WARSAW UNIVERSITY OF TECHNOLOGY Index 351733
FACULTY OF CIVIL ENGINEERING
COMMITTEE FOR CIVIL AND WATER ENGINEERING
POLISH ACADEMY OF SCIENCES ISSN 1230-2945

DOI: 10.24425/ace.2023.146068

ARCHIVES OF CIVIL ENGINEERING

Vol. LXIX ISSUE 3 2023

pp. 79 –94

Research paper

Effective control measures to minimize cost overrun during construction phase of high-rise residential building projects in Chongqing, China

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Abstract: Cost overrun during construction is one of the most common problems occur in construction projects around the world, which also includes the area of Chongqing in China. At present, there are few studies related to cost overruns at the construction stage of high-rise residential building projects (HRBPs) in Chongqing. The purpose of this study is to develop effective control measures from the contractor's perspective to help projects to minimize cost overruns during the construction phase of HRBPs in Chongqing. Firstly, through the literature review and semi-structured interviews, 65 cost overrun-related risk factors in construction projects were identified. All the risk factors have been prioritized through the analytic hierarchy process (AHP) based on their importance to project success. Out of the 65 factors identified, 12 were classified as the critical ones that have a great potential to instigate a cost overrun during construction to take place in the real project. There were four risk factors that have the greatest impact on cost overruns, and their weights were 0.04 or above, including low bid, force majeure, undetailed/inaccurate geological survey data, and increased loan interest rates. Finally, control measures were developed for these four critical cost overrun risk factors (CCORFs). The measures developed provided a guideline to control the risk of cost overruns and clear control key points to help contractors minimize cost overruns on construction projects.

Keywords: high-rise residential building projects (HRBPs), construction phase, analytic hierarchy process (AHP), critical cost overrun risk factors (CCORFs), control measures

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1. Introduction

The construction industry is a significant component of the world economy [1, 2] and the construction industry is a good indicator of a country's economic performance and growth [3]. Through the multiplier effect, the construction industry has made great contributions to the national economy, either directly or indirectly [4]. The construction industry is vital to the overall economy of many countries [5], including China [6].

The construction industry has made a great contribution to the development of China's national economy [6]. Since 2011, the added value of the construction industry has contributed more than 6.75% to China's GDP [7]. In 2020, the added value of the construction industry accounted for 7.1% of the GDP, worth 7,244.5 billion yuan [8]. In addition, the construction industry provided employment opportunities for 53.6692 million people [7].

The construction industry is also crucial to the economy of Chongqing, China. In 2020, the added value of the construction industry accounted for 9.3% of Chongqing's regional GDP, totaling 897.497 billion yuan; the total output of the Chongqing construction industry contributed 3.4% to the total output value of China's construction industry, ranking 12th in the country [9].

The characteristics of construction projects are very complex, dynamic, and unique, so compared to other industries, the construction industry faces greater risks [10, 11]. In addition, it is also more difficult to manage the cost of construction projects. Like in other countries around the world, construction projects in China are also facing serious cost overruns.

As one of the most serious problems in construction projects all over the world [6, 12], cost overruns have always been a concern for scholars around the world. Some researchers [6, 13] have identified risk factors for cost overruns in construction projects. In addition, some researchers have identified risk factors leading to cost overruns in construction projects and have developed control measures [12, 14–16]. However, there are still some limitations. In different regions or periods, construction projects face different risk factors of cost overruns. Moreover, studies on cost overruns during the construction phase of HRBPs are still lacking, especially in Chongqing, China.

The research work presented in this paper is part of an ongoing master's thesis. This study is conducted in the main urban area of Chongqing and only focuses on the construction phase of HRBPs. This study aims to develop effective control measures from the perspective of the contractor to minimize cost overruns during the construction phase of HRBPs in Chongqing.

