

Construction Management Characteristics and Quality Control Strategies for Higher Education Infrastructure Projects

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Abstract: *With the rapid development of higher education and the promotion of modernization of campus infrastructure, construction projects in universities are emerging like spring bamboo shoots. These projects not only carry the campus culture and spiritual characteristics, but also serve as important support for scientific research and teaching activities. Compared with other types of construction projects, university construction projects exhibit distinct features, including specific policies and regulations they follow, complex stakeholder relationships involved, and special requirements for completing high-intensity construction during the academic term breaks. Therefore, construction management and quality control become particularly crucial. This article will delve into the uniqueness of construction management in university construction projects and the common challenges they face, and propose a series of quality control strategies, accompanied by specific management practice cases, with the aim of providing practical guidance for the implementation of relevant projects.*

Keywords: *Higher education infrastructure projects; Construction management; Quality control*

1. Introduction

In recent years, with the thriving development of the education sector, university infrastructure projects have emerged in abundance like mushrooms after rain. These construction projects not only represent the expansion of educational resources, but also directly impact the overall image of the institution and the enhancement of teaching and research quality in the future. Therefore, the characteristics of construction management and quality control strategies have become crucial topics regarding the future development of universities. Compared to other types of construction projects, university infrastructure projects exhibit a unique face in terms of construction management. The specific policy and regulatory environment provide a normative framework for project implementation. Under the dual management of the education authorities and local governments, university infrastructure projects must adhere to more stringent regulations in terms of job responsibilities and financial operations. Additionally, the academic environment and complex stakeholder structure within the university require the management of projects to strike a balance between teaching and research and construction progress. Moreover, due to the academic schedule of the university, university infrastructure projects often face the pressure of completing high-intensity construction within a short period of time. In such a special context, construction management and quality control strategies for university infrastructure projects are particularly important. A well-designed management strategy can ensure that projects are of high quality while also meeting the specific needs of the educational environment. On one hand, it is possible to ensure effective quality assurance of construction projects by establishing a dedicated quality management team, refining project planning, and strengthening process supervision. On the other hand, enhancing the training and cultural development of construction personnel in terms of quality and safety, and fostering a consensus of prioritizing quality within the team also play a crucial role in improving construction quality.

2. Characteristics of construction management of university infrastructure projects

2.1. Unique policy and regulatory environment

In the construction management of infrastructure projects, universities, as educational institutions,

face a regulatory environment that includes general regulations applicable to the construction industry and specific provisions tailored for higher education institutions. The uniqueness of this environment is first and foremost manifested in the special requirements for engineering quality and safety standards. Given that university infrastructure projects typically involve educational facilities such as teaching buildings, laboratories, and student dormitories, the safety, stability, and environmental quality of these areas directly impact the safety and teaching quality of faculty and students. Consequently, compared with general commercial or residential buildings, university infrastructure projects must adhere to more stringent safety and quality standards in their design and construction processes, often surpassing the country's basic requirements. Moreover, the influence of policies and regulations on university infrastructure projects is also reflected in the utilization and management of funds. As projects funded by national fiscal appropriations, donations, and institutional funds, university infrastructure projects must comply with strict financial management and auditing systems when it comes to fund usage. In China, on the one hand, projects with a value of more than 4 million yuan must be publicly tendered; in Zhejiang Province, China, projects with a value of 1 million to 4 million yuan need to follow the government procurement procedures; in the vast majority of universities, according to the school's regulations, projects with a value of less than 1 million yuan but above a certain amount also need to follow the school's prescribed bidding or procurement procedures. For example, Wenzhou Medical University stipulates that projects with a value of 200,000 to 1 million yuan also need to determine the winning bidder through public bidding or government state-owned asset procurement, and for projects with a value of less than 200,000 yuan, they also need to be contracted through the form of establishing a construction designated unit pool by bidding every 2-3 years. On the other hand, for projects exceeding 4 million yuan, universities need to submit project initiation applications to the education department, development and reform department, and finance department. The initiation application generally includes the project proposal stage, feasibility study stage, and preliminary design stage. The entire process will be reviewed and demonstrated by the administrative department on the necessity of the project, the feasibility of the plan, and the adequacy of funds, and the whole process will last for more than half a year. These systems are aimed at ensuring the rational use of funds, preventing waste and corruption, and guaranteeing that every penny is used to enhance the teaching environment and student living conditions [1]. Therefore, in the construction management process, meticulous planning, budget allocation, and cost control must be ensured while maintaining project quality. Additionally, environmental protection and energy conservation are significant requirements imposed on university infrastructure projects by the regulatory environment. As bearers and exemplars of social responsibility, higher education institutions must fully consider environmental protection and energy conservation requirements during the design and construction phases of infrastructure projects. This involves the utilization of green building materials, implementation of energy-saving designs, and minimizing the impact on the surrounding environment during the construction process. For example, the Ministry of Construction and the Ministry of Education jointly issued the "Management Measures for Energy-Saving Operation of Campus Facilities in Higher Education Institutions", the "Index System and Assessment and Evaluation Measures for Energy-Saving Campus in Higher Education Institutions", and the "Technical Guidelines for the Construction of Energy-Saving Supervision Systems for Campus Buildings in Higher Education Institutions", aiming to improve the energy efficiency of universities and reduce energy waste. Not only does this reflect the responsibility of universities towards society, but it also serves as an important means of environmental education and demonstration for students. Ultimately, in facing this unique regulatory environment, the construction management of university infrastructure projects not only needs to comply with relevant national and local building regulations but also must closely integrate with the actual situation and specific needs of higher education institutions, taking more meticulous and rigorous management measures. This requires the construction management team to possess not only professional technical capabilities but also a high sense of responsibility and acute awareness of policy and regulations to ensure the smooth progress of the projects, enhance the quality of engineering, and create a safe, comfortable, and environmentally friendly teaching and living environment for faculty and students.

