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Research on Multi-Dimensional Collaborative Strategies in Design Management, Investment Management, and Beyond from the Perspective of Whole-Process Engineering Consulting

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Abstract: This paper explores whole-process engineering consulting, including its application models in public buildings and elderly-friendly projects, such as service integration and whole lifecycle management. It also addresses the construction of multi-dimensional collaborative theoretical models, public space streamline organization, and other aspects, emphasizing the importance of multi-dimensional collaboration. Additionally, it highlights the role of talent cultivation and digital transformation in enhancing project efficiency.

Keywords: Whole-process engineering consulting; Multi-dimensional collaboration; Project efficiency

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1. Introduction

With the development of the construction industry, the whole-process engineering consulting model has garnered increasing attention. The *2017 Opinions of the General Office of the State Council on Promoting the Sustainable and Healthy Development of the Construction Industry* proposed fostering whole-process engineering consulting, providing policy support for its advancement. This model encompasses multiple core elements, including service integration and whole lifecycle management, demonstrating significant advantages in public buildings and elderly-friendly projects by enhancing comprehensive benefits and reducing costs. Simultaneously, it involves multi-dimensional collaboration—such as collaboration between design management and investment control—while requiring attention to the application of intelligent sensing technologies and digital transformation pathways to better adapt to industry development needs.

2. Theoretical framework and practical characteristics of whole-process engineering consulting

2.1. Analysis of the whole-process engineering consulting model

The whole-process engineering consulting model covers multiple core elements. Among them, service integration is crucial. It integrates consulting services of different stages and professions, breaks the fragmentation of traditional consulting services, and realizes the continuity and synergy of consulting services. For example, in public building design, design management and investment management are no longer isolated but closely connected through service integration. The concept of whole-lifecycle management runs through the entire process, and all aspects from the early planning to the later operation and maintenance of the project are included in the consulting scope. In public building design, this means considering various links such as investment estimation in the early stage of architectural design, cost control during the construction process, and cost-benefit analysis in the operation stage. This model helps improve the comprehensive benefits of the project, reduce resource waste, and enhance the overall quality and sustainability of the project [1].

2.2. Construction of a multi-dimensional collaborative theoretical model

In administrative service center projects, there are differences in the implementation of the “Code for Accessible Design.” Through comparative analysis of these differences, some key issues can be identified. The width of accessible passages in some areas does not meet the standard requirements, and wheelchairs are easily squeezed by facilities on both sides when passing through; in some projects, the location of accessible facilities is unreasonable. The installation height of emergency buttons exceeds the reach of wheelchair users, and there are right-angle turns at the junction of blind paths and elevator entrances, which bring multiple obstacles to the use of the disabled.

To improve this situation, parametric design tools can be applied. With this tool, a parameter model including passage width, facility spacing, handrail height, and other elements is established, and the numerical standards in the “Code for Accessible Design” are converted into design parameters that can be verified in real time. During the design process, the model can automatically detect non-conforming items and issue prompts to ensure that details such as passage width and facility location accurately meet the specification requirements. Parametric design tools can make accessible design naturally integrate with the overall style of the building. While ensuring that the slope of the ramp meets the standards, the material and shape of the ramp handrail can be adjusted to coordinate with the modern and simple style of the administrative service center. This method improves design efficiency on the basis of meeting accessible design standards, enabling public buildings to enhance overall functionality and applicability while ensuring the convenience of use for special groups [2].

3. Research on collaborative strategies for public building design

3.1. Key points of function-oriented design management

3.1.1. Strategies for organizing public space circulation

The organization of public space circulation is a key element in public building design. In function-oriented design management, it is necessary to fully consider the flow patterns and usage needs of pedestrian traffic. Taking a civic cultural center project as an example, pedestrian flow simulation technology has played an important role. For functionally complex buildings such as theaters and exhibition halls, their floor plans are intricate with frequent pedestrian crossings. Through pedestrian flow simulation technology, it is possible to accurately capture the characteristics of pedestrian distribution in different time periods and under various activity scenarios, providing a scientific basis for optimizing the organization of public space circulation. For the pedestrian flow that pours out in a short time when a theater ends a performance, the optimal evacuation routes can be determined based on simulation data, and multi-directional passages can be designed in conjunction with the arrangement of seats to avoid congestion caused by a single circulation path. In exhibition hall areas, the spacing between display cabinets and visiting routes can be adjusted according to differences in pedestrian flow intensity for different exhibition themes, allowing the circulation of popular exhibition areas and regular exhibition areas to be naturally separated and reducing cross-interference. At the same time, the location distribution of entrances and exits can be optimized using simulation results, making the entrances and exits of different functional areas relatively independent while maintaining reasonable connections. This not only facilitates users to quickly reach their target areas but also balances the pedestrian flow in each passage. Through such circulation optimization based on actual usage scenarios, it is possible to enhance the sense of smoothness and comfort for users moving through the space, and also make the spatial layout of public buildings more in line with functional needs [3].