2. An overview of cost overruns on construction projects

Many researchers have studied cost overruns in construction projects. Love, et al. [17] conducted a study of cost overruns in the Australian construction industry. The sample for this study included 161 construction projects and 115 civil engineering projects. The results of the study showed that the average actual cost overrun ratios for construction projects and civil engineering projects were 12.22% and 11.76%, respectively. Saidu and

Shakantu [18] investigated cost overruns on 30 ongoing construction projects in Abuja, Nigeria. The findings indicated that all 30 projects in the study faced cost overruns. The average cost overrun rate of these projects was 44.46%, among which the lowest was 5.56% and the highest was 85.62%. Haslinda et al. [19] studied cost overruns in high-rise buildings in Penang, Malaysia. The researchers found that 7 experts (23%) said more than 30% of projects had cost overruns; 18 experts (60%) said 10% to 30% of projects experienced cost overruns. Ling et al. [20] studied the cost performance of public construction projects in China. The study found significant cost overruns on public construction projects in both Beijing (10.42% cost overrun) and Hong Kong (12.50% cost overrun). In addition, construction projects in Chongqing also faced serious cost overruns during construction problem in the real project practice [21].

Haslinda, et al. [19] investigated the risk factors affecting cost overruns for high-rise construction projects in Penang, Malaysia. Firstly, eight CORFs were obtained from previous studies. Using the severity index method, the study found that the three factors that most affect cost overruns were "poor pre-construction budget and material cost planning", "inaccurate quantity take-off" and "materials cost increased by inflation".

From the consultants' perspective, Mahamid and Dmaidi [12] studied the cost overruns faced by building construction projects in the West Bank of Palestine. Through a literature review, 41 CORFs in construction projects were obtained. Using risk map with frequency index and severity index, the study found that the five biggest cost overrun factors for Palestinian construction projects were "political situation", "fluctuation of prices of materials", "economic instability", "currency exchange", and "level of competitors".

Mbachu and Cross [22] studied the factors that caused the difference between the initial contract price and the actual cost of completing construction projects in New Zealand. Through personal interviews, the researchers obtained CORFs and classified CORFs into six categories. A 5-point Likert scale was used to assess CORFs. In each category, the factors that had the greatest impact on construction project cost overruns were "change orders resulting in variations to the contract", "quality of design information, documentation & communication", "failure to adequately analyse contractual risks at the onset and apply sufficient contingencies", "unbalanced bidding at the tendering stage", "unforeseeable underground conditions requiring changes in design or work method", "costs/delays due to council officials in relation to consents, permits or inspections".

Mansur, et al. [6] investigated the factors influencing cost overruns in China's construction industry. Through a literature review, 43 risk factors for cost overruns were identified and grouped into four categories. Using the Relative Importance Index method (RII), the study found that the factors that most affected cost overruns in the four groups were respectively "low productivity of labour", "escalation of material prices", "high cost of machineries", "cash flow and financial difficulties".

3. Methodology

This study aims to develop effective control measures to help contractors to minimize cost overruns in HRBPs in Chongqing. In order to achieve the research aim, a combination of quantitative and qualitative research methods was adopted, and the study was divided into four stages, including the implementation of a literature review, the implementation of semi-structured interviews, the application of AHP, and the development of control measures.

3.1. Conduct literature review

In the first stage of this study, the literature review was conducted. Through the literature review, the previous research results were widely obtained, and the current situation in the field of construction project cost overruns was grasped. CORFs of construction projects around the world were widely identified. These obtained risk factors were used to build the hierarchical structure model.

3.2. Semi-structured interview

In the second stage, semi-structured interviews were conducted, which is a qualitative approach [13, 23]. The semi-structured interviews were conducted to collect CORFs and control measures during the construction phase of current HRBPs in Chongqing, China.

The sampling method used in this research was convenience or snowball sampling [13, 24]. This method belongs to non-probability sampling. The samples are obtained mainly through convenience (friends, colleagues, classmates and professional contacts). A total of 31 interviewees participated in the semi-structured interview. 31 (100%) interviewees came from general contractors. Thirty (97%) respondents had 4 years or more experience in the construction industry. All 31 (100%) respondents had participated in the construction of HRBPs in Chongqing, and 36% of them had participated in the construction of four or more high-rise buildings. All 31 (100%) interviewees had higher education.

In order to ensure the rationality of this interview outline, a pilot study was conducted. Two experts from the general contractors with construction experience in HRBPs in Chongqing and an academic who has a civil engineering background participated in the pilot study. The outline of the semi-structured interview was determined based on feedback from the pilot study.

