Research on Quality Risk Assessment and Application of Large-scale Clusters of Engineering Project

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Abstract. In order to study the quality risk of large-scale clusters of engineering project and makes the characteristic analysis of large-scale clusters of engineering project and evaluates quality risk, the author uses analytic hierarchy process to quantify quality risk factor, and the following conclusions are obtained: (a) Construction management unit that makes the project decision-making mainly controls the QRM, comparatively speaking, it has little control over quality risk when the project is completed and ready to get acceptance (b) In the project decision-making stage, the Construction Technology has the greatest influence on the project quality management. This paper puts forward the suggestion that the influence of quality risk factors should be quantified by associated experts, so as to provide a reference for the construction quality management of large-scale cluster projects.

1 Introduction

With the development of social economy, people have an increasing reliance on high-quality buildings (structures) which ensure their comfortable and safety living environment. When the large-scale clusters of engineering project starts, limited time requires accelerated project schedule, so that the project quality management is neglected, leading to quality problems of varying degrees. Domestic and foreign researchers have carried out a series of studies to find solution countermeasure. For example, research literature [1] proposed that the contractor should be responsible for the project quality. The construction company should encourage the operator with the help of contract management so as to improve its work. Research literature [2] points out that the entire process control is required in quality management in the United States, however, it focuses on the early stage of project investment and design. Literature [3] studies the predictable risks faced by settlement project in different time and puts forward corresponding measures. Literature [4-6] analyzes and evaluates the quality risk by discussing the safety quality potential and then find corresponding measures to ensure the quality risk management in advance. Literature [7] provides analysis of human, management, technology and other factors. In order to ensure the project quality, the construction company uses the correlation matrix model to select senior managers and divide the bid section, so as to lower the quality risks. Literature [8-9] showed that preliminary work, scientific management methods and good organization shall be taken into consideration when the construction management unit conducts the quality management to ensure the project runs smoothly.

To sum up, it can be seen that subjective factors exist in domestic and foreign researches about quality risk management of large-scale clusters of engineering project, while the researches on quantitative analysis of PQM from the perspective of construction company are still rare. Therefore, from the perspective of organization and management of construction, this paper studies the risks that affect the project quality in the implementation process of large-scale cluster projects, in order to reduce the frequency of problems in quality management, and hopes to provide a reference for the construction quality management of large-scale cluster projects.

2 Characteristics of large-scale clusters of engineering project

2.1 Large project investment and long construction period

Large-scale clusters of engineering project are often composed of multiple individual projects. The total investment amount of the projects is relatively high after the investment amount of multiple projects is summarized. Moreover, due to the different construction characteristics and management methods of each individual project, the construction period is longer.

2.2 Difficult control of the quality for multiple departments construction

Compared with the single project that one unit participates, large-scale clusters of engineering project is

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composed of the construction management department, the survey department, design department, construction contractor, the construction control department, and the related government departments responsible for administrative examination and approval and supervision etc. (Figure 1). The large-scale clusters of engineering project involves many single projects. Different participants and a permanent participant-the government are involved in the project. The completion of large-scale cluster projects often requires multiple departments and varied types of collaborative construction. Different qualifications, technical levels and manual operation of each unit in survey, design, construction and supervision lead to the different quality and the quality control is difficult.

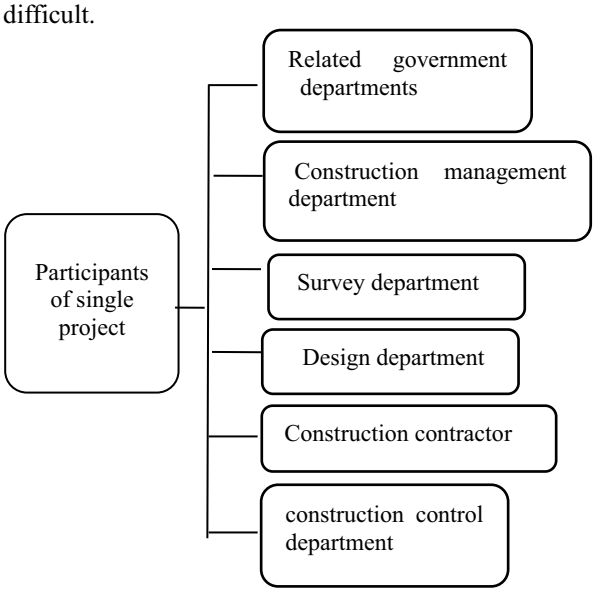

Figure 1. Participants of single project construction

2.3 Social Focus and High Benefit

Compared with single project, large-scale clusters of engineering projects can be seen as commercial complexes, landmark buildings, schools, cultural centers and stadiums, which trigger wider concerns. At the same time, large-scale clusters of engineering projects often bring huge economic and social benefits to the local areas.

