioned in Q 2, which are the three most important ones?

They were : (1) quality of tender documents; (2) nature of variations ; (3) market trend in building design; and (4) unfamiliarity with GMP methodology by contractor.

4. Were there any mitigation measures to deal with these risk factors? If so, please illustrate how they were treated.

The underlying philosophy of GMP is to let the main contractor seek any cost savings arising from the procurement of subcontracted works packages due to his expertise and the proposition of using other alternative methods or materials with equal or better quality to complete a project.

(1) Quality of tender documents:

The upfront preparation work of tender documentation was important in risk mitigation. Data and information collected from past "reference projects" with complete set of contract documentation in which the developer and/or the contractor were /was engaged could be referred to as the benchmarks or yardsticks for new projects (e. g. expected construction cost of high quality office building = HK$18,000 per m^2). All these data and information could certainly help both contracting parties to ascertain the initial GMP value.

(2) Nature of variations:

Partnering approach would help with the mitigation of this risk. The disputed variations were fully explained and discussed via adjudication committee which was composed of representatives of different contracting parties for the project (i.e. developer, architect, engineer, quantity surveyor, main contractor or even subcontractors). Partnering facilitated the implementation of GMP concepts based on identified common project goals.

(3) Market trend in building design

The developer could mitigate this risk by negotiating leasing terms and conditions with potential shop tenants. For example, if the standard of a shopping mall was upgraded at the construction stage, the developer may in turn negotiate a leasing term with higher rent with the potential shop users to compensate his extra cost of construction.

(4) Unfamiliarity with GMP methodology by contractor

Tender briefings and tender interviews were conducted at pre-contract stage to ensure the tenderers to have a sound understanding of the scope of works involved and potential risk factors inherent with GMP projects.

5. How were these 3 most important risk factors allocated amongst various contracting parties in this project? Who took up each of these risks?

(1) Quality of tender documents:

This risk was taken by the main contractor

(2) Nature of variations:

This risk was shared by the employer and main contractor.

(3) Market trend in building design

This risk was taken by the employer.

C. Risk Sharing Mechanisms

6. How did you develop a proper risk allocation (sharing) mechanism to deal with risks inherent in GMP/TCC projects? (e.g. use of risk register, risk management workshop, etc)

Early involvement of contractor in design development can improve the buildability of project design and also reduce the construction risk. The contractor was invited to review the preliminary design drawings and contract specifications at tender documentation stage, so there would be fewer errors and omissions in the tender. Even if errors and omissions were discovered at the post-contract stage, the contractor would be in a weaker position to claim for monetary compensation because the risk of tender documentation was partially borne by the contractor himself under GMP procurement approach.

Value engineering workshops were introduced to further improve the buildability of project design by group effort and hence mitigating the construction risk.

Adjudication committee was a useful venue to resolve disputes about the nature of variations (DDI vs GMPV). The disputes could be settled by open-minded discussion during the meeting with different contracting parties concerned. If there were any discrepancies in the contract documentation of subcontracted works packages, the main contractor should voice out to the employer and consultants before tendering out subcontracts, not until at the adjudication committee meeting.

A provisional sum was priced by the contractor in the GMP contract and thus he needed not take this risk.

7. How were you satisfied with the performance / effectiveness / appropriateness of the existing risk allocation mechanisms for those projects? What aspects would need for further improvement?

The performance of existing risk allocation mechanism for this project was satisfactory in general.

Regarding the aspects for further improvement, any cost saving could be shared by the employer, main contractor and also the team of consultants who might also have made remarkable contributions to the success of the project. But opposite opinions were solicited from some employers that consultants had already been rewarded with their respective consultancy fees.

Moreover, it is advisable to share the cost saving between main contractor and subcontractors with large contract sums such as E&M subcontract and curtain wall subcontract.

D. Risk Mitigation Measures

8. Can you provide some strategies or guidelines to mitigate the risks involved in GMP/TCC projects?

Strategies to mitigate the risks associated with this project were proposed as follows:

1. Right selection of project team with those familiar with GMP methodology.

2. Open discussion with consultants after tender briefings and tender interviews.

  3. Clearly defined and comprehensive scope of work in client's project brief to let the consultants and tenderers have a better understanding of the scope of work involved and the philosophy of GMP contractual arrangements.

