Research and Discussion on Design Method of Energy-saving Architecture Oriented to the Full Life Cycle

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Abstract. The full life cycle architectural design requires to start at the design stage, fully consider the important links in each stage of architectural design, construction as well as operation management and optimize the design of green energy saving on the basis of the concept of taking the whole situation into consideration. Different from traditional architectural design, the building energy-saving design oriented to the full life cycle has higher design requirements for the integrity, coordination, integration and parallelism of the project life cycle. In this paper, it starts from the design concepts of energy saving, environmental protection and green to discuss the methods of energy saving and emission reduction in architectural design. It aims to provide some references for green architectural design.

1. Introduction
The full life cycle of architectural products ranges from 30 or 40 years, to hundreds of years or even thousands of years. From design and development to operation, the problem of resource and energy consumption is constantly occurring throughout the life cycle. Based on the increasing demand for green buildings in the new era, the application of information management technology, BIM technology and others to strengthen planning and design throughout the life cycle of a building has become an important direction of architectural design development. Researching the design of energy-saving buildings for the full life cycle is of great significance for optimizing the design schemes of green building, which is helpful to manage and restrict the design of the architecture in advance, find errors in the architectural design earlier, correct deviations and perfect the design in time, so as to improve the quality of construction projects, reduce the energy consumption that may occur during the operation cycle of construction projects, and reduce the overall cost of architectural design and operation management.

2. Energy-saving building of full life cycle and its design requirements
2.1. Energy-saving building of full life cycle
The energy-saving architectural design of full life cycle is the overall planning and design of architectural projects and continuous improvement based on the factors of each link of the building life cycle, so as to achieve the goal of maximizing energy saving and emission reduction of building design. It includes design optimization for the links of project planning, design, construction, operation, maintenance management, recycling and so on. With the goal of reducing the total energy consumption in the life cycle of construction projects, it improves the environmental and economic benefits of construction projects through effective control and information management [1].

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2.2. Requirements of design

- Integrity: Integrity requires that the architectural design should start from the overall situation, coordinate all stages of the full life cycle of the building, and implement systematic and integrated supervision and management to the project.
- Coordination: The green design of the architecture for the full life cycle should comprehensively coordinate resources, technology, and management for the convenience of timely sharing and exchanging information when adjusting the plan, and improving the efficiency of building distributed environmental management.
- Integration: The architectural green design oriented to the full life cycle requires the integration of information resources. For the integrated management of the management process, it can establish an information management platform by the aid of Internet technology, information technology, network control technology, etc. to achieve the sharing and comprehensive utilization of information, so as to improve the utilization ratio of resources, lay the foundation for coordinating resources and implementing refined management sources, and improve the efficiency and effectiveness of full life cycle management.
- Parallelism: The architectural green design oriented to the full life cycle is required to take the needs of the implementation stage and the operation management stage into consideration in advance in the project setup phase and the initial design phase, so as to control the frequency of feedback during the implementation stage and reduce energy consumption in an effective way.

3. Methods of energy-saving architectural design oriented to the full life cycle

The methods of energy-saving architectural design oriented to the full life cycle includes five stages of determining design goals, planning, formulating alternatives, life cycle evaluation, and re-optimization of comprehensive analysis, which constitute a cyclically rising system (as shown in Figure 1).

Fig1. methods of energy-saving architectural design oriented to the full life cycle

3.1. Determine design goal

The design goal of the architectural project is the prerequisite for the design of the building lifecycle, and also the basis for determining the goal of each stage of the architectural planning and design. The general goal of the full life cycle design must include the four basic principles of green, energy saving, ecology and sustainable development. Before starting the design, it is a must to carefully and comprehensively understand the users' planning and design demands, understand the market needs, combine user needs with market needs, apply BIM technology, Internet information management technology, etc. on the basis of user needs, so as to achieve the overall deployment of design resources and the whole process development of energy-saving design. The general design goals should be
compatible with the design goals of each link, and they all should reflect the design of energy saving and consumption reducing for the purpose of achieving a balance between the economic benefits and environmental benefits of the buildings.

3.2. Conceive initial plan
The initial plan should be expanded on the basis of the design goals and should always focus on the design goal of buildings' full life cycle to strengthen cost design, strengthen energy-saving design, and strengthen risk control design. Through initial conception, a set of design framework for the full life cycle of the building is established, then a risk management system is gradually applied to predict and control possible risks, and energy-saving measures are put forward. The investment of energy-saving equipment in the initial design should be approximately 10%.

3.3. Design alternatives
There are a lot of uncertain factors in the design, construction and operation period of architectural projects. In order to avoid the influence of uncertain factors on the development of construction projects, the design of alternatives should be done in the design stage. Similarly, the alternatives should also focus on the expansion of design goals and adhere to the design of energy saving and consumption reduction. The raw materials, equipment, and plans of the alternatives are a substitute for the initial plan to a certain extent. Considering the volatility of material market prices, differences in the functions and attributes of the equipment, and the feasibility of the plans, the materials, equipment, and design of alternatives should be diversified as much as possible to provide energy-saving management of buildings for the full life cycle with more reference options [2].

