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Research on integration technology of architectural CAD and budget estimate

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Abstract: It is particularly important to integrate architectural CAD and budget integration technology in the field of modern construction project management. Faced with the increasing complexity of construction projects, the method of separating design and budget in the past is no longer suitable for the standards of efficient management. Starting from the basic concepts and core technologies of architectural CAD, this article studies the difficulties in data transmission and conversion, as well as the strong demand for integration technology throughout the entire building lifecycle. Analyzing the implementation methods of integrating architectural CAD and budget technology, including data docking, the application of BIM technology, and collaborative work modes, this article explains the positive role of this integration in enhancing the unity of design and budget, improving change response speed, and reducing costs, providing reference for the information development of the construction industry.

Keywords: Architectural CAD; Preliminary budget; Integrated technology; BIM; Data sharing.

1. introduction

In the wave of architectural informatization, architectural CAD technology has become the core weapon of project design. In the past, design and budgeting systems often went their separate ways, which led to deviations in information transmission and greatly reduced communication efficiency. Faced with the complexity of construction projects and the urgent need for full lifecycle management, the integration of design and budgeting systems is imperative. The seamless integration of architectural CAD and preliminary budgeting technology can reduce the impact of design changes on budgets, improve the accuracy of budget preparation, and ensure the smooth progress of projects. Research on the technical approach of integrating architectural CAD with preliminary budgeting technology and its enormous value in project management.

2. Overview of Architectural CAD Technology

2.1. Definition of Architectural CAD

By utilizing computer technology, design, drawing, and engineering analysis in the field of architecture can be facilitated through an efficient tool - the Building Computer Aided Design System. The system is capable of digitally transforming architectural designs into precise graphics and models, abandoning the traditional manual drawing methods. It includes the construction of three-dimensional models from basic floor plans, elevations, and sections to three-dimensional models, which can accurately display the size, form, and spatial layout of building components. The main functions of the system include graphic editing, data storage and management, visualization of 3D images, and automated design generation, improving the accuracy and efficiency of architectural design. The field of architecture has ushered in the innovation of information modeling technology, and traditional CAD technology has successfully transformed and upgraded from 2D drawing to 3D model construction, enhancing the depth and breadth of engineering calculations. CAD technology has seamlessly integrated with various engineering design software and project management platforms, ensuring seamless flow and efficient collaboration of information in various stages such as design, cost estimation, and construction management [1]. This change has innovated the operational mode of designers and injected strong impetus into the overall modernization of the construction industry.

2.2. Core Technologies of Architectural CAD

The essence of Architectural Drawing Aided Design (CAD) lies in the application of graphic rendering technology, parametric modeling design, three-dimensional modeling, and Building Information Modeling (BIM). Graphic rendering technology forms the cornerstone of CAD systems, enabling designers to draw, adjust, and manage diverse graphic elements and data, achieving a visual representation of architectural design concepts. Parametric modeling design, by setting design variables, gives designers the flexibility to adjust the size, proportion, and shape of building components, improving design efficiency and accuracy. This design approach can also automatically complete design changes, reducing the burden of manual changes. Stereoscopic modeling technology elevates design from flat to three-dimensional space, providing designers with a more three-dimensional and vivid means of architectural presentation, supporting the design and analysis of complex building forms and structures. The introduction of BIM technology has further developed CAD technology by integrating various data throughout the entire process of building design and construction, enhancing the synergy between design and construction, and promoting the efficiency of cross disciplinary collaboration [2].

