Risk Management for Contractors in Marine Projects

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Brief introduction to the problem

Risk management is one of the important management strategies that lead the success of major construction projects. Managing risks has become an important part of the management activities in construction industry. In Hong Kong, marine construction forms a major part of the construction business. In fact, it is appeared that marine construction exposes to serious risks in comparing to other types of construction work, which contributes the potential loss to both clients and contractors. There is a need for systematic risk management approaches that can help contractors for reducing and controlling risks thus to effectively improve project management. This paper focuses on contractor parties who work on marine construction work, and aims to identify critical risks and risk response techniques in managing marine projects. Questionnaire survey and structured interviews are conducted. It is found that "underwater conditions are different from tender assumptions" is the most common risk factor encountered in marine projects, "unavailability of materials, plant and labour" is the most impact to the project if risk is encountered. The most effective risk response technique to tickle risks encountered is "refer to previous experience". Recommendations for improving risk management are also discussed.

Keywords

Risk management, contractor, marine project, Hong Kong.

Introduction

Marine projects are one of major work in the Hong Kong construction industry. More than forty marine projects are in progress by the Hong Kong government (see Table 1) (Hong Kong Government, 2007), which include bulkheads, seawalls, foundation piles, docks, inspections, piers dredging and pipe work. The Civil Engineering and Development Department reported that there are about $168.7 million for their marine projects in 2006-2007 (Civil Engineering and Development Department, 2007). This highlights the importance of marine projects in the local construction industry.

Completed Date	Type	Location
13 Jun 2008	Reclamation	Penny's Bay, Lantau Island
9 Jan 2008	Silt Curtains	Pai Tau Kwu, Lantau Island
31 Jan 2007	Construction of Landing Steps and Viewing Platforms	Ma Liu Shui, Tolo Harbour
2 Nov 2007	Capping of Mud Pits	North of the Hong Kong International Airport
7 Nov 2006	Reconstruction Works	Sha Tau Kok Public Pier
20 Jan 2007	Submarine Outfall Construction Works	Tai Lei, Peng Chau
12 Jan 2007	Submarine Cable Laying Operations	Cyberport, Hong Kong Island to Yung Shue Wan, Lamma Island
24 Nov 2006	Construction of Seawall	West of Tsing Lung Tau
21 Nov 2006	Viaduct and Seawall Construction	Tai Lam Chung
29 Jul 2008	Construction of an Offshore Jetty	Pillar Point, Urmston Road
15 Apr 2008	Establishment of a Temporary Barging Point	at East of Kau Sai Chau
10 Nov 2006	Dredging Operations	Deep Bay
22 Oct 2006	Marine Site Investigation	Tung Wan, Cheung Chau
1 Jan 2007	Rubble Removal and Sand Replenishment Works	Tung Wan, Peng Chau
10 Mar 2007	Marine Works	Ping Chau Public Pier, Mirs Bay
1 Jan 2007	Construction of Temporary Unloading Frame and Unloading of Steel Segments	Temporary Jetty at West of Stonecutters Island
12 Nov 2006	Marine Site Investigation	Lei Yue Mun
24 Nov 2006	Maintenance Dredging	Kau Yi Chau Dangerous Goods Anchorage
1 Nov 2006	Marine Site Investigation	Cyberport, Hong Kong Island
7 Nov 2006	Dredging Operations	Kwai Chung Container Terminals 4 and 6
7 Nov 2006	Marine Works	Entrance to the Ex-Wan Chai Cargo Basin
19 Jan 2007	Reconstruction Works	Ko Lau Wan Public Pier, Long Harbour
11 Jan 2007	Demolition of Temporary Access Bridge	Shenzhen Western Corridor in Deep Bay
16 Jan 2007	Fender Replacement Works for Dolphins	New Yau Ma Tei Typhoon Shelter
20 Oct 2006	Submarine Outfall Repair Works	Wah Fu, Hong Kong Island
30 Jan 2007	Marine Site Investigation	Sai Kung
7 Dec 2006	Marine Site Investigation	Victoria Harbour
27 Oct 2006	Submarine Outfall Repair Works	Wan Chai, Victoria Harbour
8 Dec 2006	Repair Works for the Pier	Po Toi
19 Oct 2006	Submarine Outfall Repair Works	Aberdeen West Typhoon Shelter
30 Oct 2006	Dredging Operations	Tuen Mun Public Cargo Working Area
22 Nov 2006	Submarine Outfall Survey and Repair Works	Sai Kung
21 Dec 2006	Marine Site Investigation	Picnic Bay, Lamma Island
22 Jan 2007	Marine Site Investigation	Yung Shue Wan, Lamma Island
25 Feb 2008	Silt Curtains	Penny's Bay, Lantau Island
6 Nov 2006	Marine Site Investigation	Wan Chai
8 Jan 2007	Dredging, Rockfilling, Reclamation, Piling and Seawall Construction Works	Central Harbour
25 Nov 2006	Dredging Operations	Ninepin Group Spoil Disposal Area
24 Oct 2006	Submarine Outfall Survey	Cyberport, Hong Kong Island
28 Nov 2006	Submarine Cable Removal Works	Middle Island
16 Oct 2006	Submarine Cable Maintenance Works	Siu A Chau Wan, Siu A Chau and Lan Nai Wan, Tai A Chau
7 Nov 2006	Marine Site Investigation	Northeast of Ninepin Group
25 Oct 2006	Submarine Outfall Maintenance Works	Western Dangerous Goods Anchorage
20 Oct 2006	Submarine Cable Maintenance Works	Lo Kei Wan,Lantau Island and Pak Sha Wan, Siu A Chau
17 Nov 2006	Marine Site Investigation	Lung Mei Wan, Tai Po