2.2. Academic environment and complex stakeholder structure

The management of construction projects in higher education institutions involves a complex process that encompasses various technical, managerial, and stakeholder balancing aspects. Higher education institutions are not only places for the inheritance of knowledge and culture, but also frontiers for modern scientific research and innovation. Therefore, construction projects need to not only meet the daily needs of education and administrative offices, but also provide necessary physical space and technical support for research activities. This dual requirement makes the construction

management of higher education institutions present unique academic environmental characteristics. Foremost, it entails high standard requirements in the design and planning phase. Campus construction projects should not only embody the uniqueness of campus culture, but also integrate the latest research facilities and environmental conservation and energy-saving concepts. This necessitates that engineering designs be innovative and practical, aesthetically pleasing, as well as meeting the high-level requirements of scientific research activities. These high standard design and planning requirements demand that the construction management team possess a multidisciplinary knowledge structure and coordination ability to adapt to the special needs of the academic environment. Moreover, the stakeholders involved in the construction management process of higher education institutions are extremely complex. From the school leadership, teachers, and students to government departments, construction units, and supervisory companies, each link has different needs and expectations [2]. The school leadership focuses on whether the project can embody the school's spirit, while teachers and students are more concerned about whether the building's functionality can meet teaching and research needs. The government and construction units may pay more attention to the economic benefits and social impact of the project. Moreover, there are different colleges and disciplines within a university. Taking a medical university as an example, there are colleges of pharmacy, basic medicine, stomatology, and optometry within the school. If a research and experiment building is to be constructed, the needs of all the above-mentioned colleges must be taken into account simultaneously. Due to the differences in research directions and equipment, teachers from each college have different requirements for the layout and function of the building. These different needs and expectations create a complex web of interests. Managing this web of interests not only requires the construction management team to have outstanding technical capabilities, but also to have good communication and coordination skills. At every stage of the construction project, it is necessary to balance the expectations of different stakeholders to ensure the smooth progress of the project. This is not only a technical challenge, but also an art of management. Additionally, construction projects in higher education institutions often have a certain degree of public and demonstration significance. Many campuses are located in the core areas of cities, and the quality of their construction projects directly affects the image of the school and even the surrounding community. Therefore, construction management not only needs to strictly control the quality of the projects but also needs to consider the impact on the surrounding environment, and minimize disruptions to the normal campus order and the life of the surrounding community during the construction process.

2.3. High-intensity construction within a short period of time

The characteristics of construction management in university infrastructure projects are unique and challenging, especially in the aspect of "intensive construction in a short period." Due to the strict academic calendar and student campus life, construction projects often need to closely follow the school's academic schedule to ensure key projects are completed during semester breaks or holidays, minimizing the impact on the normal operation of the school. As a result, construction units often have to mobilize a large amount of labor and machinery in a very short time frame to carry out efficient construction operations. This construction approach typically involves continuous work day and night. Lighting equipment becomes the highlight of night-time construction, with the vast construction site illuminated even in the dark nights, the roar of machines blending with the voices of construction workers, painting a picture of a city that never sleeps. The high intensity of work in a short period of time often requires construction workers to work overtime, their sweat and dedication bearing witness to the changes and development of the campus. However, under the pressure of high intensity, inevitably a series of management and quality control issues will arise [3].