3 Project Quality Risk Assessment

3.1 Analysis of influencing factors on quality management of large-scale clusters of engineering projects

Five stages are needed by the construction of large-scale clusters of engineering project: project decision-making stage, project design stage, construction preparation stage, construction and commissioning preparation, and completion acceptance. Different stage has distinct impact on the quality of engineering. Therefore, by expounding the economic factors, technical factors, organizational factors, environmental factors and management factors, the author analyzes the quality management of each stage representing the construction management unit [7] .

3.1.1 Analysis of influencing factors of quality management in project decision-making

In the decision-making stage of the project, the construction management unit entrusts the relevant consulting company to prepare the project proposal before writing the feasibility study report, which help the decision-maker finally determines the construction period, cost and quality of the project. However, many construction management units did not take it seriously, nor paid attention to the qualification or the ability of consulting companies. Perfunctory or feasibility study report which neglecting market, or the compilers who were not familiar with the policy update makes the report, which laid hidden dangers for the follow-up projects.

3.1.2 Analysis of influencing factors of quality management in project design

The designer which carried out design as requested. If the construction management unit failed to communicate with designer, it will find that the site design does not meet its anticipation and change of design is required, or the design drawings is poor. All will affect the project quality.

3.1.3 Analysis on the influencing factors of quality management in the preparation

The quality management in the preparation stage which is mainly led by the construction management unit, including bidding methods (including bid section division, engineering subcontracting, etc.), organization, etc. which will affect the construction quality management of large-scale clusters of engineering projects.

(1) In the early stage of bidding, detailed study should be carried out on the division of project bid section and engineering subcontracting, so as to meet the requirements of project duration, quality and cost. However, project decision makers often divide bid sections only relying on professional knowledge, or allow the bidding agencies to prepare general bidding documents according to their decisions. As a result, the construction management unit failed to make the best choice when it finds the construction contractor.

(2) In order to ensure smooth progress of a project, the established the project department clarify the responsibilities according to the relevant organizational structure, t. The professional knowledge and technical ability of personnel in the organization directly affect the implementation of the whole project. The specific organizational structure is shown in Figure 2.

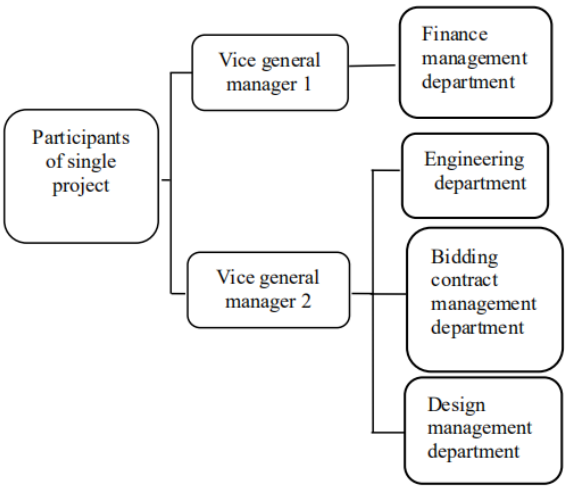

Figure 2. project organization structure of construction management unit

3.1.4 Analysis of influencing factors of quality management before project construction and preparation stage

The influencing factors of quality management before the construction and preparation stage mainly come from the implementation quality of the construction constructor and the contract agreement of the construction management unit. Due to the tight schedule, the construction should be carried out in strict accordance with the construction contract. However, in case of force majeure, the construction unit will claim the construction period according to the contract requirements. Extended period will affect the original schedule of project planned by the decision makers. Therefore, some construction management unit may require the construction constructor to complete the project according to the original schedule at no cost. Therefore, when the construction of the project is accelerated, the participants may ignore some engineering problems that affect the quality of the project.