Combining the responses of the interviewees and the literature review, a total of 65 risk factors leading to cost overruns were identified and divided into nine groups. Table 1 shows the corresponding codes of the risk factor groups and sub-factors.

Table 1. Cost overrun risk factors (CORFs)

Code	Risk Factors	Code	Risk Factors
ER	**Group 1**: Environmental related factors		
ER1	Force majeure	ER6	Poor geographical conditions
ER2	Poor weather conditions	ER7	Public reaction/complaints/misperceptions
ER3	Government activities/inspections	ER8	Corruption and inaction by government officials

Continued on next page

Table 1 – *Continued from previous page*

Code	Risk Factors	Code	Risk Factors
ER4	Changes in government policies or regulations	ER9	Increased loan interest rates
ER5	International political environment		
DR	**Group 2**: Design related factors		
DR1	Design variations	DR4	Innovation in design
DR2	Undetailed/inaccurate geological survey data	DR5	Lack of flexibility in design
DR3	Defective design		
LR	**Group 3**: Labour related factors		
LR1	Lack of skilled labour	LR4	Inadequate safety awareness of workers
LR2	Labor shortage	LR5	Increase in labor costs
LR3	Inadequate cost awareness of workers	LR6	Labour absenteeism
SS	**Group 4**: Subcontractors and suppliers related factors		
SS1	Subcontractors with low cooperation	SS4	Subcontractors defaulted on workers' wages.
SS2	Poor on-site supervision and management of subcontractors	SS5	Dishonest material suppliers
SS3	Inadequate subcontractor experience	SS6	Monopoly by suppliers
MM	**Group 5**: Material and machinery related factors		
MM1	Poor quality materials/equipment	MM5	Unreasonable mechanical arrangement at the construction site
MM2	Late delivery of materials/equipment	MM6	Equipment breakdown
MM3	Rising cost of materials/machinery	MM7	Inexperienced or unqualified machine operators
MM4	Shortage of materials/equipment	MM8	Poor on-site material management and supervision
BC	**Group 6**: Bid and Contract related factors		
BC1	Low bid	BC4	Ambiguous or conflicting contract information
BC2	Unbalanced bidding	BC5	Incomplete contract presentation
BC3	Unreasonable contract terms	BC6	Omissions or errors in the bills of quantities
CR	**Group 7**: Client related factors		
CR1	Client's verbal instructions	CR6	Corruption of the client representatives

Continued on next page

Table 1 – *Continued from previous page*

Code	Risk Factors	Code	Risk Factors
CR2	Variations by the client	CR7	Incomplete of approval and other documents
CR3	Client with poor management skills	CR8	Delay in inspection and approval of completed works
CR4	Client defaults on project payment	CR9	Unusually high quality requirement
CR5	Client asks to rush the construction period		
GC	**Group 8**: General contractor's construction site management related factors		
GC1	Inadequate safety measures/facilities	GC6	Unskilled new techniques/processes
GC2	Poor data management during construction	GC7	Incomplete technical disclosure
GC3	Poor communication and coordination	GC8	Lack of supervision and control of the construction process
GC4	Theft on site	GC9	Project department without adequate decision-making authority
GC5	Unreasonable construction organization plan		
MG	**Group 9**: Managers of general contractor related factors		
MG1	Lack of regular job training for managers	MG5	Insufficient professional competence of managers
MG2	Unreasonable number of managers	MG6	Managers lack cost awareness
MG3	High turnover of managers	MG7	Managers lack safety awareness
MG4	Managers lack accountability		

* These CORFs were derived from semi-structured interviews and references [6, 12–15, 19, 22, 23, 25–35]

3.3. Application of analytic hierarchy process (AHP)

In the third stage, AHP was applied. AHP is a powerful tool for decision-making techniques and measures the priority of all alternatives based on a ratio scale and was proposed by Thomas Saaty in the early 1970s [36–38]. One of the main advantages of AHP is that it deals with multiple criteria with relative ease [39]. AHP obtains the scale of value from the pairwise comparison combined with the rating, and it can be used for multi-objective, multi-criteria, and multi-participant decision-making of multiple alternatives [10].

