

# Research on Object Control and Application of University Maintenance Project Management

Weijiao Liu

Shandong University, Shandong 250100, China

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**Abstract:** In this paper, the object control theory is applied to the design of the management scheme of the university maintenance project. The design content is covered the project object control, The overall trade-off of the three goals, the management performance appraisal and the safeguard measure. At the same time, scientific theory and method are used to guide the design process, and then achieve the design goal. The ultimate goal of the research is effectively improving the effectiveness of the comprehensive management of the maintenance project, thereby promoting the optimal allocation of the renovation funds and other educational resources.

**Keywords:** University maintenance project, Object control, Performance evaluation.

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## 1. Introduction

The management of university maintenance project is a key work to ensure the smooth progress of teaching and scientific research, which is important to promoting the development of the university. From the perspective of business form, the operation of university life service facilities is facing great challenges. On one hand, the obsolete service facilities are still overloaded, on the other hand, with the new service facilities put into use and the end of the warranty period, the number and scale of maintenance works are increasing sharply. How to manage the repair project, guarantee the project quality, schedule and cost target, and better serve the development of the university is a key and difficult problem in the reform of university governance system.

## 2. Control Objectives of Maintenance Engineering

The central task of universities is teaching and scientific research. The engineering projects of universities are different from the investment projects of enterprises and other infrastructure construction projects of the government. Generally speaking, university engineering project is a non-productive investment, which main goal of investment is to improve the conditions for running schools, optimize the allocation of resources and other social benefits.

The quality control objective of university renovation projects is to meet the design requirements, contract quality standards and the unified construction quality acceptance standards; The schedule control objective is to ensure that the project completes all the tasks stipulated in the contract within the construction period, or to shorten the construction period appropriately without increasing the actual cost and ensuring the quality of the project; The cost control objective is to achieve the goal of not exceeding the budget while meeting project duration and quality objectives, and to maximize the value of limited renovation funds. When determining the project target, it is necessary to consider the coordination and balance of multi-objectives in an all-round way, so as to make the project achieve a satisfactory result.

## 3. Quality Control of Maintenance Project

Quality control should run through the whole process of the life cycle of a project. At different stages of implementation, various measures to ensure quality should be formulated and implemented, and quality trends should be followed up and corrective measures should be taken in time, ensure that the project quality does not deviate from the target track, and ultimately achieve the agreed quality requirements and standards of the contract. The quality control plan of university renovation project should be made according to the above ideas, including work decomposition, flow chart, technical method selection and corrective measures.

### 3.1. Break down the quality control work according to the implementation stage of the project

(1) Project stage:

(a) Trade-off the overall project quality objectives reasonably by taking into account the characteristics, schedule and cost objectives of maintenance project;

(b) According to the total quality target, design and optimize the alternative maintenance scheme, and select the optimal design scheme on the premise of guaranteeing the quality standard;

(c) Compare the main materials and equipment proposed by the design, and confirm the quality is up to the requirements on the basis of reasonable price;

(d) Promote the application of new technologies, technologies and materials actively.

(2) Tender stage:

(a) Assist the tender office to establish the qualification criteria of the tenderers, including personnel quality, technical strength, construction performance and social reputation;

(b) Assist the tender office to develop scoring criteria for technical tender sections based on project profile and technical characteristics. Review the overall strength of bidding units from the construction organization design, quality, safety management system etc.;

(c) Draw up the relevant terms of the quality part of the contract, including material purchase, process and project

acceptance, warranty period, warranty liability, etc.

(3) Construction phase:

(a) Prepare and provide qualified construction site for the builder;

(b) Review the construction organization design, construction plan or Operation Instruction submitted by the builder;

(c) Check whether the preparation of manpower, materials and equipment of the builder is in accordance with the construction organization plan;

(d) Control the quality of the construction process by checking the quality of the process and process handover inspection system strictly;

(e) Check the hidden project and do the quality acceptance in the construction process carefully, exercise the right of quality supervision and veto correctly, ask for corrective action or rework in time for any quality problems found;

(f) Compare and select the project change program to ensure the quality of the project carefully.