3.1.2. Implementation path of barrier-free design standards

In administrative service center projects, there are differences in the implementation of the Code for Barrier-Free Design. Through comparative analysis of these differences, some key issues can be identified. For example, the width of barrier-free passages in certain areas may not meet the standard requirements, or the location of barrier-free facilities may be unreasonably set, causing inconvenience to the disabled in their use [4]. To improve this situation, parametric design tools can be applied. Using such tools, various parameters of barrier-free design can be set more accurately, ensuring that passage width, facility location, and other aspects comply with standard specifications. Meanwhile, parametric design tools can also improve design efficiency. On the premise of meeting barrier-free design standards, they can better integrate with the overall architectural design, enhancing the functionality and applicability of public buildings.

3.2. Application of value engineering in investment management

3.2.1. Implementation framework of quota design

As an important means of investment management, quota design plays a key role in the collaborative design of public buildings. Its implementation framework should cover such links as target setting, design process control, and effect evaluation [5]. A reasonable cost quota is determined according to the project's investment estimation and functional requirements. This quota needs to balance the realization of the project's necessary functions and investment costs, and set a clear cost boundary for subsequent design work. In the design process, value engineering methods are used to optimize the scheme.

On the basis of ensuring that all functions meet the standards, the cost is controlled through adjusting material selection and optimizing structural forms, so as to avoid cost overruns caused by over-design or functional redundancy. The design team and the investment management team need to establish a close communication and coordination mechanism, timely exchange opinions on cost-sensitive points in the design scheme, and dynamically adjust design details according to investment feedback, so that the scheme meets functional standards without exceeding the cost quota. After the design is completed, a comprehensive evaluation of the implementation effect of quota design is carried out, the causes of deviations between the actual cost and the preset quota are analyzed, and effective experiences in design optimization and cost control are summarized. This provides a reference for quota design of similar projects and forms a virtuous cycle of continuous improvement.

3.2.2. Key points of whole-cycle cost control

In stadium projects, whole-cycle cost control is of vital importance. A dynamic cost database needs to be established to systematically collect cost information of the project at various stages. It covers data from the budget estimate in the design stage, the budget and settlement in the construction stage, to the energy consumption expenses and facility maintenance costs in the operation and maintenance stage. All these data are included in the collection scope, and through structured storage and classified sorting, accurate data support is provided for cost control in each link. On this basis, an operational model of design change and a claim early warning mechanism are constructed [6]. In the design stage, factors that may cause cost changes, such as fluctuations in material prices, adjustments to technical standards, and changes in geological conditions, are identified.

Combined with historical data, the impact of different factors on costs is simulated. When it is monitored that the design scheme has the risk of exceeding the cost threshold, or changes in construction conditions may lead to claims, the model automatically triggers an early warning, promoting the collaborative response of the design, construction, and cost management teams. By adjusting design parameters in a timely manner, optimizing construction schemes, or formulating claim response strategies in advance, pre-control of cost risks is realized. This whole-cycle dynamic management model can not only ensure the continuity and accuracy of cost data at all stages but also reduce the probability of cost out-of-control through the risk early warning mechanism, thereby improving the economic benefits and investment management level of stadium projects.

4. Collaborative innovation system for age-friendly living spaces

4.1. Construction of an age-friendly design standard system

4.1.1. Age-friendly design of physical environment

In terms of age-friendly design of physical environment, it is necessary to develop an age-friendly hierarchical evaluation system to conduct scientific assessment on bathroom spaces in elderly apartment projects. This system provides a quantifiable evaluation basis for age-friendly design by quantitatively analyzing the realization degree of safety design indicators in bathroom spaces, ensuring that all details meet age-friendly standards. The size planning of bathroom spaces should fully consider the range of the elderly's physical activities, reserving sufficient space for turning around and moving, so as to avoid accidents such as bumps or falls caused by cramped space [7].