  4. High quality of tender documents based on previous "reference" projects as benchmarks or yardsticks.

  5. Early involvement of main contractor in design development. For negotiated tendering, the employer may issue a call for tender submission to preferred contractor at around 20-30% design complete while for selective tendering, the call for tenders may be launched at about 70-80% design complete.

  6. Productive attitude of working team.

  7. Value engineering workshops or design review workshops to review the project design with the main contractor and integrate his expertise to improve the buildability of project design.

  8. Partnering approach could be applied to cultivate an environment of mutual trust and effective communication between employer and main contractor.

9. Can you provide some strategies or guidelines for better risk allocation in GMP/TCC projects?

Suggested guidelines for better risk allocation for GMP projects were summarized as follows:

1. Use of 'open-book' accounting regime also enabled quantification of the costs of risks and prevented the project risks from causing adverse effects on overall project performance in terms of time and cost. This approach requires high level of mutual trust between the employer and main contractor. In my opinions, open-book accounting arrangement would be a prerequisite for negotiated tendering while for selective tendering, open-book regime should be applied to subcontracts, but not necessarily to main contract.

2. Partnering approach could be applied to cultivate an environment of mutual trust and effective communication between employer and main contractor.

3. Reasonable share of cost saving between employer and main contractor. The gain-share ratio in this project was 60:40 for the employer to main contractor. The share ratio would be computed based on historical data set of GMP projects in future.

4. Effective adjudication process at post-contract stage to resolve intractable disputes.

5. The fundamental principle of risk allocation is that the party who can best manage and control a certain risk should be allocated such risk in the project. For example, the employer should bear the risk of market trend in building design. The risk of price fluctuation of materials (e.g. steel reinforcement bars) may be taken by the contractor due to more purchase orders under a long-term contract with his suppliers or the employer may also bear this risk by placing pre-orders one year before.

6. In principle, GMP looks for "no variations" at all unless those changes due to client's requirements.

13 March 2009

Dear Sir/Madam,

Re: Invitation for Participation in a GMP/TCC Research Survey

The research team at the Department of Building and Real Estate of The Hong Kong Polytechnic University, in collaboration with the Loughborough University and the University of South Australia, is currently undertaking a research project funded by the Research Grants Council of the HKSAR Government entitled *"**An Investigation of the Risk Factors and Risk Allocation for Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) Schemes in Hong Kong, the United Kingdom and Australia**"*.

We are now launching a questionnaire survey, the main objective of which is to identify the key risk factors and explore the existing risk sharing mechanisms of GMP/TCC contracts based on selected case study projects in Hong Kong, the United Kingdom and Australia, so as to enable a thorough understanding of this procurement strategy and its risk management process for achieving excellence in construction project delivery.

As an experienced practitioner, you are cordially invited to give your opinions by completing the survey questionnaire as enclosed. All the information you provide will be kept in strict confidence and used solely for research purposes. We strongly believe that your experience and professional advice are highly valuable to our research study and the construction community at large. We would appreciate if you could help complete the enclosed survey questionnaire **based on your hands-on experience in managing GMP/TCC construction projects OR your understanding of their underlying principles even though you may have not participated in such projects yet**.

Kindly return the completed questionnaire by your preferred choice: (a) by post to Dr Daniel Chan using the attached stamped self-addressed return envelope; or (b) by fax to (852) 2764-5131 for the attention of "Dr Daniel Chan"; or (c) via email to bsdchan , **on or before 27 March 2009 (Fri)**.

Should you have any further enquiries, please feel free to contact Mr Joseph Chan at (852) 2766-5873 or via e-mail to joseph.chan.

Thank you in anticipation for your generous assistance with our research. We are looking forward to receiving your early response.