3. Strategies for quality control of university infrastructure projects

3.1. Establishment of specialized quality management team

The establishment of a dedicated quality management team is one of the crucial strategies for ensuring the quality of construction projects in university infrastructure development. During the expansion or renovation of campus facilities, the projects are often numerous, large-scale, and involve a certain level of specialization and complexity. The quality management team is tasked with coordinating the overall process and implementing specialized, systematic management techniques to monitor and enhance the quality of the construction. Throughout the university infrastructure development, the quality management team not only meticulously supervises every stage of the

construction process but also strengthens control over construction materials, mechanical equipment, and construction methods. Such a team typically comprises seasoned engineers, quality inspection experts, and contract management specialists, each with rich experience and deep understanding in their respective fields. Firstly, the establishment of a dedicated quality management team facilitates the decomposition of complex engineering projects into different management modules, each with individual responsible personnel, thus forming a streamlined accountability management system from a professional perspective. In addition, through regular project reviews, on-site inspections, and third-party testing, the quality management team can effectively identify defects and potential issues during construction. This proactive identification and swift response mechanism ensure that problems are addressed at an early stage, thus preventing minor issues from accumulating into major ones and significantly reducing the cost and risk of later repairs and rework. Furthermore, while enhancing the quality of the construction, the quality management team also needs to balance efficiency and cost. By streamlining workflows, reducing unnecessary waste, and optimally allocating resources, they can guarantee the quality of the construction while smoothly completing the construction tasks within the budget. Quality control is an ongoing, continuous task in infrastructure development, and the establishment of a dedicated quality management team indeed plays a crucial role in university construction projects. Through scientific management and meticulous operations, it effectively raises the quality standards of the entire project, ensuring the durability and safety of the school's construction. The quality management structure is shown in Figure 1. In the future, with technological advancements and accumulated management experience, the role of the quality management team in university infrastructure projects will become even more prominent, making greater contributions to creating a high-quality educational environment.

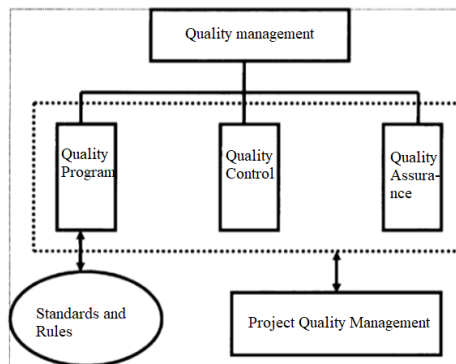


Figure 1. Quality management structure

3.2. Refined project planning and preliminary work

The construction projects of university infrastructure are closely related to the long-term development of the campus and the need of the faculty and students.. Therefore, it is extremely important to plan which functional buildings will be constructed on campus and whether the proposed buildings are in line with the future developing plan of the school, otherwise the infrastructure work will be off the mark. This work cannot be completed by the school's infrastructure department alone, but requires careful planning by the school's leadership, considering from multiple aspects, and communicating through multiple levels and channels. The following is a workable way to formulate the construction plan. In China, government departments will make a five-year plan to setup the next five year overall goals. Each university will also make a corresponding five-year plan to plan the goals that the university will achieve in the next five years, including student size, student structure, discipline construction tasks, etc. At the same time, the Ministry of Education has also issued the "Index of Building Area of Ordinary Colleges and Universities", which stipulates 12 per capita building indicators such as classrooms, laboratories, and dormitories, aiming to provide guidance for the scale of infrastructure required for schools to carry out teaching and living. The school's leadership and heads of various departments can comprehensively consider the three aspects of the school's future planning, the current existing building area, and the construction indicators stipulated in the "Index of Building Area of Ordinary Colleges and Universities". The ultimate goal is to create a construction blueprint that plans the construction of the school's future infrastructure, and these construction contents can match the school's future development plans and scale, providing a comfortable teaching and living environment for teachers and students.