(4) Completion stage:

(1) Examine the completion materials submitted by the builder, check and accept the project quality according to the quality standards and compulsory standards stipulated in the contract;

(2) If the acceptance is not up to standard, ask the builder to make rectification in time, and supervise the builder to strengthen the protection of the project finished products;

(3) Guide the builder to handle the project warranty and supervise the builder to organize the implementation of the project warranty;

(4) Promote the application of new technologies, technologies and materials actively.

### 3.2. Draw the quality control flow chart

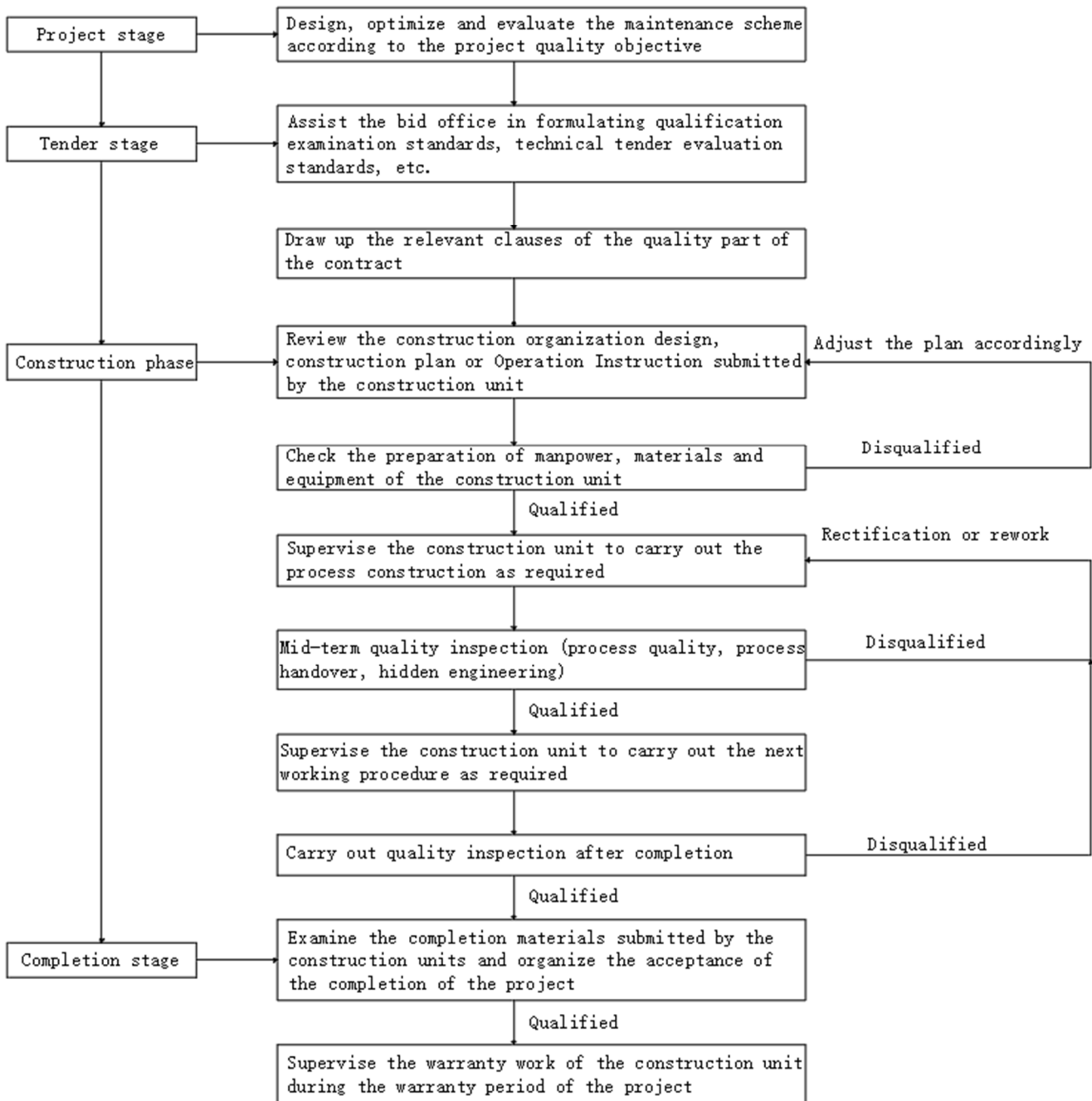


Figure 1. The quality control flow chart of the university repair project

### 3.3. Select the appropriate technical methods

Considering the applicable conditions of each method of quality control and the characteristics of repair engineering, the following two technical methods are recommended in the process of quality control of university repair engineering:

(1) The method of check-list, which means that the inspectors fill in the check-list (figure or form) with the check results in the form of check record symbols according to the pre-determined check items, frequencies and methods, and then make statistics and collation of their data, for quantitative analysis or comparison check.