Yours sincerely,

Dr Daniel Chan (Principal Investigator)

Assistant Professor

Department of Building and Real Estate

The Hong Kong Polytechnic University

SURVEY QUESTIONNAIRE

An Investigation of the Risk Factors and Risk Allocation for Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) Schemes in Hong Kong, the United Kingdom and Australia

Introduction and Instruction

As a result of the increasing constraints on tight schedule, limited budget and project complexity, there is a strong call for changes in contracting procedures in construction. The aim of this research is to investigate the risk factors and risk allocation for Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) construction projects (see definitions under Part D on Page 3) in Hong Kong, the United Kingdom and Australia. It takes about 15 minutes to complete this survey questionnaire. Please return your completed questionnaire by your preferred choice: (a) by post to Dr Daniel Chan using the attached stamped self-addressed return envelope; or (b) by fax to (852) 2764-5131 for the attention of "Dr Daniel Chan"; or (c) via e mail to bsdchan@inet.polyu.edu.hk, **on or before 27 March 2008 (Fri)**.

Part A – Background of Respondent

1. Country where you work: ❑ Hong Kong (China) ❑ United Kingdom ❑ Australia
   ❑ Other (please specify): ____________________
2. Name of your working organization: ____________________
3. Type of organization in which you are working:
   ❑ Client Organization ❑ Main Contractor ❑ Architectural Consultant
   ❑ Engineering Consultant ❑ QS Consultant ❑ Project Management Consultant
   ❑ Subcontractor ❑ Academic ❑ Other: ____________
4. Size of your organization:
   ❑ Below 100 staff ❑ 100-300 staff ❑ Over 300 staff
5. Years of professional working experience in the construction industry :
   ❑ Below 5 years ❑ 5-10 years ❑ 11-15 years ❑ 16-20 years
   ❑ Over 20 years
6. Please indicate your experience in GMP/TCC construction projects.
   ❑ 1-2 projects ❑ 3-4 projects ❑ More than 4 projects ***(You may proceed to Part B below)***
   ❑ No hands-on experience but with a basic understanding of GMP/TCC schemes or principles ***(You may proceed to Part B below)***
   ❑ No hands-on experience in GMP/TCC projects ***(You may stop here and please return this survey form to us for record.)***
7. Please name a project with GMP/TCC contractual arrangement on which your answers base:
   ❑ GMP ❑ TCC

Part B – Level of Severity and Likelihood of Occurrence of Risk Factors and Risk Allocation for GMP/TCC Schemes in Construction

Please rate the Level of Severity and Likelihood of Occurrence of each potential risk factor associated with GMP/TCC construction projects with a Likert scale ***(where 1 = "Very low", 2 = "Low", 3 = "Medium", 4 = "High" and 5 = "Very high" for <u>SEVERITY</u>);*** *and* ***(1 = "Very very low" (Almost no possibility of occurrence), 2 = "Very low" (Very unlikely to occur), 3 = "Low" (Unlikely to occur), 4 = "Medium" (Likely to occur), 5 = "High" (Very likely to occur), 6 = "Very high" (Expected to occur) and 7 = "Very very high" (Expected to occur with absolute certainty) for <u>LIKELIHOOD</u>****, together with the party best capable to manage a particular risk. The meanings of choices 1, 2, 3, 4 and 5 are as follows:*

1	*Client (100%)*	*Client is best capable to manage the risk*
2	*Client > Contractor (Ctr)*	*Client is more capable than Contractor to manage the risk*
3	*Client = Contractor (Ctr)*	*Both Client and Contractor are equally capable to manage the risk*
4	*Contractor (Ctr) > Client*	*Contractor is more capable than Client to manage the risk*
5	*Contractor (Ctr) (100%)*	*Contractor is best capable to manage the risk*