3.1.5 Analysis of influencing factors of quality management in project completion acceptance stage

The acceptance at the completion stage must be carried out in strict accordance with the relevant national acceptance standards. Some large-scale clusters of engineering project construction management units which hope to make benefits as soon as possible carry out the acceptance of a single project when other supporting facilities are still in implementation or the project finishing work is in progress. The unqualified project quality is easy to find in the cross use and construction.

As mentioned above, both internal causes and external causes affect the project management of large-scale clusters of engineering. The internal causes include the decision-makers of the construction unit, the design quality of the design unit and the construction quality of the construction constructor; the external factors involve changes of the national policy laws and regulations, and the inflation caused by the social and economic development.

3.2 Analysis of influencing factors in quality risk management

It is impossible to start a project again whether the it is successful or failed. Therefore, for the smooth implementation of large-cluster project, it is necessary for the construction unit to take the economic factors, technical factors, organizational factors, environmental factors and management factors into consideration in each stage of project.

3.2.1 Technical factors

During the period from construction to completion, the decision-makers, who has desire to find good plan, shall chooses excellent consulting company, design unit and construction unit that show professional and technical ability. All these facilitate the section division, bidding and follow-up work.

3.2.2 Organizational factors

Large-scale clusters of engineering construction is featured by big work quantities, many participants and large cross interference and big operating area. Therefore, he construction unit needs to exchange views about project with the construction constructor and solves engineering problems by modification. Strong organizational ability helps the construction management unit to communicate with other participating units, who will complete the project together with construction management unit.

3.2.3 Management factors

The construction management unit completes the project together with other participating units by means of contract agreement. A participating unit who has strong ability of project management promotes the high-quality project. In the term of the project construction, the construction management unit mainly drafted the contract. Therefore, it is necessary for construction management unit to strengthen the personnel management, contract management and claim management with the help of the contract. A good relevant process scheme is essential. All causes of problem shall be taken into consideration. The unit shall list some foreseeable problems and preventive measures in the contract. Relevant systems and procedures shall be made to facilitate other works.

3.2.4 Economic Factors

The large-scale clusters of engineering project is constructed with high cost. Good capital turnover ensures the quality of the project. Therefore, project decision makers can keep capital turnover by different financing

channels while guaranteeing the project quality and function. But the construction management unit shall choose financing channel according to its financial situation and risk-resistance.

3.2.5 Environmental Factor

Social environment and the nature will also affect project quality. Therefore, decision makers should take the initiative to pay attention to social, political, legal and other changes might have impacts on the project. When nature affect the project, the construction management unit can transfer risks by increasing investors and purchasing relevant insurance.

3.3 Numerical simulation and theoretical analysis

By the analysis of the five factors influencing the quality risk management of the construction management unit, the relevant quality risk matrix is established to provide the basis for the follow-up quality risk management.

3.3.1 Risk matrix model

(1) The quality risk matrix of large-scale cluster project is established through the comparison and simulation analysis of various influencing factors.

Table 1. quality risk matrix [10]

Project phase	Risk	Effect Level	Risk Probability	Risk Level	Borda	Risk weight	Risk Total Level(RTL)
Project completion acceptance	Organizational risk Managing risk economic risk Technical risk Environmental risk	-	-	-	-	-	-

(2) Quality impact grade and quality risk probability

In the quality risk matrix, the impact level can be divided into five situations (critical, serious, general, small and negligible); the probability of quality risk occurrence is determined from 0% to 100% [10] .

(3) Ordinal value

$$b_i = \sum_{k=1}^{2} (N - r_{ik}) \text{ (formula 1)}$$

Where: n – number of risks;

K = 1 – impact level EL;

K = 2 – risk probability RL.

Using the above formula, B_i can be calculated, and then the B_i is sorted according to the results from large to small.

(4) Determine the comprehensive risk level

By issuing the questionnaire, the project management experts compare and grade the quality risks of each stage according to their importance in order B, and then construct the judgment matrix, and then determine the weight of the quality risk in each stage by using the analytic hierarchy process (AHP). The stage with great weight indicates that the probability of quality risk will be greater. If the decision-maker finds out the main factors and strengthens the management, it is beneficial to reduce the quality risk of the project.