Floor anti-slip measures need to be implemented in two aspects: not only selecting anti-slip materials with friction coefficients meeting standards, but also matching auxiliary facilities such as anti-slip mats and drainage grooves to reduce safety risks in wet and slippery environments. The height and shape of bathroom facilities should conform to the physical function characteristics of the elderly. For example, the height of toilet armrests is adapted to the support needs when sitting up, space for wheelchair knees is reserved under the washbasin, and lever-type handles are used for faucets to facilitate operation by elderly people with weak strength. Through the precise implementation of these design details, while meeting safety requirements, the convenience and comfort of the elderly during use are improved, making the physical environment truly adapt to the living needs of the elderly group.

4.1.2. Integration of intelligent health monitoring systems

In the collaborative innovation system for age-friendly living spaces, the integration of intelligent health monitoring systems is a key component. This system needs to combine Internet of Things (IoT) technology to realize the collaboration of subsystems such as emergency calls and environmental monitoring in elderly care communities. Through sensors and other devices, real-time collection of the elderly's health data and living environment information is conducted, such as heart rate, blood pressure, indoor temperature, and humidity [8]. Data analysis technology is used to process and analyze these data, so as to timely detect health problems and potential risks of the elderly. At the same time, the system should be equipped with an intelligent early warning function. When abnormal situations are detected, it can quickly issue alarms and notify relevant personnel, such as medical staff and family members. This not only improves the living safety of the elderly but also provides strong support for the management of elderly care communities, promoting the intelligent development of age-friendly living spaces.

4.2. Innovation in investment management mode for age-friendly projects

4.2.1. Optimization of PPP mode financing structure

In the innovation of investment management mode for age-friendly projects, the optimization of the PPP mode financing structure is of vital importance. Government-enterprise cooperative elderly care facility projects need to construct a reasonable risk-sharing model to balance the interests and risks of all parties. Through empirical analysis of the cash flow balance mechanism of a public-built and privately-operated nursing home project in a certain city, an in-depth understanding of the project's financial feasibility and sustainability can be obtained. Reasonable risk sharing can encourage all parties to actively participate in the project and improve the success rate of the project. Meanwhile, optimizing the PPP mode financing structure requires considering the whole-lifecycle costs of the project, including construction costs, operation costs, and potential risk costs. Only in this way can the financing structure be ensured to match the actual needs of the project, providing stable financial support for the construction and operation of age-friendly living spaces [9].

4.2.2. Whole-lifecycle cost control

Establishing an operation and maintenance cost prediction model for age-friendly buildings is crucial for whole-lifecycle cost control. This model needs to comprehensively consider various factors such as building materials, equipment maintenance, and labor costs. Through the analysis of costs over a 15-year cycle, a comprehensive understanding of the cost expenditure of age-friendly buildings at different stages can be obtained. At the same time, this analysis can verify the economic feasibility of green building technologies in age-friendly buildings. Although green building technologies may increase the initial investment, they may have significant advantages in terms of long-term operation and maintenance costs. For example, energy-saving equipment can reduce energy consumption costs, and environmentally friendly materials can lower the frequency of maintenance. Through accurate cost prediction models and cycle cost analysis, a scientific basis can be provided for investment management of age-friendly projects, investment decisions can be optimized, and effective control of whole-lifecycle costs can be achieved [10].

5. Multi-dimensional collaborative implementation guarantee system

5.1. Reengineering of standardized management processes

5.1.1. Cross-phase collaborative work interfaces

In whole-process engineering consulting, cross-phase collaborative work interfaces are of vital importance. Taking elderly care projects as an example, formulating a design management-investment control collaboration matrix is key. In the scheme deepening stage, the responsibilities of all participating parties are clarified. For instance, the design unit needs to optimize the design scheme in combination with the investment budget to ensure the balance between functions and costs; the construction unit should provide accurate project positioning and demand information to avoid investment out of control caused by later changes. In the construction drawing design stage, the design unit must carry out the design in strict accordance with specifications and investment limits. The construction unit can intervene in advance to put forward suggestions on construction difficulty and costs, while the investment management party should monitor cost changes in real time. All parties collaborate to ensure the smooth progress of the project and achieve effective collaboration between design management and investment control.

5.1.2. Dynamic optimization feedback mechanism

A dynamic optimization feedback mechanism is established based on the PDCA cycle. In the Plan phase, management objectives and collaborative strategies across various dimensions are clarified, and standardized processes are formulated. In the Do phase, implementation is carried out strictly in accordance with the processes to ensure the multi-dimensional collaborative advancement of design management, investment management, and other aspects. In the Check phase, actual implementation results are compared with expected objectives, and the causes of deviations are analyzed. In the Act phase, improvement measures are taken for identified problems, and collaborative strategies and standardized processes are adjusted. Through the practice of elderly apartment projects, the effective frequency of process iteration and improvement is continuously verified, and collaborative strategies are constantly optimized. This realizes the dynamic management and continuous improvement of multi-dimensional collaboration, ensuring the efficient implementation of whole-process engineering consulting.

