Research on the Theoretical Collaborative Mechanism of Multi-Objective Management in Construction Engineering

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Abstract

This article focuses on the theoretical collaborative mechanism of multi-objective management in construction projects for research. This paper expounds the connotation and characteristics of multi-objective management in construction projects and analyzes the challenges such as complexity and uncertainty faced by multi-objective management. The significance of the theoretical collaboration mechanism in the multi-objective management of construction projects was deeply explored. From multiple dimensions such as the construction of the objective system, resource integration, information communication, and stakeholder coordination, the specific working modes of the theoretical collaboration mechanism were analyzed. It aims to provide theoretical support for enhancing the multi-objective management level of construction projects and promote the efficient and coordinated development of construction projects under multiple objectives such as quality, progress, cost and safety.

Key words: Construction engineering; Multi-objective management; Theoretical collaboration mechanism.

1. Introduction

With the acceleration of global urbanization, the scale of construction projects is constantly expanding, and their complexity is increasing day by day [1]. In modern construction projects, the expectations of project owners are no longer confined to the realization of a single goal, but rather they demand an optimal balance among multiple objectives such as quality, progress, cost, safety, and environmental protection [2]. For instance, the construction of a large commercial complex not only requires ensuring the safety of the building structure and the completeness of its usage functions (quality target), but also opening at the scheduled time to seize market opportunities (progress target), while controlling construction costs to ensure the economic benefits of the project (cost target), and abiding by relevant safety regulations during the construction process. To ensure the life safety of construction workers (safety objective), it is also necessary to meet environmental protection requirements and reduce the impact on the surrounding environment (environmental protection objective).

However, there are inherent conflicts and contradictions among the multiple objectives of construction projects. Improving the quality of engineering projects often requires increased investment, leading to rising costs. Speeding up the project progress may affect the construction quality and increase potential safety hazards. Strict environmental protection requirements may restrict the selection of construction techniques and materials, affecting progress and costs [3]. The traditional single-objective management model is no longer able to meet the demands of modern construction project management, and multi-objective management has become an inevitable trend.

2. The Connotation and Characteristics of Multi-objective Management in Construction Projects

2.1 Connotation

Multi-objective management in construction projects refers to a management approach that, throughout the entire life cycle of a construction project, comprehensively plans, organizes, coordinates and controls multiple objectives such as quality, progress, cost, safety and environmental protection, in order to maximize the overall benefits of the project [4]. It requires managers to take a systematic perspective, comprehensively consider the relationships among various goals, avoid blindly pursuing a single goal while neglecting others, and ensure that all goals achieve dynamic balance and coordinated development during the project implementation process.

At different stages of construction projects, the focus and content of multi-objective management also vary. During the project decision-making stage, the main focus is on determining the overall project goals and their respective sub-goals, conducting feasibility studies and scheme comparisons. During the design stage, various objectives should be integrated into the design plan for multi-objective optimization design. During the construction phase, construction management must be carried out strictly in accordance with the design requirements and the standards of each target, and any target conflict issues that arise during the construction process should be resolved in a timely manner. During the completion acceptance stage, a comprehensive assessment and acceptance of the realization of each objective should be conducted [5].

2.2 Features

2.2.1 Multi-purpose Nature

Construction engineering involves multiple objectives, which have different natures and requirements. Quality objectives are one of the core goals of construction projects. They focus on the performance and functional use of the engineering entity and directly affect the service life and safety of buildings. [6] The progress target emphasizes the timely delivery and use of the project. The cost target is to complete the project within the budget. The safety objective ensures the safety of personnel and property during the construction process. Environmental protection goals focus on reducing the negative impact on the environment. The various goals are both independent of each other and interrelated, with complex contradictions and unified relationships.

2.2.2 Complexity

Construction projects are large in scale, long in cycle, involve numerous participants, and involve complex technologies and processes. Multi-objective management requires coordinating the work among different specialties and departments, handling a large amount of information and data, and dealing with various uncertainties and risks. Therefore, it is highly complex [7].

2.2.3 Dynamics

During the implementation of construction projects, the status and requirements of various goals will also undergo dynamic changes due to the influence of changes in the internal and external environment. For instance, factors such as design changes, fluctuations in market prices, and natural disasters may all lead to adjustments in targets like schedule and cost. Multi-objective management requires timely adjustment of management strategies and methods in response to these changes to ensure the smooth realization of each objective.

3. Challenges Faced by Multi-objective Management in Construction Projects

3.1 Conflict and Coordination of Objectives

There are inherent conflicts among the various objectives of construction projects. For instance, enhancing the quality of engineering projects often requires increased investment, leading to rising costs. Speeding up the project progress may affect the construction quality and increase potential safety hazards. Strict environmental protection requirements may restrict the selection of construction techniques and materials, affecting progress and costs. How to find a balance point among these conflicting goals and achieve the collaborative optimization of each goal is the primary challenge faced by multi-objective management in construction projects.