3.4. Evaluation of full life cycle
In order to ensure the feasibility of buildings' energy-saving design of the full life cycle, the full life cycle of the architectural project should be evaluated after completing the design of the project. For building lifecycle evaluation, the evaluation of buildings lifecycle should analyze the effectiveness of building energy-saving design from the investment and proportion of each stage, and evaluate the technical, functional, economic, environmental protection and other related indicators of the building, among which, there is a resource residual value index in environmental protection requires the net residual value rate of the equipment should not be lower than 5% in the design of green buildings. The evaluation process is carried out from three stages: building material selection, building structure design and equipment selection, as well as post-building processing [7]. (Figure 2)

Fig 2. Evaluation chart of building energy efficiency indicators oriented to full life cycle
3.4.1. Construction material selection stage.
Building materials account for a large proportion of full-life buildings and are the most energy-consuming part of the building at the same time. The energy consumed in the process of transforming building materials from raw materials through production and processing to building materials products represents the embodied energy of the materials. The embodied energy is an important indicator reflecting the economic performance and ecological performance of buildings. The smaller the embodied energy of the building materials, the higher the recycling rate, the better the environmental performance, the less maintenance requirements during the constructional operation cycle, and the higher the economic as well as environmental benefits applied in construction [8]. (As shown in Table 1)

Table 1. Economic analysis of different technologies

| Renovation investment / s | Renovation income / s | Payback period / s |
|--------------------------|-----------------------|-------------------|
| Improve the level of operation management | 1 | 10-20 | <0.2 |
| Replace the draught fan and water pump | 1 | 0.8-1.0 | 1-1.2 |
| Add automatic control system | 1 | 0.3-0.5 | 2-3 |
| Overall update of system form | 1 | 0.2-0.4 | 3-5 |
| Replacement of building material | 1 | 0.1-0.05 | 5-10 |

3.4.2. Equipment selection stage of building structure design.
In building lifecycle, its own embodied energy is about 35%, and the rest are 65% of energy consumption generated by operation. While the energy consumption of building operations is closely related to its structural design and equipment selection. The better the energy saving of the selected equipment, the lower the energy consumption generated by the operation during the full life cycle. In addition, the management costs are reduced accordingly. On the contrary, if the structural design is unreasonable and it needs to use equipment to improve the internal environment of the building, the energy consumption within the building lifecycle will increase. The greater the energy consumption of the equipment in the interim, the higher the cost and the more energy consumption during the building lifecycle. Therefore, strengthening the rationalization of building structure design is of great significance for reducing energy consumption during the building operation period. Considering that the cost of disposable design is too high, for the sake of controlling the investment cost at the initial design stage, energy saving methods can be gradually introduced into the later stage to control the cost and energy consumption [3].

3.4.3. Post-processing stage of the building.
Extension of the building life cycle is also a major way to control costs as well as reduce energy consumption. Due to the aging of equipment and technology, the function of the building begins to decline at a later stage. For the purpose of extending the life of the building, it is feasible to transform the aging construction equipment and improve some building functions at the same time, or develop new functions of the building according to the market demand so as to meet the need of market [4].

3.5. Determine the best plan
After evaluating the technical, functional, economic, environmental protection and other indicators of the construction project engineering design plan oriented to the full life cycle, the design and optimization are optimized and adjusted from the initial design plan according to the evaluation results, and the imperfect design content in the original design is supplemented to improve, so as to improve the entire quality of construction projects and reduce energy consumption during the full life cycle of the building, ensuring the balance of environmental and economic benefits [5]. For those who have
insufficient technical, functional, economic, and environmental protection requirements in the original plan, it can select alternative materials, equipment, and plans from the alternatives to finally determine an optimal plan. The indicators of the best plan should be consistent with the design goals, and the energy-saving design goals of each period should meet the requirements of energy saving and emission reduction of buildings in the design goals [6]. (As shown in Table 2)

|                      | Energy-saving evaluation index system                              |
|----------------------|---------------------------------------------------------------------|
| Building acquisition | Raw material energy-saving amount                                   |
|                      | Energy consumption of building materials production                 |
|                      | Energy consumption of building materials transportation             |
| architectural planning and design | Use area of energy-saving materials                                 |
|                      | Number of energy-saving equipment used                              |
|                      | Number of new energy equipment used                                 |
| Building construction | Amount of energy saving in construction                              |
| Building use         | Building energy-saving amount                                       |
|                      | Energy-saving amount of energy-saving equipment                      |
|                      | Reduction in maintenance investment                                 |
| Building demolition  | Energy-saving amount of demolition construction                      |
|                      | Amount of energy saving in building construction                    |
|                      | Reduction amount of pollutant emission                              |
| Recycling of waste building materials | Recycling rate of building materials                               |
|                      | Waste treatment quantity                                            |

4. Conclusion

For building design oriented to the full life cycle, it should strengthen the energy-saving design from multiple stages like building materials, building structure design and equipment selection, and post-period of building. In the design of each stage, it should follow the principles of energy consumption minimization, efficient utilization of resources, environmental load minimization, and economic rationalization. It should obey the process of full-life and energy-saving building design: first determine the design goals, do a preliminary plan concept and alternatives, do a full life cycle evaluation, apply Internet technology to strengthen management, continuously optimize and improve the design plan, and finally choose the plan with the most energy-saving environmental protection and economic benefits.

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