AHP has been widely used to prioritize key factors in various fields of construction engineering [36, 39, 40]. In this study, AHP was applied to rank the importance of CORFs, and AHP was divided into four steps to implement.

Step 1. Building a hierarchy structure model

The first step in AHP was to build a hierarchical structure model. According to Table 1, a hierarchical structure model was built, as shown in Fig. 1 [41]. The hierarchical structure model consisted of three layers. The established hierarchical structure model was input into Expert Choice11 software. As an AHP tool, Expert Choice 11 has been widely used to determine the importance ranking of key factors in various fields of construction engineering [36, 39].

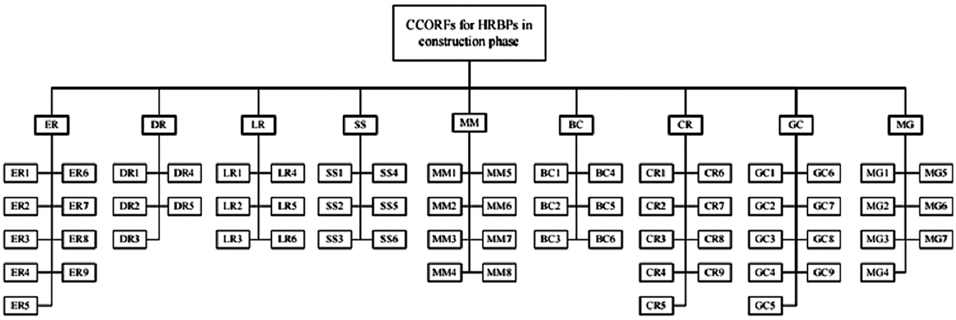

Fig. 1. The hierarchical structure model of CCORFs

Step 2. To implement pairwise comparisons

The second step was to implement pairwise comparisons. After the establishment of the hierarchical structure model, it is necessary to make pairwise comparison between factors to determine the relative importance of factors. These pairwise comparisons are often based on a nine-point scale, as shown in Table 2 [37]. The matrix consisting of the pairwise comparison result aij is called the judgment matrix A, as shown in Eq. (3.1) [10, 37].

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{3.1}$$

Table 2. AHP pairwise comparison scale

Weight	Definition	Weight	Definition
1	Equal importance	7	Very strong importance
3	Weak importance of one over other	9	Absolute importance
5	Essential or strong importance	2, 4, 6, 8	Intermediate values between the two adjacent judgments
Reciprocals of previous values	If factor ‘i’ has one of the previously mentioned numbers assigned to it when compared to factor ‘j’, then j has the reciprocal value when compared to i.		

Matrix A has the following properties, as shown in Eq. (3.2) [37]:

$$a_{ij} > 0; \quad a_{ij} = \frac{1}{a_{ji}}; \quad a_{ii} = 1; \quad \text{where: } i, j = 1, 2, \cdots n \tag{3.2}$$

AHP questionnaire were created and used to collect data. AHP questionnaires were sent to five experts in the construction industry in Chongqing via email. Five (100%) respondents who participated in the AHP questionnaire were from the general contractor, and they were members of the leading team of the construction project department. All five (100%) respondents had six years or more of experience in the construction industry. All respondents had work experience in the construction phase of HRBPs in Chongqing, and 80% of them have participated in the construction of three or more HRBPs. All five (100%) respondents had a higher education.

A small sample is not uncommon in the related field of research on construction project management [38]. With a sample size of 5 experts, predecessors [38,41] carried out relevant studies.

According to their own practical experience and combined with the rules described by the researchers, the experts pairwise compared and scored the CORFs in each judgment matrix in the AHP questionnaire. The data collected from each of the five experts was entered into the Expert Choice 11 software for analysis.

Step 3. Checking consistency

The third step was checking consistency. When experts compare many factors in pairs, the judgment matrix is likely to have logical errors. In order to ensure the logical rationality of the judgment matrix, it is very important to test its consistency. The specific steps were as follows:

Firstly, for the Consistency Index (CI), Eq. (3.3) was used [37].

$$\text{CI} = \frac{\lambda_{\max} - n}{n - 1} \tag{3.3}$$

where: $\lambda_{\max}$ refers to the matrix A's greatest eigenvalue.