3.2 Limited Resources and Multi-objective Demands

The resources required for construction projects include human, material and financial resources, etc., and these resources are limited. Multi-objective management requires simultaneously meeting the demands of multiple objectives such as quality, progress, and cost, which puts forward higher requirements for the allocation and utilization of resources. How to rationally allocate resources under limited resource conditions and ensure the realization of each goal is an important issue that needs to be addressed in multi-objective management of construction projects.

3.3 Poor Information Communication and Sharing

Construction projects involve multiple participants, such as the owner, design unit, construction unit, supervision unit, etc. There exist problems of information asymmetry and poor communication among these participants. The untimely transmission and inaccurate sharing of information can lead to decision-making mistakes, coordination difficulties, and

affect the effectiveness of multi-objective management. For instance, if design change information is not promptly conveyed to the construction unit, it may lead to construction errors and rework, increase costs and delay the schedule.

3.4 Coordination of Stakeholder Interests

There are numerous stakeholders in construction projects, including property owners, investors, contractors, suppliers, government regulatory authorities, etc. Each stakeholder has different interests and goals. In the process of multi-objective management, it is necessary to coordinate interest relationships among various stakeholders, ensure that the interests of all parties are reasonably met, and avoid project progress being hindered due to conflicts of interest.

4. The Importance of Theoretical Synergy Mechanism in Multi-objective Management of Construction Projects

4.1 Promote the Coordinated Realization of the Goals

The theoretical coordination mechanism emphasizes starting from a systematic perspective, comprehensively considering the relationships among various goals, and promoting the coordinated realization of these goals by establishing an effective coordination mechanism. It can help managers pursue a single goal while taking into account the demands of other goals, avoid conflicts and contradictions among goals, and maximize the overall benefits of construction projects.

4.2 Optimize Resource Allocation

The theoretical collaborative mechanism can rationally allocate resources based on the importance and priority of each goal to ensure the efficient utilization of resources. Through the overall planning and coordinated allocation of resources, waste and idleness of resources can be avoided, the efficiency of resource utilization can be improved, and the needs of multi-objective management in construction projects can be met.

4.3 Strengthening Information Communication and Sharing

The theoretical collaboration mechanism emphasizes the establishment of smooth information communication channels to promote information exchange and sharing among all participants. Through timely and accurate information transmission, the scientific and rationality of decision-making can be enhanced, the coordination and cooperation ability among all participants can be strengthened, and problems and risks caused by poor information flow can be reduced.

4.4 Coordinate the Interests of Stakeholders

The theoretical coordination mechanism can fully consider the interest demands of all stakeholders. By establishing a fair and reasonable interest distribution mechanism and coordination mechanism, it can coordinate the interest relationships among all stakeholders. Under the premise of safeguarding the interests of all parties, promote cooperation and win-win results among all stakeholders, and create a favorable environment for the smooth implementation of multi-objective management in construction projects.

5. The Specific Mode of Action of the Collaborative Mechanism of Multi-objective Management Theory in Construction Projects

5.1 Synergy in the Construction of the Target System

During the initiation stage of a construction project, it is necessary to clarify the connotations and specific requirements of various goals such as quality, progress, cost, safety and environmental protection. Through thorough communication and consultation with all stakeholders, reasonable and feasible target values are determined to provide a clear direction and basis for multi-objective management. By applying the method of systems analysis, conduct in-depth research on the interrelationships among various goals, including mutual promotion and mutual restraint relationships. For instance, analyze the relationship between quality, progress and cost, identify the balance points and synergy points among them, and provide support for formulating a scientific and reasonable target system. Based on the connotations, requirements and interrelationships of each objective, establish a comprehensive objective system. Integrate each goal organically to form an interrelated and mutually supportive whole, ensuring that while pursuing a single goal, the realization of other goals is not compromised. For instance, when formulating a schedule, fully consider the requirements of quality and safety, and avoid neglecting quality and safety issues in the pursuit of meeting deadlines.

5.2 Resource Integration and Synergy

Conduct a comprehensive assessment of the human, material and financial resources required for construction projects, and analyze the quantity, quality and supply of these resources. In accordance with the requirements of multi-objective management, formulate reasonable resource planning, clarify the direction and focus of resource allocation, and ensure that resources can meet the needs of each objective. During the implementation of construction projects, resources should be dynamically allocated in a timely manner based on the actual progress of each target and changes in resource demands. When there is a shortage of resources for a certain goal, allocate resources from other relatively abundant goals to ensure the smooth progress of each goal. For instance, when the progress target is delayed, the input of human resources and equipment can be increased to accelerate the construction progress. Encourage all participants to share resources and improve the efficiency of resource utilization. For instance, construction units can share construction equipment and temporary facilities among themselves, reducing the repetitive purchase and waste of resources. At the same time, through the optimal allocation and rational utilization of resources, the cost of resources can be reduced, and the economic benefits of the project can be improved.