Table 1: **The existing marine projects by the Hong Kong government (Hong Kong Government, 2007)**

Most part of the marine work is under water. To investigate under water circumstance, only divers and survey records can be measured. The marine construction work requires special and sophisticated equipment such as barges, tugs and clamshell cranes. These are not commonly used for general inland construction projects. Moreover, engineering and construction principles for land-based structures are not directly transferable to marine areas. Environment, physical forces and soil types are required for specialized construction materials and techniques in marine construction. Information for marine conditions such as waves, currents and transportation is also important.

Risk and uncertainty cannot be avoided in the construction development particularly in the marine projects (Akintoye and MacLeod, 1997; Ling and Hoi, 2006). It is easily to discover that there are high risks in marine construction work. The risks can cause problems of cost overrun, time delay and poor quality (Kartam and Kartam, 2001; Miller and Lessard, 2001). Currently, the local industry has adopted certain measures to manage risks like changes of contractual arrangement, risk sharing with contractors and implementing a risk management system (Shen, 1997; Uher and Toakley, 1999; Carr and Tah, 2001; Chapman, 2001; Oztas and Okmen, 2004; Oztas and Okmen, 2005). All these approaches would increase the quality of work and provide a positive image to the public (Shen and Fan, 1994; He, 1995; Hung, 1997; Li, 1997; Shen, 1997). Therefore, an appropriate strategy such as a risk management system is essential for reducing and controlling the risks (Lifson, 1982; Crockford, 1986; Cooper, 1987; Flanagan and Norman, 1993; Raftery, 1994; Rejda, 1995; Edwards, 1999). An effective risk management system can bring following major benefits for organizations (Shen, 1997): i) to enable a systematic and objective decision making; ii) to allow comparison of the robustness of projects to specific uncertainties; iii) to rank the relative importance of each immediately risk; iv) to provide an improved understanding of projects through identifying risk through response scenarios; v) to demonstrate company responsibilities to customers; and vi) to improve corporate experience and communication.

Therefore, this paper aims to:

- Identify major risk factors encountered in marine projects;
- Evaluate the impact of each risk factors in ma rine projects; and
- Determine the effectiveness of different risk response techniques; and
- Recommend alternative measure for solving and reducing risks in marine projects.

Risk Factors in Marine Projects

There are various risk factors affecting marine projects. Six major categories can be grouped (Flanagan and Norman, 1993) (see Table 2): i) acts of god; ii) physical; iii) financial and economical; iv) political and environmental; v) design; and vi) construction related.