(2) Causality analysis, also known as Fishbone diagram, shows the relationship between quality problems and quality factors through arrow lines, examines possible causes layer by layer, and then identifies the most important ones, to carry out targeted treatment and management.

### 3.4. Establish quality corrective measures

If the quality is found to be unqualified after inspection, rework and re-inspection is required, and if there is any quality defect, rework or reinforcement shall be adopted in each case. In addition, in-depth analysis and identification of the causes of quality deviation, targeted measures to effectively prevent or correct quality deviation, mainly including:

(1) The quality control of the construction personnel is not in place: urge the construction unit to strengthen the quality awareness of the workers education and technical training, improve their quality activities and self-control ability;

(2) The quality control of materials and equipment is not in place: strengthen the inspection of raw materials, semi-finished products and engineering equipment, prohibit the use of substandard or inconsistent with the design requirements of materials and equipment;

(3) The quality control of technology method is not in place: the establishment and adoption of advanced technology, safe and reliable construction technology or construction methods, optimization of construction section division, construction flow and labor organization;

(4) The quality control of mechanical equipment is not in place: reasonable selection and correct use of mechanical equipment, focus on control and acceptance of templates, scaffolding and other construction equipment design and production quality;

(5) The control of construction environmental factors is not in place: make clear the construction measures under adverse weather and climate conditions, carry out the preparation of personnel and equipment, and strengthen the monitoring and early warning during the process; Straighten out and coordinate the management relationship, so that the smooth construction.

## 4. Progress Control of Maintenance Project

### 4.1. Break down the schedule control work according to the implementation stage of the project

(1) Project stage:

(a) Make the overall progress schedule according to the overall progress goal;

(b) Make the implementation schedule of this stage according to the requirement of the total time limit of the maintenance project,;

(c) Carry out various activities of organization and coordination, to advance the work of site investigation, formulation of alternative plans, optimization and selection of design plans as planned;

(d) Advance the application procedure for project establishment.

(2) Tender stage:

(a) Assist the tender office to make the bidding schedule according to the requirements of the master schedule;

(b) Assist the tender office to complete the bidding preparation according to the schedule, complete the preparation of the complete bidding documents and pass the examination and approval;

(c) Promote contract negotiation and signing.

(3) Construction phase:

(a) Review the construction progress plan of the builder to confirm its feasibility and meet the requirements of the project controlled progress plan;

(b) Review and control the material and equipment supply schedule of the builder to meet the construction requirements;

(c) Study and formulate measures to prevent construction claims, timely processing of construction claims, and reasonable counter-claims;

(d) Supervise and urge the builder to keep progress under control by Coordinating relations between the parties concerned ,such as holding schedule coordination meetings timely or otherwise;

(e) Track the construction progress, grasp the construction dynamic, progress deviation analysis and take corrective measures timely;

(4) Completion stage:

(1) Supervise and urge the builder as soon as possible to meet the end conditions in accordance with the project contract and the requirements of construction units;

(2) Supervise and urge the builder to compile and submit the completion data and settlement data;

(3) Promote the organization of project completion acceptance and completion settlement;

(4) Supervise and urge the builder to handle the project warranty and implement the warranty.