Secondly, select Random Consistency Index (RI) as viewed in Table 3 which was calculated from 500 matrices sample size [36].

Table 3. Average values of random consistency index

Matrix size n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Finally, Eq. (3.4) was used to calculate the consistency ratio (CR) [37].

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \tag{3.4}$$

The CR value is less than 0.1, and then judgments are accepted. The researchers examined all pairwise comparison matrices filled in by five experts, and the CR of each matrix was less than 0.1, so the consistency of all pairwise comparison matrices passed the test.

Step 4. Final rankings

The fourth step was the final rankings. After all the judgment matrices filled in by the five experts passed the consistency test, these pairwise comparison matrices were combined with the method of geometric mean in Expert Choice 11. The combined matrices were computed with local weights and checked for consistency. The CR of 10 combined pairwise comparison matrices was less than 0.1, so the consistency of all the combined pairwise comparison matrices passed the test. In this study, the total hierarchical ranking after the combination of judgment matrices and the overall inconsistency are shown in Fig. 2. The overall inconsistency was 0.01, which was less than 0.1, so the consistency test of the total ranking of the hierarchy was passed. Due to the limited space of the journal, only the top 20 of the 65 risk factors for cost overruns were listed in Fig. 2.

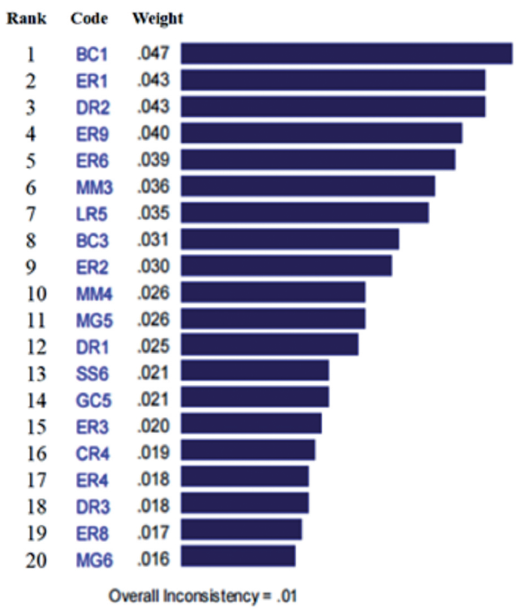

Fig. 2. Total hierarchical ranking and weights of CORFs

4. Results and discussions

In this section, CCORFs determined in this study were compared and discussed with the results of previous studies. In addition, effective measures to control cost overrun were developed.

4.1. Critical cost overrun risk factors (CCORFS)

In this study, the top 12 factors were identified as CCORFs because they all had a weight of 0.025 or more, and the 12th and 13th factors had a weight difference of 0.004. The 12 CCORFs were "low bid" (0.047), "force majeure" (0.043), "undetailed/inaccurate geological survey data" (0.043), "increased loan interest rates" (0.040), "poor geographical conditions" (0.039), "rising cost of materials/machinery" (0.036), "increase in labor costs" (0.035), "unreasonable contract terms" (0.031), "poor weather conditions" (0.030), "shortage of materials/equipment" (0.026), "insufficient professional competence of managers" (0.026), "design variations" (0.025).

The four factors that had the biggest impact on the construction stage of high-rise residential projects were "low bid", "force majeure", "undetailed/inaccurate geology survey data", "increased loan interest rates", and their weights were 0.04 and above. The four CCORFs were discussed next.

"Low bid" (0.047) was the primary factor causing cost overruns in the construction phase of HRBPs. Meanwhile, S. Sharma and Goyal's [29] study of construction in India showed that the "lowest bid procurement policy" was the second-largest risk factor for cost overruns. Alshihri, et al. [35] investigated government-funded construction projects in Saudi Arabia and found that "contract awarded to lowest bidder" ranked second among 83 CORFs. In Chongqing, China, clients usually adopt the policy of winning the bid with the lowest price, and the competition in the construction industry is fierce, so contractors often bid down or even lower the cost of the construction project to obtain the project. As long as there is a slight risk in the construction process, it will lead to a project cost overrun. As a result, "low bid" ranked first among all 65 factors leading to cost overruns during the construction phase of HRBPs in Chongqing.