Acts of God

Weather conditions can affect construction progress. Most parts of marine work must be operated by vessels such as dredger, derrick lighter and motor tugs. If inclement weather comes, all construction vessels require to be towed to shelters. Hong Kong is situated in a sub-tropical area. Chances to have heavy rain are high. It may cause delay in critical activities, so inclement weather would be one of the major risks faced by main contractors.

Physical

A diver in marine projects is very important, as only diver can illustrate the situation under water. As a result, their duties are very dangerous so that their insurance cost is very high.

Financial and Economical

Late delivery of materials, deterioration of materials and poor storage environment are major factors causing shortage of materials or plant resources. These factors are highly related to procurement and management of materials. In fact, most construction materials used in Hong Kong is delivered from overseas. There is a lack of land to set up large material plants in Hong Kong. And, material quality from overseas is normally higher than that in

Category	Risks
Acts of god	Poor inclement weather conditions
	High tides
Physical	Damages to equipment
	Labour injuries
Financial and economical	Fluctuations greater than estimated values
	Unavailability of materials, plant or labour
Political and environmental	Changes in legislations, regulations and code of practices
	Public disorders
Design	Variations of design
	Late information or site instructions by engineers
Construction related	Possession of sites
	Inaccessibility to sites
	Third parties delays
	Poor site controls
	Poor workmanships
	Lack of technical experiences
	Poor communications and management skills
	Underwater conditions are different from tender assumptions

Table 2: **Risk factors for marine projects**

Hong Kong as the lack of local capital and experts. As a result, material delivery time is required for about one to two months. A good planning for delivery of materials is thus very important.

Political and Environmental

Local legislation has increased costs. The expensive cost can be created by environmental issues if there are not identified and managed. For instance, contractors should be paid the additional cost for liability of environmental damage such as air pollution and water pollution, for example, contractors required to pay clean-up cost after polluting a river system with oil during construction. When contractors estimate the cost for marine work, statutory requirements are the major risk factors affecting the overall profit in the project. Construction activities are restricted with water pollution for marine projects. This restriction would affect the programme of work. Each project may have an additional requirement for the protection of environment.

Design

Insufficient communication between designers and contractors strongly affects buildability and constructability of a project. Late in issuing information to the contractor is the most controversial relevant event and it is interesting to note that the larger the project scale, the most likely the construction delays occur. In addition, engineers also instruct many variations to contractors. This affects construction progress which plan from pre-contract stage.

Construction Related

Subcontracting system plays an important role in the Hong Kong construction industry. Subcontractors usually engage for almost all major parts of large projects because subletting work to subcontractors can acquire labour with special skills to undertake work without increasing contractors' overheads. In addition, it is hard for contractors to complete a project by themselves as construction projects become more complex than before. Nevertheless, subcontracting system invariably causes many serious problems causing time overrun of projects such as insufficient manpower supply. This is because subcontractors usually allocate their human resources to different projects for maximizing their profits. As work has been sublet to them, main contractors have no authority to affect subcontractors' policy. This results in serious insufficient supply of workers on site and project delay. There are other factors such as poor site control, communication skill, management skill and underwater conditions which are the risk factors in marine project. Poor accuracy of project programme, abortive work due to poor workmanship, poor coordination with subcontractors and variations in group are also the common risks associated with project delays (Shen, 1997).

Research Methodologies

To examine occurring chances and impacts for different risk factors and effective risk response techniques for marine projects, questionnaire survey is conducted. The survey is sent to 250 contractors. 78 are received with a response rate of about 31.2%. However, two of the questionnaires are not properly completed and only 76 questionnaires are valid.

After received the questionnaire responses, individual structured interviews are arranged with eight respondents, selected from different sizes of contractors. The interviews are intended for gathering further comments; elaboration and interpretation on the results obtained from the questionnaire.