### 4.2. Draw the schedule control flow chart

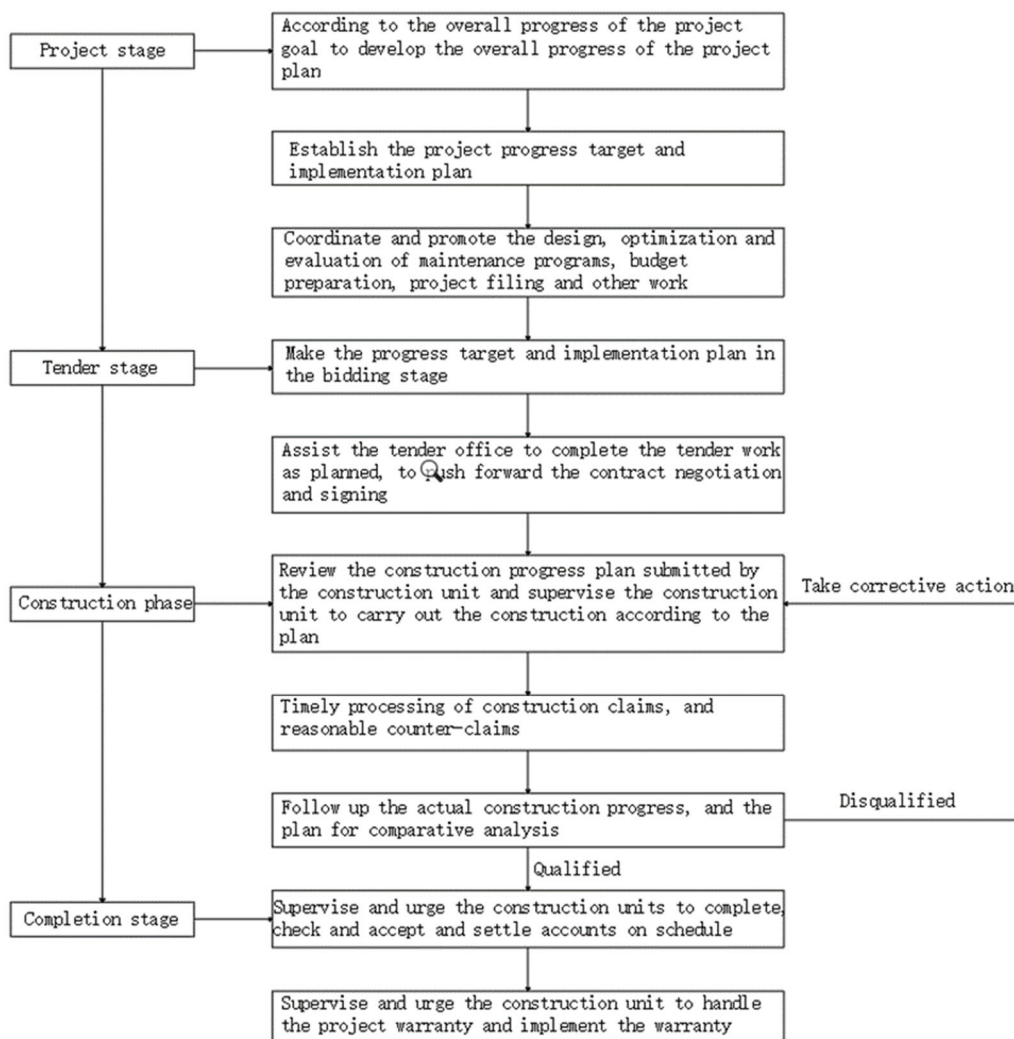


Figure 2. The process control flow chart of university renovation project

### 4.3. Select the appropriate technical methods

Considering the applicable conditions of each method of schedule control and the characteristics of the renovation project, it is recommended to adopt the comparison method of double-proportion and one-side horizontal chart or earned value method in the process of the renovation project of university.

The comparison method of double-ratio and one-side transverse chart is suitable for the case of the work progress according to the variable speed. In this method, the actual progress of a task is represented by a thick line, and the cumulative percentage of tasks completed at the corresponding time is marked and compared with the cumulative percentage of tasks scheduled to be completed at the same time, judge the relationship between the actual progress of the work and the planned progress.

### 4.4. Establish schedule corrective measures

In the process of implementing the schedule plan, due to the influence of technology, organization, economy, resources, natural conditions and other factors, the actual schedule and the schedule will often cause deviation, if the deviation can not be corrected in time, will affect the progress of the goal. Therefore, the establishment and adoption of effective schedule corrective measures to ensure the smooth realization of the plan is of great significance.

(1) Technical measures: analysis of the existence of

construction technology factors, in order to achieve the progress of the goal of design changes, changes in construction technology and construction methods possibility; Adopting scientific and applicable planning methods such as network planning technology and flow construction;

(2) Organization measures: strengthen the construction progress control, establish and guarantee the progress information communication channels, organize the progress coordination meeting, etc.