Part B – Potential Risk Factors Associated with GMP/TCC Construction Projects		**Risk Analysis**		**Party best capable to manage the risk**				
				1	**2**	**3**	**4**	**5**
	(If you perceive the severity of Risk Factor 1 to be "high" and "very likely to occur", and the contractor is more capable than the client to manage this risk, then write down 4 against "Severity", 5 against "Likelihood" and choose 4 as the answer under "Party best capable to manage the risk".) If you are uncertain in evaluating a particular risk factor, please simply leave the relevant boxes blank.	**Severity Scale (1-5)**	**Likelihood Scale (1-7)**	Client (100%)	Client > Ctr	Client = Ctr	Ctr > Client	Ctr (100%)
	Risk Factor 1 (example)	***4***	***5***	❑	❑	❑	☑	❑
Contractual Risks	1. Actual quantities of work required far exceeding estimate			❑	❑	❑	❑	❑
	2. Delay in resolving contractual disputes			❑	❑	❑	❑	❑
	3. Unrealistic maximum price or target cost agreed in the contract			❑	❑	❑	❑	❑
	4. Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor			❑	❑	❑	❑	❑
	5. Change in scope of work			❑	❑	❑	❑	❑
	6. Errors and omissions in tender document			❑	❑	❑	❑	❑
	7. Difficult for main contractor to have back-to-back GMP/TCC contract terms with nominated or domestic subcontractors			❑	❑	❑	❑	❑
	8. Inaccurate topographical data at tender stage			❑	❑	❑	❑	❑
	9. Loss incurred by main contractor due to unclear scope of work			❑	❑	❑	❑	❑
	10. Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage			❑	❑	❑	❑	❑

Constrn. Risks	11.	Technical complexity and design innovations requiring new construction methods and materials from main contractor			❑	❑	❑	❑	❑
	12.	Poor quality of work			❑	❑	❑	❑	❑
Third Party Risks	13.	Delay in availability of labour, materials and equipment			❑	❑	❑	❑	❑
	14.	Low productivity of labour and equipment			❑	❑	❑	❑	❑
	15.	Selection of subcontractors with unsatisfactory performance			❑	❑	❑	❑	❑
	16.	Delay in work due to third party			❑	❑	❑	❑	❑
Design Risks	17.	Insufficient design completion during tender invitation			❑	❑	❑	❑	❑
	18.	Poor buildability / constructability of project design			❑	❑	❑	❑	❑
	19.	Little involvement of main contractor in design development process			❑	❑	❑	❑	❑
	20.	Unforeseeable design development risks at tender stage			❑	❑	❑	❑	❑
Economic and Financial Risks	21.	Exchange rate variations			❑	❑	❑	❑	❑
	22.	Inflation beyond expectation			❑	❑	❑	❑	❑
	23.	Market risk due to the mismatch of prevailing demand of real estate			❑	❑	❑	❑	❑
	24.	Change in interest rate on main contractor's working capital			❑	❑	❑	❑	❑
	25.	Delayed payment on contracts			❑	❑	❑	❑	❑
	26.	Global financial crisis			❑	❑	❑	❑	❑
Physical Risks	27.	Force Majeure (Acts of God) (e.g. natural disasters)			❑	❑	❑	❑	❑
	28.	Inclement weather			❑	❑	❑	❑	❑
	29.	Unforeseeable ground conditions			❑	❑	❑	❑	❑
Others	30.	Change in relevant government regulations			❑	❑	❑	❑	❑
	31.	Difficult to obtain statutory approval for alternative cost saving designs			❑	❑	❑	❑	❑
	32.	Lack of experience of contracting parties throughout GMP/TCC process			❑	❑	❑	❑	❑
	33.	Impact of construction project on surrounding environment			❑	❑	❑	❑	❑
	34.	Environmental hazards of constructed facilities towards the community			❑	❑	❑	❑	❑
	35.	Other (please specify): ____________________			❑	❑	❑	❑	❑
	36.	Other (please specify): ____________________			❑	❑	❑	❑	❑

Part C – Risk Mitigation Measures for GMP/TCC Schemes in Construction

Please rate the effectiveness of the following possible risk mitigation measures for GMP/TCC construction projects.