Results and Discussions

Respondent Background

From the survey results shown in Table 3, it should be highlighted that about 70% of the respondents are from large-sized contractor organizations and about 30% of the respondents are from medium-sized organizations. More than 75% of the respondents had over 6 years of working experience in the construction industry. In addition, all respondents worked for marine projects before. It can show that the respondents are experienced project participants in the industry. For the understanding of risk management, about 90% of the respondents highlights that they know the importance of risk management. It is also showed that there are about 40% of the respondents' organizations applying risk management strategies. For the necessary to implement risk management in marine projects, about 90% of the respondents consider it as necessary and highly necessary in the industry. It is found that most of the respondents support and apply risk management strategies in handling their marine projects. (Table 3)

Occurring Chances of Risk Factors

Table 4 shows the survey results on the occurrence of each risk factor in marine projects. It should be highlighted that the top five most common occurred risk factors are: i) underwater conditions are different from tender assumptions; ii) poor inclement weather conditions; iii) unavailability of materials, plant or labour; iv) lack of technical experience; and v) late information or site instructions by engineers. There are fewer occurrences on two risk categories: (1) political and environmental; and (2) physical. (Table 4)

From the interview discussions, the interviewees highlight that nearly all projects found the underwater situations

Respondents' background	Respondents (in %)
Sizes of contractor	
Small	0
Medium	30
Large	70
Years of working experience	
Less than 1 year	5
1 to 5 years	20
6 to 10 years	40
More than 10 years	35
Experience in marine projects	
Yes	100
No	0
Understand risk management	
Know very well	10
Know	80
A little bit	7
Cannot understand	3
Your company has risk management strategies	
Yes	40
No	60
You think that it is necessary to implement risk management in marine projects	
Highly necessary	30
Necessary	60
Unnecessary	7
Not sure	3

Table 3: **Respondents' background**

Risks	Rank
Acts of good	
Poor inclement weather conditions	2
High tides	9
Physical	
Damages to equipment	14
Labour injuries	15
Financial and economical	
Fluctuations greater than the estimated values	13
Unavailability of materials, plant or labour	3
Political and environmental	
Changes in legislations, regulations and code of practices	12
Public disorders	16
Design	
Variations of design	10
Late information or site instructions by engineers	5
Construction related	
Possession of sites	8
Inaccessibility to sites	18
Third parties delays	7
Poor site controls	17
Poor workmanships	11
Lack of technical experiences	4
Poor communications and management skills	6
Underwater conditions are different from tender assumptions	1

Table 4:

is different from tender assumptions. Before tendering the projects, contractors will predict underwater conditions around the areas. As construction organizations do not want to bring tender cost increases to lower their chances to win the projects, conservative assumptions are normally used. Another interviewee also notes that underwater investigation with heavy equipment and facilities are used after companies win the projects, but not before tendering, as companies cannot afford to invest money just for tendering investigation.

Risk categories on physical, and political and environmental, are not ranked as the commonly occurrence risks in marine projects from the survey. One of the interviewees explain that occurrence of physical risks, for example, damages on equipment and labour injuries, are mainly due to the carelessness from the organizations and from the workers, which can easily be controlled by training and development. Although political and environmental risks, for example, changes in legislations, regulations and code of practices, and public disorders, cannot be controlled by the organizations, the occurrence chances are not high. An interviewee also explains that the governmental normally will provide a short trail period for the industry if any new legislations or regulations are issued.

Impacts of Risk Factors

From the survey results shown in Table 5, it should be highlighted that the top five risk factors have the highest impacts to the projects are: i) unavailability of materials, plant or labour; ii) lack of technical experiences; iii) changes in legislations, regulations and code of practices; iv) underwater conditions are different from tender assumptions; and v) poor inclement weather conditions. Risk categories on design and physical are not considered as the major risk factors impacted to projects.

Risks	Rank
Acts of good	
Poor inclement weather conditions	5
High tides	16
Physical	
Damages to equipment	7
Labour injuries	11
Financial and economical	
Fluctuations greater than the estimated values	10
Unavailability of materials, plant or labour	1
Political and environmental	
Changes in legislations, regulations and code of practices	3
Public disorders	15
Design	
Variations of design	12
Late information or site instructions by engineers	6
Construction related	
Possession of sites	13
Inaccessibility to sites	14
Third parties delays	17
Poor site controls	8
Poor workmanships	18
Lack of technical experiences	2
Poor communications and management skills	9
Underwater conditions are different from tender assumptions	4

Table 5: **Impacts of risk factors**

From the survey results, unavailability of materials, plant and labour, and lack of technical experiences, are ranked as the first and the second risk factors most impacting to the projects. From the interview discussions, the interviewees explain that two major project scopes for most marine projects are lowering project cost and shortening project duration. Lack of resources and experiences can significantly be affected project cost and time, thus it can also directly affect profits gained from the projects to the organizations.