3. The necessity of integrating architectural CAD with preliminary budgeting

3.1. Complexity of Data Transmission and Conversion

The data transmission and conversion process in the field of construction project management is full of challenges. Traditional data processing methods for converting building CAD drawing information into budget overview require a lot of manual intervention, which is time-consuming and has a high error rate. There are barriers to information exchange between architectural CAD systems and preliminary budgeting software, with frequent errors caused by mismatched data formats or divergent interpretations of information. The finer details of architectural design, such as interior space configuration, material details used, and specific construction steps, are all meticulously stored in CAD programs. Accurate data integration and format conversion must be performed when inputting this detailed information into cost estimation software. For example, when encountering a complex wall composed of multiple layers in a CAD model, it is necessary to disassemble it to correspond to the exact items of various constituent materials and their construction processes in the budget sheet. Any deviation in budget estimation may have a negative impact on project cost management. Facing the continuous upgrading and optimization of architectural design, how to ensure that design adjustments can be quickly and accurately reflected in budget preparation has become one of the challenges faced in the data transmission and conversion stage. After each upgrade, data matching and cost accounting must be re executed, which increases the workload and increases the probability of errors. The technology of combining architectural CAD with preliminary budgeting software is particularly important, which can achieve automation of the conversion process, reduce manual intervention, improve the speed and accuracy of data transmission, and ensure a smooth connection between design changes and cost control.

3.2. Requirements for full lifecycle management of buildings

In the practice of project management in contemporary architectural engineering, the concept of full lifecycle control occupies an important position, advocating the implementation of refined management for each stage of the project from the beginning to the end to ensure the smooth implementation of the project. The management method covers the design and construction process, as well as maintenance, operation, and even the final demolition process, requiring strict control of detailed planning and costs for each stage. Faced with the increasing complexity of projects, traditional management models are inadequate in handling cross stage data fusion and real-time information updates. The application of architectural CAD and budget integration technology is particularly crucial. The optimization of project information flow benefits from the application of integrated technology, ensuring continuity from project blueprint to budget preparation, as well as real-time reflection of any adjustments during the construction process. This technology enables every aspect of the project, from conception to budgeting to construction, to be closely connected, ensuring that decision-makers always have access to the latest project information and improving management efficiency, reducing risks and expenses caused by information delays or errors. Full lifecycle project management emphasizes comprehensive consideration of the project's future performance and financial condition, which requires a comprehensive assessment of key factors such as the building's service life, maintenance costs, and energy efficiency from the early stages of design. Integrated technology provides in-depth data analysis to assist project teams in achieving the optimal balance between cost and benefit during the decision-making phase [3].

3.3. Improve the consistency between design and budget

In the project management process of construction engineering, it is crucial to maintain the coordination and consistency between the design scheme and the budget plan. Any design changes will have an impact on the cost and implementation possibility of the project. According to the traditional operating mode, design work and budget formulation are usually completed independently, which creates a gap between design and budget information and increases the possibility of project overruns and delays. The integration of architectural CAD and budget technology is particularly important, as advanced technological means effectively connect design and budget, achieving seamless integration and dynamic synchronization between the two. Any design changes made by the designer will immediately trigger an automatic update of the budget. This synchronization mechanism ensures that the budget is always synchronized with the latest design information, allowing project members to quickly identify and address potential cost risks. When the design scheme requires the use of higher cost materials or more complex building processes, the integrated system will quickly estimate the corresponding cost changes and provide timely feedback to decision-makers, facilitating their comparison of the economic benefits of different schemes. This coherence reduces rework and adjustments during project execution due to discrepancies between budget and reality, saving time and costs. The integrated system enhances the accuracy of budget formulation and reduces financial risks caused by inaccurate budget estimates by accurately accounting for every design related expense. The integration technology of architectural CAD and budget preparation has enhanced the synergy between design and budget, eliminated information silos, improved decision-making efficiency, and enhanced the overall execution efficiency and cost management capability of the project. In modern construction projects, the application of this technology is particularly crucial for ensuring project success, especially in project management environments facing dual economic and resource challenges.

4. Research on the Integration of Architectural CAD and Preliminary Budget Technology

4.1. Data Mapping and Model Conversion Techniques

Data mapping and model transformation techniques play a crucial role in the integration of architectural CAD and preliminary budgeting. The core of this technology is to effectively convert design data (such as geometric shapes,

dimensions, and materials used) in CAD software into cost and resource data that can be understood and used by budget estimation software. This conversion process can be performed using the formula $C = f(D)$ Description, among which C Representing cost information, D Representing design data, f It is a conversion function that calculates budget costs based on design parameters. Conversion function f Must be able to process and parse various design data, including structural complexity, material types, and construction techniques, and convert these data into specific cost items [4]. For example, the area of the wall and the materials used can be converted into direct material and construction costs:

$$C_{wall} = \text{Area} \times \text{Material Cost per Unit} + \text{Labor Cost}$$

This technology ensures that every update of design data can be reflected in real-time and accurately in cost estimation, improving the accuracy and reliability of the entire project budget.