(3) Economic measures: to give emergency rush-related costs; to give incentives in advance of the construction period and the delay of the construction period and quality and safety claims;

(4) Contract measures: strengthen contract management, correct processing of claims and counter-claims.

## 5. Cost Control of Maintenance Project

### 5.1. Break down the cost control work according to the implementation stage of the project

(1) Project stage:

(a) According to the department's maintenance application, engineers and technicians survey the scene to confirm the maintenance content, measure related data and obtain detailed site information;

(b) Make reference to the information and data of the similar maintenance project, draw up the feasible alternative

maintenance plan and prepare the project budget;

(c) Organize technical discussion to optimize design scheme, make techno-economic analysis, compare alternative schemes and select the best;

(d) Make a detailed project budget as the basis of cost control in subsequent stages.

(2) Tender stage:

(a) Assist the tender office in the preparation and revision of the tender documents, focusing on clauses relating to cost control in the tender documents and the preparation of the base price;

(b) Assist the tender office to develop scoring criteria for commercial tender sections, with reasonable low price as the main condition for winning the bid and meeting the comprehensive evaluation criteria in the tender documents to the greatest extent possible;

(c) Draw up the relevant clauses of the economic part of the contract, such as the contract pricing method, the settlement of breach of contract disputes etc.

(3) Construction phase:

(a) According to the requirements of the contract, complete the owner's preparation in time and formulate measures to prevent claims for expenses;

(b) Do engineering measurement work best and manage

on-site visa strictly;

(c) Manage design change or engineering change strictly, select the optimal change scheme and strive to reduce the cost of change;

(d) Handle cost claims in time and make counter-claims reasonably;

(e) Collect actual data to conduct cost deviation analysis, take corrective action in time to control deviation within the allowable range;

(4) Completion stage:

(1) Audit the builder to submit the project completion data for a comprehensive grasp of the project-related situation;

(2) Audit the project settlement information and settlement procedures, especially carefully check the visa contact list and other project change information;

(3) Review the bill of quantities, the unit price for settlement and the unit price of new or changed items according to the contract and visa contact list;

(4) According to the contract agreement to retain quality deposit, according to the actual situation for quality deposit settlement after the project warranty period.