3.3. Strict construction process supervision and control

Higher education infrastructure projects are special civil engineering projects, and the strictness of its construction process supervision and control is particularly important. This type of project not only involves the safety and comfort of the future campus environment, but also carries the quality of education and the shaping of the academic atmosphere. Therefore, quality control strategies play a pivotal role in this process. The first line of defense in quality control is ensuring the precise implementation of construction drawings and technical specifications. The formulation of construction plans should align with the particularities of university infrastructure projects, taking into account the specific needs of the institution and adapting to local conditions. In China, there are multiple procedures on the construction site to ensure that the project quality meets the established requirements. Firstly, the owner will invite bids for supervision, and then the owner and the supervision will form a construction site quality supervision team. The supervision team ensures that the construction enterprise completes the construction tasks in accordance with the specifications and drawing requirements through daily inspections, specific-aspect inspections, concealed works inspection, document review, etc. If it is found that the enterprise does not carry out the construction as required, the supervision team can require the construction enterprise to complete the relevant rectification work by issuing a rectification report, delaying or suspending the payment of progress payments, reporting to the government superior, or even issuing a work stoppage order. Secondly, according to the regulations of the competent department, the owner needs to entrust a third party to test the quality of raw materials used on the construction site of the construction enterprise and the finished product quality of specific structural parts, such as the raw material quality of steel bars, sand, and stones, and the quality of pile foundation. Such test reports will be the necessary information for the completion acceptance of this project. In addition, the administrative department will also send relevant supervisory personnel to check the construction quality of the project at key nodes of the project, such as the first test pile of the project, pile foundation acceptance, and main structure roofing, by on-site review and document review. On the other hand, for the construction enterprise, enhancing the professionalism and technical proficiency of workers is crucial at the management level of construction personnel. Implementing effective training measures and regularly enhancing occupational skills can guarantee that construction workers have an accurate understanding of and the ability to execute engineering quality standards. This not only reinforces quality awareness on-site but also provides human support for the long-term quality of the project. Apart from these measures, establishing a sound quality feedback and rectification mechanism is a key step in ensuring construction quality [4]. By establishing timely and efficient problem feedback channels, promoting communication between the construction site and decision-makers, quality issues can be swiftly identified and resolved. Quality inspection should not be a passive process but rather a continuous activity that actively seeks problems and drives improvement. Moreover, technological innovation and application can also enhance the quality control process during construction. Leveraging modern information technology, such as construction simulation based on Building Information Modeling (BIM), can predict potential issues before construction begins, optimize construction plans, reduce site alterations and rework, and ensure a dual improvement of project quality and efficiency. The rigorous supervision and control strategies in university infrastructure construction projects fundamentally involve a comprehensive, multi-layered, and meticulous task. From design inception, material inspection, construction practices to personnel training, each aspect is crucial. Through effective quality control strategies, not only can the construction quality of university infrastructure projects be guaranteed, but it can also further optimize the overall campus environment, creating a safe, aesthetically pleasing, and comfortable learning and working environment for both faculty and students.

3.4. Strengthen quality and safety training and cultural construction

Quality and safety training should not be confined to the mere imparting of regulations and operational procedures, but should also focus on enhancing practical skills and preventing risks. Case studies play a crucial role in training: by delving into historical incidents, identifying potential risks in projects, construction personnel can learn how to handle emergency situations in simulated environments, thus avoiding similar issues during actual operations. The training content needs to be targeted and diverse. For technical workers, simulated training in operational skills should be increased; for management, project management and risk control training should be emphasized. Furthermore, with the growing importance of new technologies such as BIM in engineering planning and management, corresponding technical training is indispensable to ensure holistic quality management. Equally important to training is the cultivation of a quality and safety culture, which involves

everyone's values, behavior habits, and work attitudes. At every stage of project construction, the concept of "quality first" must be emphasized. This should not just be a slogan displayed on the walls, but should be internalized by everyone through the implementation of daily behavioral standards, turning it into a conscious action. By organizing quality months, safety weeks, and other activities, the infectious power and coverage of this culture should be continuously strengthened. Another aspect to consider is incentive mechanisms. Clarity on the importance of quality goals through a reward and punishment system, and rewarding individuals or teams who achieve these goals. Conversely, strict accountability must be enforced for those who neglect quality standards and cause quality incidents, in order to maintain the overall quality baseline. Lastly, emphasizing sustainability is key to the success of quality and safety training and cultural development. This is not a one-time event, but an ongoing process. With the advancement of technology and the updating of management theories, training content needs to be continuously refreshed, and cultural development must keep up with the times to ensure that university infrastructure projects always maintain a competitive edge in quality control and create enduring educational facilities. In conclusion, reinforcing quality and safety training and cultural development should be comprehensively promoted through the enhancement of practical operations, raising risk awareness, ingraining quality culture, and implementing effective incentive mechanisms. This is a systematic process, where any slackness in any aspect could potentially lead to the collapse of the entire project's quality management system, highlighting its indisputable importance. Achieving high standards of quality management through such multidimensional strategies is the key to truly reaching the desired objectives of quality control in university infrastructure projects.