	Possible Risk Mitigation Measures for GMP/TCC Construction Projects	Least effective	Fairly effective	Effective	Very effective	Most effective
1.	Application of price fluctuation clause in the contract	❑	❑	❑	❑	❑
2.	Clearly stated circumstances in which agreed GMP value or target cost can be adjusted in contracts	❑	❑	❑	❑	❑
3.	Clearly defined scope of work in client's project brief	❑	❑	❑	❑	❑
4.	Prompt valuation and agreement on any variations as they are introduced	❑	❑	❑	❑	❑
5.	Proper risk register with responsible parties assigned and agreed	❑	❑	❑	❑	❑
6.	Confirming a contract GMP value or target cost after design documents are substantially completed	❑	❑	❑	❑	❑
7.	Development of standard contract clauses in connection with GMP/TCC schemes or methodology	❑	❑	❑	❑	❑
8.	Early involvement of the main contractor in design development process	❑	❑	❑	❑	❑
9.	Employing a third party to review the project design in compliance with prevailing building regulations and buildability at tender stage	❑	❑	❑	❑	❑
10.	Implementation of relational contracting within project team	❑	❑	❑	❑	❑
11.	Sufficient time given to interested contractors to submit their bids for consideration	❑	❑	❑	❑	❑
12.	Mutual trust between the parties to the contract	❑	❑	❑	❑	❑
13.	Open-book accounting regime provided by main contractors in support of their tender pricing	❑	❑	❑	❑	❑
14.	Proactive participation by the main contractor throughout the GMP/TCC process	❑	❑	❑	❑	❑
15.	Reasonable sharing mechanism of cost saving / overrun of budget between client and contractor	❑	❑	❑	❑	❑
16.	Right selection of project team	❑	❑	❑	❑	❑
17.	Tender interviews and tender briefings to ensure tenderers gain a clear understanding of scope of work involved and necessary obligations to be taken in the project	❑	❑	❑	❑	❑
18.	Establishment of adjudication committee and meetings to resolve potential disputed issues	❑	❑	❑	❑	❑
19.	Other (please specify): ______________________	❑	❑	❑	❑	❑

Part D – Personal Opinions on GMP/TCC (OPTIONAL)

GMP: *A contractual agreement under which any savings below the guaranteed maximum price are shared between client and contractor, whereas contractor assumes the sole responsibility for any cost overruns beyond the guaranteed maximum price (i.e. gain-share only without pain-share arrangement)*

TCC: *A contractual agreement under which any differences between the target cost of the work and actual cost at completion are shared between client and contractor with a pre-determined sharing ratio (i.e. both gain-share and pain-share arrangements)*

1. Which procurement option will you favour in future projects? ❑ GMP ❑ TCC ❑ No preference
2. Supporting reasons for your choice:

____

____

End of the questionnaire. Thank you for your valuable contribution

10 October 2010

Dear Sir,

Invitation to Validation of a Fuzzy Risk Assessment Model for GMP/TCC Schemes

A questionnaire survey on risk assessment and risk allocation of projects procured by the Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) schemes had been launched last year, the research team of The Hong Kong Polytechnic University developed a "**Fuzzy Risk Assessment Model" (FRAM)** for projects procured by the GMP/TCC schemes. You are cordially invited to attend a face-to-face interview for the validation of this model.

The proposed agenda of the short interview for validation of the model is as follows:

1. Presentation of the FRAM for GMP/TCC schemes by Mr Joseph Chan (around 10 minutes)
2. Filling in a validation form comprising 5 multiple choice questions by the interviewee (around 3 minutes)

Thank you for your kind help to our research. I look forward to seeing you at 11:00 am on next Wednesday (20 October 2010).

Regards,

____

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Fuzzy Risk Assessment Model Validation for Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) Construction Projects in Hong Kong

The purpose of this survey is to validate the Fuzzy Risk Assessment Model (the Model) generated from an empirical questionnaire survey on GMP and TCC schemes conducted between March and May of 2009. It takes **about 3 minutes** to complete this validation questionnaire.

Please rate the extent of satisfaction (i.e. 1 presents "poor" and 5 indicates "excellent") to the model against each validation aspect.

Validation Aspects	Poor ⟶ Excellent 1	2	3	4	5
1. Degree of Comprehensiveness of Risks included in the Model	❑	❑	❑	❑	❑
2. Degree of Clarity of the Model	❑	❑	❑	❑	❑
3. Degree of Objectivity of the Model	❑	❑	❑	❑	❑
4. Degree of Practicality of the Model	❑	❑	❑	❑	❑
5. Overall Reliability of the Model	❑	❑	❑	❑	❑

Note: 1 denotes "poor" and 5 denotes "excellent".

End of the questionnaire. Thank you for your valuable contribution

9.0

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