### 5.2. Draw the cost control flow chart

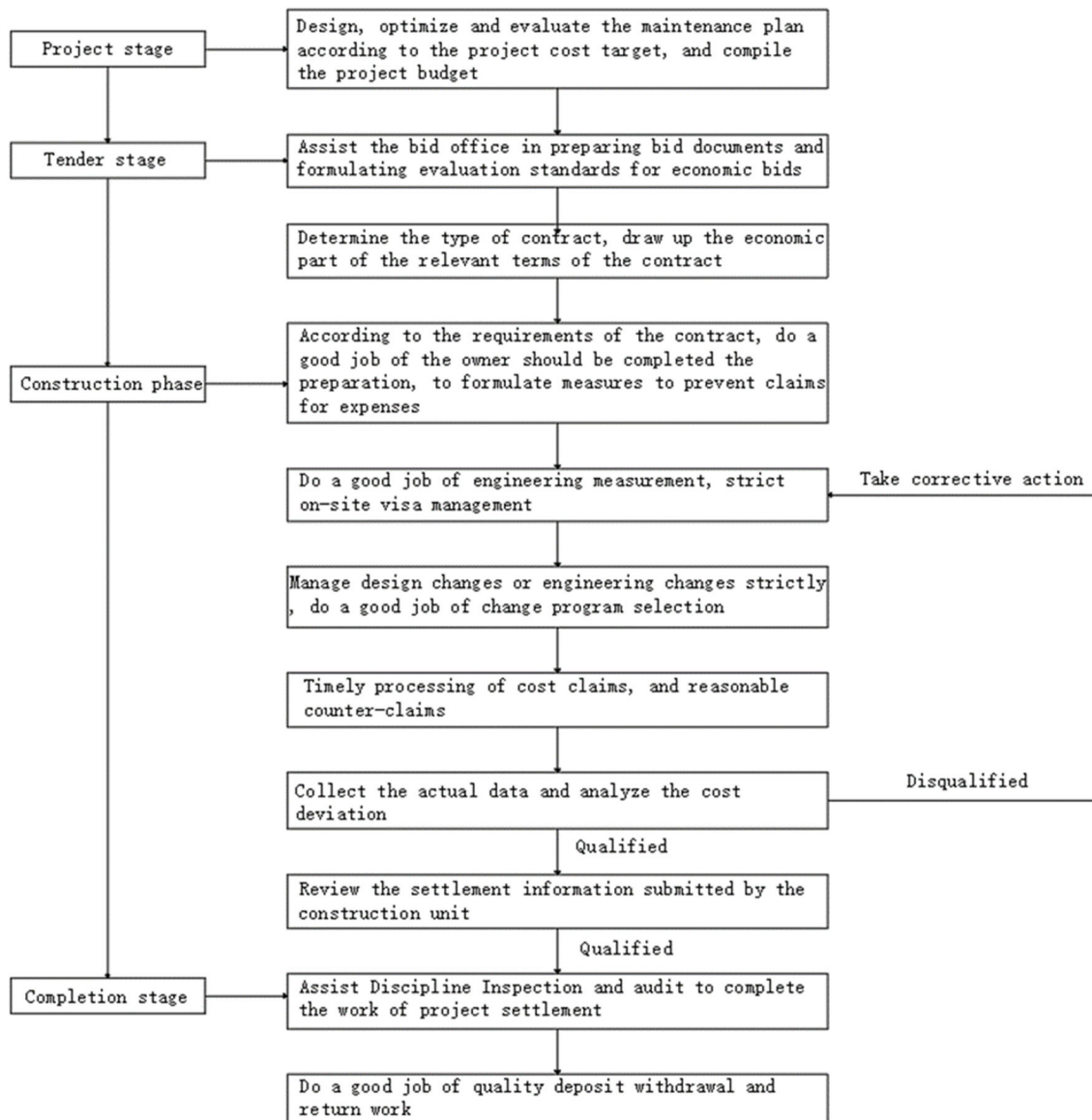


Figure 3. Flow chart of cost control of university renovation project

### 5.3. Select the appropriate technical methods

Considering the applicable conditions of each method of cost control and the characteristics of repair engineering, the earned value method is recommended to analyze the cost deviation in the process of cost control of university repair engineering.

Earned value is a method of evaluating the actual cost and schedule of a project, by measuring and calculating the budgeted cost (BCWS) of the planned workload, the actual cost of the completed workload (ACWP) and the budgeted cost of the completed workload (BCWP), it obtains the cost bias (CV), schedule bias (SV), Cost Performance Index (CPI) and Schedule Performance Index (SPI) related to the implementation of the plan, thus can accurately measure the project cost, progress of integrated control of the situation. The advent of earned value methods overcomes the disadvantage of analyzing cost variances separately, that is, when cost overruns are found, it is difficult to immediately determine whether they are due to cost overruns or early schedule; similarly, when cost savings are found, it is also difficult to immediately determine whether it is due to cost savings or schedule delays, so it has been widely used in a variety of project cost bias analysis.

The specific calculation and expression methods are as follows:

$SV = BCWP - BCWS$ , when SV is negative, it indicates the progress delay, otherwise the progress is ahead;

$CV = BCWP - ACWP$ , when CV is negative, it shows cost overrun, otherwise it is cost saving;

$SPI = BCWP/BCWS$ , when  $SPI < 1$ , indicates the progress delay, otherwise the progress is ahead;

$CPI = BCWP/ACWP$ , when  $CPI < 1$ , indicates cost overrun, otherwise the cost is saved.

### 5.4. Establish cost corrective measures

In order to achieve the ideal effect of cost control, when the actual cost deviates from the planned cost through cost analysis, measures should be taken from various aspects to correct the cost deviation.

Technical measures: analysis of the existence of design technology impact, in order to achieve the cost objectives of design changes, changes in construction technology or construction method possibility;

Organization and measures: strengthen the management of project measurement, require the construction units to strictly comply with the contents of the bill of quantities and the construction volume;

Economic Measures: Technical and economic analysis of the project change program to determine the best program; may cause the cost of unfinished projects to increase the starting point of active control to take preventive measures in a timely manner;

Contract measures: pay close attention to the implementation of the contract between the two parties, correct claim for the contract and counter-claim.