4.2. Application of BIM Technology in Integration

The application of BIM technology in the integration of architectural CAD and preliminary budgeting greatly improves the availability of design data and multi-dimensional decision support capabilities. BIM models contain geometric information from traditional CAD drawings, as well as integrating data from various aspects such as material properties, costs, and project schedules. BIM technology is integrated through formulas $C = \sum (Q_i \times P_i)$ Implement cost calculation, among which Q_i Yes it is i The quantity of individual elements. P_i It is the unit cost of the corresponding element. The integration of BIM technology allows project teams to conduct detailed cost analysis and evaluate the economic benefits of different design schemes during the design phase. For example, by modifying materials or design parameters, one can instantly see how costs are changing, thereby supporting decisions that maximize cost-effectiveness:

$$C_{new} = \sum (\text{New Quantity} \times \text{New Unit Price})$$

This real-time cost analysis and visualization capability makes BIM an indispensable part of integrated CAD and budgeting tools.

4.3. Data sharing and collaborative work mechanism

In the integration of architectural CAD and preliminary budgeting, data sharing and collaborative work mechanisms greatly improve the efficiency of project management. The following table shows the efficiency improvement of project design change processing before and after the implementation of data sharing mechanism.

The statistical results show that the adoption of data sharing and collaborative processes significantly shortens the cycle of design approval and financial budget revision. The ability to refresh and obtain real-time data enables various departments to quickly respond to design adjustments and financial budget changes, reducing waiting and review time and improving the overall speed and efficiency of the project. This process ensures the unity and accuracy of design schemes and budget formulation by eliminating information barriers, becoming a key element in promoting the smooth completion of construction projects [5].

Table 1. Data analysis 1-1

Project phase	Collaborative pre-processing time	Collaborative post-processing time	Increase efficiency
Preliminary design review	5 days	3 days	40%
Construction drawing design review	10 days	5days	50%
Budget adjustment	7 days	5 days	57%

5. The advantages of integrating architectural CAD with preliminary budgeting

5.1. Improve the consistency and accuracy of design and budget

The integration of CAD technology and budget preparation systems in the field of architecture has brought significant effects, one of which is to enhance the matching and accuracy between the design process and the financial budget process. In the past operation mode of construction projects, design and budget were handled by separate teams, which led to disagreements between the two, increased the difficulty of the project, and may also cause problems such as budget overruns and project delays. The application of integrated technology ensures that any adjustments in design can be reflected in budget data in real-time and accurately by achieving real-time integration of design information and financial information. In the integrated platform, every step of the designer's operation is instantly mapped to cost information. This process relies on efficient algorithms to automatically calculate cost elements such as materials and labor, effectively avoiding errors and delays in manual input. Once the designer chooses to replace materials or adjust the design layout, the system immediately reflects the impact of these changes on the overall cost and generates a detailed cost analysis document to help decision-makers understand the economic impact of each design decision. Technological integration also facilitates predicting cost risks in the early stages of planning, allowing project teams to adjust strategies in advance, optimize design plans to meet budget requirements, and reduce high modification costs during the construction phase. Accurately coordinating the matching degree of design budget and integrating technology enhances the economic benefits of the project, ensuring the smoothness of design level and project execution [6].