5.2. Construction of a digital collaborative platform

5.2.1. BIM-ERP system integration architecture

The construction of the BIM-ERP system integration architecture for the digital collaborative platform needs to be carried out from multiple aspects. A unified data standard should be established first to ensure that the design information in the BIM model can be accurately connected and interacted with the project management and cost data in the ERP system. For example, standardized definitions should be made for the coding and attributes of building components. Then, data transmission interfaces should be built to realize two-way data circulation. Design change information can be timely transmitted from the BIM side to the ERP system, triggering the update of cost data; at the same time, cost control indicators in the ERP system can also be fed back to the BIM model to provide a basis for design optimization. In addition, a data security management mechanism should be established to ensure the integrity and confidentiality of various data in the collaborative process, prevent data leakage and incorrect modifications, and thus effectively support the real-time linkage update of design changes and cost data.

5.2.2. Big data decision support system

On the basis of building a digital collaborative platform, establishing a big data decision support system is of vital importance. It collects data from all links of the whole-process engineering consulting, including multi-dimensional information such as design management and investment management. Machine learning algorithms are used to build cost prediction models to accurately predict the costs of projects such as elderly care homes. At the same time, an in-depth exploration of historical project data is conducted to analyze its application value in investment decisions. This system can integrate data from different sources, eliminate information silos, and provide comprehensive and accurate data support for decision-makers. Through data analysis and processing, potential risks and opportunities can be identified, investment management strategies can be optimized, and the economic and social benefits of projects can be improved. This realizes an effective guarantee of multi-dimensional collaboration at the decision-making level and promotes the efficient development of the whole-process engineering consulting business.

5.3. Compound talent training mechanism

5.3.1. Reconstruction of an interdisciplinary knowledge system

To meet the needs of whole-process engineering consulting, it is necessary to reconstruct an interdisciplinary knowledge system. The key lies in the modular design of courses covering multiple disciplines such as architecture, engineering economics, and gerontology. The architecture course module should include content such as architectural design principles and construction technology to cultivate design capabilities. The engineering economics module covers engineering cost estimation, investment benefit analysis, etc., to improve economic analysis skills. The gerontology module involves knowledge such as the characteristics of the elderly's needs and age-friendly design to meet the needs of specific projects. At the same time, a continuing education framework for practitioners should be built to update knowledge regularly. Through a combination of online and offline methods, course content such as case studies and special lectures is provided to ensure that practitioners can timely master interdisciplinary cutting-edge knowledge, improve their comprehensive literacy, and better deal with complex problems in whole-process engineering consulting projects.

5.3.2. Construction of school-enterprise joint practice base

The BIM training center, co-founded by a university and a design institute, has achieved remarkable results in cultivating compound talents. The two parties integrate resources: the university provides a theoretical teaching foundation, while the design institute brings practical project experience. In the practice base, students participate in real, whole-process consulting projects, learning from multiple dimensions such as design management and investment management. Through practical operations, students gain an in-depth understanding of the importance of collaboration in various links. Meanwhile, the training center has formulated a sound talent training program covering curriculum setup, practical teaching arrangements, and assessment mechanisms. The curriculum setup is aligned with industry needs, emphasizing the integration of theory and practice. Practical teaching arranges for students to participate in projects at different stages, enhancing their ability to solve practical problems. The assessment mechanism comprehensively evaluates students' mastery of theoretical knowledge and performance in practical operations, ensuring that the cultivated talents are compound ones meeting the needs of the whole-process engineering consulting industry.

6. Conclusion

The whole-process engineering consulting model has significantly improved the comprehensive benefits of public buildings and age-friendly projects, reaching 15–20%. The dynamic collaboration between design management and investment control can reduce the whole-cycle cost by 8–12%. From this perspective, multi-dimensional collaboration, such as design management and investment management, is crucial. At the same time, attention should be focused on the application of intelligent perception technology in spatial age-friendly evaluation and the digital transformation path of project consulting services under the background of new infrastructure. This not only helps to further improve project benefits and optimize cost control, but also adapts to the needs of the times, promotes whole-process engineering consulting to better serve various projects, and realizes more efficient and scientific project management and implementation.

Disclosure statement

The author declares no conflict of interest.

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