"Force majeure" (0.043) was listed as the second risk leading to cost overruns. In line with this finding, Sohu, et al. [42] found that "natural disaster" was one of the top 10 risk factors leading to cost overruns in Pakistan's construction industry. The study by Khan, et al. [27] showed that "act of God" was one of 13 key risk factors leading to cost overruns in Indore's government construction projects. When COVID-19 broke out in China at the end of 2019, the government took the strictest measures to prevent and control the epidemic. During the COVID-19 pandemic, the cost of construction projects has increased dramatically due to government measures such as city closures and shutdowns [43].

"Undetailed/inaccurate geological survey data" (0.043) was also determined to be the second-largest risk for cost overruns. At the same time, Mbachu and Cross [22] found that "not municipal proper site analysis and geotechnical" impacted on cost overruns of construction projects in New Zealand was "high". Wang and Yuan [14] studied construction projects in China and found that "inadequate site information" was the 10th-ranked risk factor for cost overruns. Chongqing is a mountainous area with large terrain height differences and complex geological conditions. Therefore, "undetailed/inaccurate geological survey data" has a greater impact on the cost overruns of construction projects in Chongqing than in general areas.

"Increased loan interest rates" (0.040) was the fourth highest risk factor for cost overruns in HRBPs. In line with this finding, the study of Alinaitwe et al. [44] on public sector construction projects in Uganda showed that "high inflation, insurance and interest rates" were the second most important factors leading to cost overruns. Since China's interest rate liberalization reform, the loan interest rate has fluctuated constantly [45]. Ke et al. [46] pointed out that "interest rate" was the eighth highest potential risk for PPP projects in China. In 2017, bank lending rates increased significantly [47]. The increase in loan interest rates will increase the financial burden on enterprises.

4.2. Control measures for CCORFS

In this section, effective control measures were developed for the top four CCORFs to help contractors to minimize project cost overruns.

According to the study, "low bid" was the number one factor leading to cost overruns during the construction phase of HRBPs. Measures were developed in three stages, including before bidding, during the bidding process, and after winning the bid. Firstly, strong comprehensive strength and a reasonable enterprise quota can improve the probability of winning the bid of the construction unit, which is the construction unit needs to work hard all the time (see measures 1 and 2). Secondly, detailed records in the bidding process can help to develop measures after winning the bid (see measure 3). Finally, after winning the bid, the solution measures for the low-priced list items are essential (seeing measures 4 and 5). During the construction stage of HRBPs, the measures for controlling cost overruns developed for "low bid" were as follows:

1. The contractor should enhance their overall strength to increase their comprehensive competitiveness in the construction market.
2. Construction units should formulate enterprise quota according to their own strength and characteristics.
3. When compiling the bid price, the bidder shall record the list items of low price or loss in time. After winning the bid, the bidder shall disclose the contract to the cost leader of the project department in detail and accurately inform the person of the problems in the bid quotation list.
4. Before the start of construction, for low-priced or loss-making list items in the contract, the project commerce department and technology department can negotiate together to find a lower-cost construction method to eliminate or reduce losses.
5. During the construction process, for the materials with lower prices on the list, the project technology department can re-prepare the technical plan to replace the materials and communicate with the owner's representative to strive for material changes.