## 6. The Overall Trade-off of the Three Major Controls

Quality Control, cost control and schedule control are the

main components of the management system of university renovation project, and they restrict and influence each other to form a whole which is interrelated and unity of opposites. In order to achieve the overall goal of the project, it is necessary to balance the three objectives control from beginning to end in the process of project implementation.

The specific work of the trade-off analysis includes the following steps: analysis of the causes of the conflict analysis and outlook of the project objectives analysis of the project environment and situation identification of multiple alternatives analysis and optimization of the best options. In the process of implementing target control, trade-off analysis is applied to all kinds of control work as a train of thought and method, in the design of the scheme, the best scheme is selected by designing several schemes and weighing the merits and demerits of different schemes. During the construction stage, the construction organization design of the construction unit is carefully examined to ensure that the construction scheme meets the requirements of technically feasible, economically reasonable and technologically advanced, it is necessary to balance and select the change scheme from the aspects of technology, schedule and economy, so as to ensure the coordination and balance of quality, schedule and cost. After the completion of a construction project, a comprehensive evaluation method covering three objectives is adopted to evaluate the performance of the project, so as to reflect the overall control effect.

## 7. Maintenance Project Management Performance Evaluation

Among many performance evaluation methods, fuzzy analytic hierarchy process (FAHP), which combines the advantages of fuzzy method and analytic hierarchy process (AHP), is especially favored for its systematic, flexible and concise advantages. After comprehensive consideration and comparison, it is decided to use fuzzy comprehensive evaluation method to evaluate the performance of university renovation project management.

### 7.1. Construct the performance evaluation index system

On the basis of on-the-spot investigation, comprehensive statistical probability method and expert consultation method are used to select the performance evaluation indexes of university renovation project management. First of all, according to the retrieval results obtained by inputting "Performance evaluation of engineering project management" into CNKI and WANFANG databases, the relevant research literature is sorted out, and the indicators with higher frequency are selected, a preliminary evaluation index system was established. Then, according to the characteristics and investigation of the university renovation project, and seeking the opinions and suggestions of the experts and scholars who are engaged in the related construction industry and the university engineering management, finally, the performance evaluation indexes of university renovation project management are selected, and the Performance Evaluation Index System of university renovation project management is constructed as shown in table 1.

**Table 1.** University Renovation Project Management Performance Evaluation Index System

Target layer	Level 1 indicators	Secondary indicators	Description of indicators
Performance Evaluation System of university renovation project management	Quality Control Evaluation U1	Reasonable degree of construction organization design (Quality Plan) U11	Whether the quality plan is scientific, reasonable and meets the requirements of quality objectives
		Qualified rate of material inspection U12	The ratio of the number of times the material has passed the inspection to the total number of times the material has passed the inspection
		Technical disclosure U13	Whether the technical disclosure is accurate and in place
		One-time acceptance rate of hidden process U14	Whether the ratio of the number of times that the hidden process passes the acceptance test to the total acceptance test is qualified or not
		Engineering one-time acceptance acceptance rate U15	Whether the ratio of the number of qualified items to the total number of items of a project is qualified
	Progress control evaluation U2	Rationality of schedule and plan U21	Whether the schedule is scientific, reasonable and meet the requirements of the total construction period
		Construction organization sound situation U22	Whether the construction organization is sound
		Adequacy of construction force U23	Whether the actual construction force meets the requirements of the plan
		Natural factors to deal with the situation U24	Whether can deal with the natural factors and so on weather influence promptly and effectively
		Schedule schedule execution U25	Whether the actual schedule is up to par with the planned schedule
	Cost control evaluation U3	The rationality of the scheme design U31	Whether the construction scheme design is scientific and reasonable
		Accuracy of Bill of quantities U32	Whether the bill of quantities is comprehensive and accurate
		The scientific nature of the change U33	Whether the change is necessary and the change plan is reasonable
		Visa integrity and timeliness U34	Visa procedures are complete and timely
		Reduce the cost rate U35	Is the ratio of cost reduction to cost budget ideal

**7.2. Construct the fuzzy comprehensive evaluation model**

(1) Construct the judgment matrix

Experts are invited to compare and score the evaluation factors of each level according to the scale method of 1-9(see table 2) , construct the judgment matrix A of the Performance Evaluation Index of University Renovation Project Management.