Changes in legislations, regulations and code of practices, is ranked as the third risk factor most impacting to the projects from the survey. As discussed in the last section, the interviewees explain that although changes of legislations and regulations may require the use of different construction methods for the projects. A short trail implementation period after issuing new legislations and regulations can help organizations adopting those legislations and regulations to their projects. An interviewee suggests that the government should provide financial support in helping small- to medium-size companies for purchasing equipment and facilities in implementing new legislations and regulations.

Effectiveness of Risk Response Techniques

Based on the previous researches (Flanagan and Norman, 1993; Raftery, 1994; Flin, Mearns et al., 1996; Shen, 1997; Nieuwenhuyse, Fatkhutdinova et al., 2004; Oztas and Okmen, 2004; Oztas and Okmen, 2005; Ribeiro and Fiho, 2006), nine risk responses techniques are investigated: i) refer to previous experience; ii) collect updated information; iii) adopt quantitative risk analysis; iv) plan alternative methods; v) transfer or share risks with other parties; vi) adopt subjective judgment; vii) coordinate closely with other parties; viii) provide close supervision to subordinates; and ix) provide suitable training for workers.

Table 6 shows the survey results on the effectiveness of these risk response techniques. Refer to the previous experiences is ranked as the first most risk response technique while risk is encountered for the projects. From the interview discussions, the interviewees highlight that employing an experienced project manager to manage the project is very important, particular for marine projects. Marine projects can have many unforeseen situations occurred during different project periods. The interviewee argues that an experienced project manager can help bringing these unforeseen situations as an early project period to alarm any possible lose and damages to the projects. (Table 6)

Providing suitable training for workers is ranked as the second most important factor for risk response technique from the survey. An interviewee highlights that organizations should provide regular training programs to different levels of employees for ensuring sufficient knowledge from the employees. Another interviewee notes that on-the-job training is the most common type of training provided to

Risk Response Techniques	Rank
Refer to the previous experience	1
Provide suitable training for workers	2
Transfer or share risks with other parties	3
Collect updated information	4
Provide close supervision to subordinates	5
Plan alternative methods	6
Coordinate closely with other parties	7
Adopt quantitative risk analysis	8
Adopt subjective judgment	9

Table 6: **Risk response techniques**

the employees, which can deliver the direct relations between theories and their workplace environments.

Adopt subjective judgment is ranked as the least important factor for risk response technique from the survey. From the interview discussions, an interviewee notes that subjective judgment is not suitable for marine projects as many unforeseen situations can be occurred underwater. Another interviewee argues that most superstructure construction projects with an experienced project manager may be suitable to use subjective judgment and employees can use their routine approaches for recovering the problems.

Recommendations

From the interview discussions, several recommendations are suggested to reduce possible risks and to improve the situations if risks are encountered for marine projects:

- To provide an early planning at the initial project stage in examining possible risks may be encountered;
- To undertake risk assessment at the initial project stage in providing comprehensive methods to solve different risk situations;
- To employ experienced employees for the projects;
- To provide training and development programs to the employees;
- To collect up-to-date information before project starts; and
- To communicate with other project parties by regular meetings for ensuring the project progressing well.

Conclusion

Risk management is important and useful for marine projects. Unfortunately, it is not common that Hong Kong contractors adopt risk management strategies for their projects, especially sub-contractors. Therefore, this paper investigated major risk factors encountered and their impacts to marine projects. Six categories of risk factors were investigated: i) acts of god; ii) physical; iii) financial and economical; iv) political and environmental; v) design; and vi) construction related. Questionnaire survey and interview discussions were conducted. It was found that "underwater conditions are different from tender assumptions" was the most common risk factor encountered in marine projects, "unavailability of materials, plant and labour" was the most impact to the project if risk was encountered. The most effective risk response technique to tickle risks encountered was "refer to previous experience". Recommendations for improving risk management were also given.

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