5.3 Information Communication and Collaboration

By leveraging modern information technology, a construction project information communication platform is established to achieve real-time information sharing and exchange among all participants. An information communication platform can include project management software, online collaboration tools, video conferencing systems, etc., providing convenient and efficient channels for information transmission. Establish clear information communication processes and norms and define the responsibilities and authorities of each participant in information communication. Specify the time nodes and methods for collecting, organizing, transmitting and feeding back information to ensure its timely and accurate transmission. For instance, the construction unit should regularly report information regarding the progress, quality and safety of the project to the supervision unit and the owner. The supervision unit should promptly review and provide feedback on the information. Conduct information communication training for the personnel of all participants to enhance their awareness and ability of information communication. The training content includes information communication skills, the use of information management software, etc., enabling all participants to master the methods and tools of information communication proficiently and ensuring the smooth progress of information communication.

5.4 Stakeholder Coordination and Synergy

Conduct a comprehensive identification of the stakeholders in construction projects, including property owners, investors, contractors, suppliers, government regulatory authorities, and surrounding residents, etc. Analyze the interests and influences of each stakeholder to provide a basis for formulating coordination strategies. Establish a fair and reasonable interest coordination mechanism, and coordinate interest relations among all stakeholders through consultation, negotiation and other means. For instance, during the project bidding stage, the rights and obligations of each participant should be clearly defined, and the contract price and the way of benefit distribution should be reasonably determined. During the project implementation process, disputes over interests among various stakeholders should be resolved in a timely manner to ensure the smooth progress of the project. Strengthen cooperation and communication among all stakeholders by establishing partnerships, launching cooperative projects and other means. Promote trust and understanding among all stakeholders and create a win-win situation of cooperation. For instance, the owner can establish a long-term and stable cooperative relationship with the construction unit, jointly carry out technological and management innovations, and enhance the overall benefits of the project.

6. Conclusion

Multi-objective management in construction projects is a complex and systematic undertaking, confronted with numerous challenges such as objective conflicts, limited resources, poor information communication, and the coordination of stakeholders' interests. The theoretical collaboration mechanism, as an effective management concept and method, plays a significant role in the multi-objective management of construction projects. Through the roles of collaborative construction of the target system, collaborative integration of resources, collaborative information communication, and collaborative coordination among stakeholders, it can promote the collaborative realization of various goals in construction projects, optimize resource allocation, enhance information communication and sharing, coordinate the interests of stakeholders, and improve the overall efficiency of multi-objective management in construction projects. In the actual management of construction projects, the significance of the theoretical collaboration mechanism should be fully recognized. The methods and means of the theoretical collaboration mechanism should be actively applied to continuously improve the multi-objective management system and promote the sustainable development of the construction project

industry. Meanwhile, future research can further delve into the application and optimization of theoretical collaborative mechanisms in different types of construction projects, providing more specific and practical guidance for multi-objective management in construction projects.

REFERENCES

[1] Campbell, L. (2025). Multi-Objective Cost-Time Trade-Off Analysis for Sustainable and Resilient Project Delivery under Uncertainty in Construction Management.
[2] Alothaimeen, I., & Arditi, D. (2019). Overview of multi-objective optimization approaches in construction project management. In Multicriteria optimization-Pareto-optimality and Threshold-optimality. IntechOpen.
[3] Shikhrobat, M. B., Kabiri, S., & Flanagan, R. (2019). Project planning and scheduling using system dynamics for dealing with complexity on construction projects. In THIRTY-FIFTH ANNUAL CONFERENCE (p. 689).
[4] Wang, J., Huang, Z., & Song, Y. (2025). Intelligent planning of safe and economical construction sites: Theory and practice of hybrid multi objective decision making. Frontiers of Engineering Management, 12(3), 487-509.
[5] Essam, N., Khodeir, L., & Fathy, F. (2023). Approaches for BIM-based multi-objective optimization in construction scheduling. Ain Shams Engineering Journal, 14(6), 102114.
[6] Wan, S. K., Kumaraswamy, M., & Liu, D. T. (2013). Dynamic modelling of building services projects: A simulation model for real-life projects in the Hong Kong construction industry. Mathematical and Computer Modelling, 57(9-10), 2054-2066.
[7] Zhan, Z., Hu, Y., Xia, P., & Ding, J. (2024). Multi-objective optimization in construction project management based on NSGA-III: pareto front development and decision-making. Buildings, 14(7), 2112.