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \quad (1)$$

**Table 2.** 1-9 scale method

aij	ai is compared with aj
1	ai is as important as aj
3	ai is slightly more important than aj
5	ai is obviously more important than aj
7	ai is stronger and more important than aj
9	ai is definitely more important than aj
2, 4, 6, 8	The median value between the above two judgments
Countdown	Index ai and aj were compared to get aij , Index aj was compared with ai to get aji=

Notes: aij meet (1) aij > 0; (2) aii = 1.

Source: discussion on the evaluation method of construction project bidding

(2) Determine the weight coefficient

The weight vector is standardized by the eigenvector corresponding to the largest eigenroot of the judgment matrix.

For simplicity, use the method of square root to find the weight vector:

$$W' = (w'_1, w'_2, \dots, w'_n)^T, w'_i = \sqrt[n]{\prod_{j=1}^n a_{ij}}, i=1, 2, 3, 4 \quad (2)$$

Standardize it:

$$W = (w_1, w_2, \dots, w_n), w_i = \frac{w'_i}{\sum_{i=1}^n w'_i}, \quad (3)$$

(3) Consistency testing

Calculate the maximum eigenvalue of the judgment matrix,

i. e.:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \frac{(AW)_i}{w_i} \quad (4)$$

When  $\lambda_{\max} = n$ , It can be considered that the judgment matrix is a completely consistent matrix. When  $\lambda \neq n$ , the consistency ratio is usually used to test:

$$CR = \frac{CI}{RI} \quad (5)$$

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (6)$$

Among them: CR is the consistency ratio;

CI is the consistency index;

RI is an index of average random consistency, which can be obtained by looking up table.

**Table 3.** Average random concordance index

n	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

Source: application of analytic hierarchy process to project risk management

When  $CR < 0.1$ , the judgment matrix is considered to have acceptable consistency. When  $CR \geq 0.1$ , it is necessary to adjust and modify the judgment matrix to satisfy  $CR < 0.1$ , so as to have satisfactory consistency. The detailed calculation process is shown in Appendix 2.

(4) Fuzzy Comprehensive Evaluation

The establishment of evaluation level: according to the concrete problems, the evaluation factors are graded, and the scores of each level are divided into intervals, according to which the parameters of each level are determined, and the parameter matrix C is obtained.

According to the general grading principle of international practice:  $V = \{ \text{excellent } (90 \sim 100), \text{ good } (80 \sim 90), \text{ general } (70 \sim 80), \text{ poor } (60 \sim 70), \text{ poor } (0 \sim 59) \}$ , parameter matrix:  $C = (1, 0.8, 0.7, 0.6, 0)^T$ .

Invite experts to vote on the secondary indicators of the management performance of a university renovation project according to the actual situation, and formalize the number of votes so as to obtain the subordinate degree of each indicator

to the evaluation grade, the fuzzy relation matrix R is obtained.

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} \quad (7)$$

Comprehensive Evaluation of the management performance of a renovation project in a university:

$$B = W \times R = (w_1, w_2, \dots, w_n) \times \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} = (b_1, b_2, \dots, b_n) \quad (8)$$

Fuzzy Comprehensive Evaluation Score:

$$F = B \times C = (b_1, b_2, \dots, b_n) \times (1, 0.8, 0.7, 0.6, 0)^T \quad (9)$$

In a word, the performance level of a university's maintenance project management can be judged according to the set of comments.

## 8. Conclusion

In this paper, the author tries to make a detailed consideration of the establishment and implementation of target control, management performance evaluation method and management guarantee measures. However, limited by her own theoretical level and the lack of practical constraints such as objective factors, there are still many deficiencies in this article. For example, the improvement scheme of maintenance engineering management made in this paper does not study the overall trade-off of the three objectives control in depth. In addition, the design of management improvement plan does not include safeguard measures, the performance appraisal of managers and other aspects of consideration. Therefore, the existence of the scheme design is not comprehensive and systematic, which needs to be further considered. However, the author makes some preliminary attempts to design the management improvement scheme of university's repairing engineering and intends to provide one direction of studying the management improvement scheme of university's maintenance engineering, hoping that it can inspire more scholars and practitioners to think and discuss the management of university maintenance engineering more deeply.

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