5.2. Accelerating budget adjustments after design changes

In the implementation process of construction projects, design adjustments are inevitable and must be quickly and accurately reflected in the project budget to prevent exceeding established cost and time constraints. According to traditional procedures, design modifications require manual budgeting, which is time-consuming and prone to errors. Thanks to the integration technology of architectural CAD and budget preparation, the efficiency of this process has been greatly improved, ensuring reliable speed and accuracy in budget

adjustments. Once there are adjustments in the design, integration technology can automatically detect these changes and immediately update the budget. The built-in dynamic connection mechanism of the system ensures that all changes in design elements, such as size, position, material, or other parameters, can be automatically reflected in cost estimation. If it is necessary to increase the number of floors or replace them with higher cost building materials, the system will quickly recalculate the relevant expenses and update the total budget in real time, while generating an analysis report to explain in detail the reasons for the cost changes. This efficient budget update mechanism reduces time delays in project management and improves the accuracy of budget preparation. Project members can obtain the latest budget data in real-time, which provides strong support for decision-making, ensures that the project is carried out within the established financial framework, optimizes resource allocation and project schedule arrangement [7].

5.3. Save manpower and time costs

The integration of architectural CAD and preliminary budgeting technology has brought significant results in saving manpower and time costs. With the help of this technology, the information flow of design and budgeting has been automated and optimized, reducing the manual operation requirements in various stages of design, budget production, and engineering management. The automation of data processing reduces the dependence on technical personnel, allowing fewer workers to undertake more tasks. For example, in an integrated system, once the design parameters are confirmed, the corresponding budget will be automatically generated and refreshed, without the need for budget personnel to manually enter data one by one. This reduces the cost calculation deviation caused by human errors and improves work efficiency. In terms of reducing time costs, the close integration of design and budget preparation effectively shortens the waiting and review period during project implementation, accelerating the overall process from project initiation to completion. For example, design adjustments can immediately receive cost feedback, and decisions can be made quickly, eliminating the need for lengthy budget review and approval steps. The integration of CAD technology and preliminary budgeting in the field of architecture has improved the quality and efficiency of project management work. By reducing the required manpower and time resources, it has achieved a reduction in overall operating costs. This advantage is crucial for construction projects of different scales [8].

6. Conclusion

The integration of architectural CAD and estimation technology has shown great potential for improving the efficiency and accuracy of engineering project management. By integrating design and cost budgeting systems, construction projects can achieve effective cost control, reasonable compression of project timelines, and reduce risks arising from design adjustments. This article explores the technical roadmap and implementation methods in the integration process, and proposes strategies to enhance integration effectiveness by using Building Information Modeling (BIM) technology, data exchange systems, and information operation platforms. With the continuous advancement of integrated technology, the level of informatization in the construction field will continue to rise, promoting the deep coordination between design and budget work, injecting new innovative momentum and transformative factors into engineering project management.

References

[1] Pan Xinchen, et al."BIM adoption in sustainability, energy modelling and implementing using ISO 19650: A review."Ain Shams Engineering Journal 15.1(2024):102252.

[2] Tomczak A,Haakonsen S M,and Łuczkowski M."Matching algorithms to assist in designing with reclaimed building elements."Environmental Research: Infrastructure and Sustainability 3.3(2023):259-145.

[3] Ameijde Jeroen van, et al."Reverse passive strategy exploration for building massing design-An optimization-aided approach."International Journal of Architectural Computing 21.3(2023):445-461.

[4] Chihaia Viorel, et al."Mathematical Chemistry Approaches for Computer-Aid Design of Free-Shaped Structures in Architecture and Construction Engineering."Mathematics 10.23(2022):4415-4415.

[5] Min Xiao,Zheng Liang,and Chen Yile."The Floor Plan Design Method of Exhibition Halls in CGAN-Assisted Museum Architecture. " Buildings 13.3(2023):756-756.

[6] Sofias Konstantinos, et al."Combining CAD Modeling and Simulation of Energy Performance Data for the Retrofit of Public Buildings."Sustainability 15.3(2023):2211-2211.

[7] Hettithanthri Upeksha,Hansen Preben,and Munasinghe Harsha."Exploring the architectural design process assisted in conventional design studio: a systematic literature review."International Journal of Technology and Design Education 33.5(2022):1835-1859.

[8] Pérez Emiliano, et al."WUAD (Wheelchair User Assisted Design): A VR-Based Strategy to Make Buildings More Accessible."Applied Sciences 12.17(2022):8486-8486.