3.5. Late quality assessment and continuous improvement

The quality of university campus construction directly impacts the safety, stability, and aesthetics of the campus, and serves as a crucial foundation for educational quality and campus life. Therefore, after the completion of construction projects, it is important to implement precise quality evaluation and continuous improvement strategies. The first and foremost task is to establish criteria for post-construction quality evaluation. This process not only requires meticulous inspection of the projects, including the durability of materials, adherence to construction standards, and adherence to safety regulations, but also demands the establishment of a comprehensive and systematic evaluation system. Identifying the strengths and weaknesses of project quality, utilizing data analysis, quantifying issues, and pinpointing their exact locations, enable more precise problem identification. By establishing a feedback mechanism, quality issues can be promptly reported and addressed. An unobstructed feedback channel is crucial for early detection of potential defects and maintenance needs. This mechanism must incentive all stakeholders, including construction companies, supervision agencies, and even end users, to actively participate in the quality improvement process, creating a virtuous cycle of quality management. Following this, feasible improvement plans should be formulated. Issues identified during the evaluation process should be met with corresponding measures, including prioritization, clear assignment of responsibilities, and setting timelines, so as to tangibly implement quality management through a dynamic and controllable improvement action plan [5]. For instance, for recurring leakage problems, systematic solutions can be developed through the introduction of new materials or improved construction techniques. The continuous improvement phase should emphasize the importance of education and training. Regular training and education sessions help construction workers and management personnel gain a clear understanding of new engineering technologies and quality standards, not only enhancing their technical skills, but also strengthening their awareness of quality. By focusing on enhancing the competence and skills of individuals, the quality improvement of construction projects can be better promoted. The introduction of innovative technologies should also not be underestimated. Technologies such as drones and 3D scanning can assist in precise project inspection, IoT sensors can monitor the real-time status of buildings, and big data analysis can predict potential risk points. The power of technology greatly enhances the efficiency and accuracy of post-construction quality evaluation. Post-construction quality evaluation and continuous improvement is not a static conclusion, but the beginning of a dynamic cycle. It requires targeted establishment of standards, flexible response to feedback, scientific planning of improvement measures, continuous enhancement of personnel competence, and appropriate use of technological means. Such "dynamic quality management" will serve as an inexhaustible driving force for improving the quality of university campus construction and an important guarantee for the future development of universities.

4. Conclusion

In general, quality serves as the lifeline of university infrastructure projects, and effective construction management combined with stringent quality control strategies is the key to ensuring the stability of this lifeline. While each project possesses its distinct characteristics, continuous practice, summarization, and innovation will constantly refine the quality management system, laying a solid foundation for the advancement of education. University infrastructure projects are not merely engineering endeavors; they embody the important role of education mission and social responsibility. Through the high-quality completion of these projects, not only will the school's physical facilities be enhanced, but it will also provide a safer, more comfortable, and intellectually stimulating learning and research environment for students and faculty.

References

- [1] Ruiqiu Y, Andrew G .Public opinion evaluation on social media platforms: a case study of High Speed 2 (HS2) rail infrastructure project.[J].UCL open. Environment,2023(1):63.
- [2] Luo T, Xue X ,Zhang M .Exploring Sustainable Operations Management in Major Infrastructure Projects: The Case of the Hong Kong-Zhuhai-Macao Bridge[J].Project Management Journal, 2024, 55(1):102-122.
- [3] Mashamba T ,Kanakana-Katumba G M ,Maladzi R .VARIATION ORDERS DURING EXECUTION OF CONSTRUCTION INFRASTRUCTURE PROJECTS: CASE STUDY OF AN ELECTRICITY COMPANY[J].South African Journal of Industrial Engineering,2023,34(4):86-90.
- [4] Johan N ,Rupesh Y .Megaproject and the city: Theorizing social media discourses across the lifecycle of an infrastructure project[J].City and Environment Interactions,2023(1):20.
- [5] Ding Q ,Huang S ,Fu G , et al.Investment analysis of the private firm under different financial arrangements in infrastructure projects.[J].PloS one,2024,19(2):e0287418.