3.3.2 Construction of quality risk matrix

Taking two single projects in the construction project of a new campus of a university as an example, the quality risk of each stage of the sub unit project is analyzed by the construction unit, and then the matrix is constructed by numerical simulation and hypothesis analysis.

Table 2. Construction project of a new campus of a university [7]

entry name	Building area (m^2)	Number of layers	Contract cost (RMB)	Contract period (days)	Unit square meter cost (RMB / m^2)
The first canteen for students	9846	4	19830000	320	2014.02
Student activity center	6153	4	11790000	330	1916.14

The two projects of the first canteen and the student activity center have similar unit price and frame structure. The participation capacity and construction project quality risk factors are simulated, and the relevant quality risk matrix is constructed with the average value. The calculation results are shown in Table 3.

Table 3 showed that the quantitative risk values of each stage are: $RTL_1 = 2.5223$, $RTL_2 = 2.0331$, $RTL_3 = 2.0687$, $RTL_4 = 1.4140$, $RTL_5 = 1.4122$, and the order of risk quantification values is $RTL_1 > RTL_3 > RTL_2 > RTL_4 > RTL_5$. When the construction management unit participate in the relevant projects, the quality risk in the project decision-making stage is the largest, and the quality risk in the project completion acceptance stage is the minimum.

4 Conclusion

The influence degree of quality risk factors is scored by engineering management professionals, and the value is quantified by analytic hierarchy process (AHP).

(a) When the construction management unit participates in large-scale clusters of engineering project, it mainly controlled the quality management risk in the decision-making stage, while paying little attention to the quality risk control in the completion acceptance stage.

Table 3. quality risk matrix

Project phase	Risk	Effect level	Risk probability	Risk level	Borda	Risk weight	RTL
Project decision-making	Organizational risk	Serious	60%	3.000	2	0.2831	2.5223
	Managing risk	Serious	50%	2.737	3	0.1988	
	economic risk	Critical	60%	3.500	1	0.1643	
	Technical risk	Serious	80%	3.828	0	0.0708	
	Environmental risk	Moderate	10%	1.000	4	0.2831	
Project design	Organizational risk	Serious	40%	2.000	2	0.2630	2.0331
	Managing risk	Critical	25%	2.241	1	0.4750	
	economic risk	Moderate	35%	1.414	3	0.0550	
	Technical risk	Serious	50%	2.737	0	0.0900	
	Environmental risk	Moderate	15%	1.069	4	0.1108	
Project preparation	Organizational risk	Critical	25%	2.241	1	0.4104	2.0687
	Managing risk	Critical	20%	2.155	2	0.1179	
	economic risks	Critical	35%	2.414	0	0.1197	
	Technical risk	Serious	40%	2.000	3	0.0678	
	Environmental risk	Serious	20%	1.655	4	0.2842	
Project construction and preparation before use	Organizational risk	Minor	40%	1.000	4	0.3649	1.4140
	Managing risk	Serious	60%	3.000	1	0.1702	
	economic risk	Moderate	30%	1.328	2	0.1702	
	Technical risk	Serious	95%	3.722	0	0.1021	
	Environmental risk	Moderate	20%	1.155	3	0.1925	
Project completion acceptance	Organizational risk	Minor	45%	1.086	3	0.2648	1.4122
	Managing risk	Moderate	35%	1.414	1	0.0908	
	economic risk	Moderate	25%	1.241	2	0.0797	
	Technical risk	Critical	70%	3.655	0	0.0456	
	Environmental risk	Moderate	10%	1.000	4	0.5191	

(b) The quality risk matrix showed that the construction technology has the greatest influence on the quality management in the decision-making stage. Therefore, the unit should improve professional technology in the decision-making stage to pave the way for follow-up projects.

In addition, experts in varied project areas have different engineering experiences. There are different opinions on quality risk factors. The subjective scoring actually exists. Engineering technology will be constantly updated due to the social development, and the quality risk factors will also change relatively. It is suggested that the quality risk factors should be quantified and scored by relevant experts.

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