"Force majeure" was the second-largest risk factor for cost overruns in construction projects. Force majeure includes earthquake, debris flows, floods, etc. In addition, some large-scale infectious diseases are also force majeure, such as the COVID-19 pandemic. Since the outbreak of the new crown pneumonia epidemic at the end of 2019, the new crown epidemic has had a serious impact on the construction project. Due to the limited space of this paper, this study only developed control measures for large-scale infectious diseases that fell under force majeure in order to cope with the possible outbreak of a certain large-scale infectious disease in the future. In response to the epidemic, preventive measures and material guarantees need to be taken beforehand (see measures 1–5). If epidemic patients are discovered in the project, they must be managed and controlled as soon as possible (see measure 6). In addition, it is also important to retain relevant information and reduce the pressure on corporate funds (see measures 7 and 8). Measures taken to control this risk were as follows:

1. The contractor and the participating parties shall each appoint a person in charge of epidemic prevention and control and jointly form a leading group for epidemic prevention and control.
2. The contractor shall equip a certain number of epidemic prevention commissioners according to the scale of the construction project.
3. The project material procurement department shall purchase daily life and epidemic prevention materials in time.
4. The project department regularly contacts the epidemic virus testing institution to conduct virus testing for all on-site personnel.
5. The management of access to the construction site should be strengthened.
6. An emergency response mechanism should be established.
7. Project visa and change management should be done well.
8. The management of enterprise cash flow should be strengthened.

"Undetailed/inaccurate geological survey data" was also the second-largest risk factor for cost overruns in construction projects. In the bidding process, the construction unit will first receive the geological survey report and then carry out the site survey. Finally, the construction phase after winning the bid is also crucial. It is necessary to formulate measures for this risk in the bidding stage (see measures 1 and 2) and construction stage (see measure 3). Measures taken to control this risk factor were as follows:

1. During the bidding process, the construction party shall carefully review the geological survey report and establish a risk register for the geological survey report.
2. In the bidding process, the site survey shall be emphasized, and a risk register of site visits shall be established.
3. During the construction phase, project visas and changes should be handled well. In addition, the contractor should timely communicate with the client.

"Increased loan interest rates" was the fourth biggest risk factor for cost overruns. Control this risk is mainly based on two aspects: internal (measures 1 and 2) and external (measures 3 and 4). Measures taken to control this risk were as follows:

1. The internal capital management system of the enterprise should be improved.
2. The company's internal financial supervision mechanism should be developed.
3. Wider financing channels should be actively expanded.
4. The joint bid may be used.

Based on the actual situation of the construction project and the importance ranking of the CORFs determined in this study, contractors can develop control measures suitable for the unit for more risk factors.

5. Conclusions

Cost overruns on construction projects are a problem around the world, including in Chongqing, China. At present, few studies have focused on the cost overruns in the construction phase of HRBPs in Chongqing. In this study, effective control measures were developed from the perspective of the contractor to minimize cost overruns during the construction phase of HRBPs in Chongqing.

Firstly, combined with the literature review and semi-structured interviews, this study identified a total of 65 risk factors leading to cost overruns in the construction phase of HRBPs. Secondly, using AHP, 12 CCORFs were determined. There were four risk factors that had the greatest impact on cost overruns, including low bid, force majeure, undetailed/inaccurate geological survey data, and increased loan interest rates. Each of the four CCORFs had a weight of 0.04 or above. The top four risks were consistent with the current situation in Chongqing's construction industry, including intense competition in the construction market, complex geological conditions, the impact of COVID-19, and fluctuating lending rates. Finally, control measures were developed for the top four CCORFs.

In this study, the measures developed provided a guideline for the contractor to control the cost risk and clarified the focus of control. On the basis of these measures, the construction unit can formulate more detailed control steps according to the actual situation of the project to minimize project cost overruns. This study suggests that the contractor should first improve the comprehensive strength as a basis and then control the risk according to the different stages in which each risk may occur and the characteristics of each risk.

Although the research focus and research methods were effective, it was difficult to have a perfect thesis. Inevitably, there were limitations in this study. A major limitation of this study was that the number of participants was limited due to limited time and funding. Although the number of participants in the semi-structured interview and AHP questionnaire survey in this study was valid, their views did not fully represent the situation of the whole research field.

Although this study determined the critical risk factors leading to cost overruns in the construction phase of HRBPs in Chongqing from the perspective of general contractors and also developed effective control measures, some areas of this topic need further research. Firstly, similar research can be done from the client's point of view. Secondly, similar studies should be conducted in other cities in China to compare the results with each other. Finally, similar research can be conducted on other types of construction projects, such as hospital projects, municipal projects, industrial projects, etc.

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Received: 2023-01-17, Revised: 2023-05-16