An Analysis of Residential Building Design from the Perspective of Technical Economy

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Abstract: This paper makes a detailed analysis of the necessity and specific indicator system for technical and economic analysis of residential building design scheme. It points out that different designing schemes may be evaluated by different methods so as to achieve the purposes of being reasonable economically and advanced technologically.

Building engineering designs of modern society are always carried out under the constraint of certain economic conditions. Only technologically advanced and reliable, and economically reasonable and feasible building products can be accepted by people. Relevant data show that the impact of the investment decision & preliminary design stage on investment is about 90%, with about 75% for the technical design stage, and about 35% for the drawing design stage, while only about 10% for the construction stage which was valued much in the past. Obviously, the key to engineering cost control lies in the investment and design stage before construction. Once the technologies, processes, and schemes of the project are determined, its construction cost is basically determined accordingly. Therefore, it is of great importance and significance to make a techno-economic analysis in the engineering design stage. Residential buildings account for a large proportion in civil buildings, so this paper focuses on analyzing the impact of engineering design on engineering economy from the perspective of residential building.

The purpose of the techno-economic analysis of residential design scheme

1. To select a designing scheme with the optimal techno-economic effects through analysis and evaluation.
2. To promote the continuous improvement of the architecture design level and quality.
3. To identify the function adaptability, technical advancement and feasibility, and economic rationality of the designing scheme.
4. To summarize the objective laws of technical economy, and to provide a scientific basis for establishing the proper construction technology policy.

The techno-economic evaluation indicator system of residential design scheme

The techno-economic appraisal indicators are mainly composed of land indicators and cost indicators.

Land Utilization Index System

The impact of planar shape on land utilization

The planar shape of the residence has a significant impact on land utilization. More regular planar shape will be more conducive to improve the land utilization. However, optimal land utilization and artistic style should be both considered for residential designs.

The impact of residential building layer on land utilization

Basic residential land = (depth * the number of layers * spacing factor) * (average face width for each household + average gable wall space) / the number of layers

According to the above formula, to increase residential layer can exert an operational effect on land utilization. Yet, in consideration of building density, land conservation cannot be the sole element considered for residential design.

Relationship between Layer Number and Optimal Land Utilization

Layer number	Average ousehold and/m2	The saved land compared with the previous layer / m2	Proportion compared with the first layer（%）
1	96.2		100
2	64.1	30.9	67.8
3	55.1	11.7	57.1
4	49.3	6.0	51.8
5	46.4	3.8	48.5
6	44.7	2.3	46.4
7	43.8	1.7	44.9

The above table shows that land conservation effect is very remarkable when the number of layers is from 1 to 4; and the effect weakens significantly when the layer number is larger than 6. This is because residential sunshine spacing increases correspondingly as the number of layers becomes larger, and as a result, the effect of land conservation will gradually weaken accordingly. So land conservation does not progressively increase by the same proportion as layers increase.

The impact of the storey height of the residential building on land utilization

Sunshine spacing is proportional to the total height of residential building. So the overall height can be reduced if the storey height is lowered, and so does the sunshine spacing between buildings, so as to attain the purpose of saving the land. However, the storey height should also conform to people's living habits and the national health standards. China's current general residential storey height is 2.8m.

The impact of the space between residential buildings on land utilization

The confirmation of the space between residential buildings is not just related to sunshine conditions. Also, fire prevention, ventilation, roads, construction and other issues should be taken into consideration. Properly reducing residential building spacing can play a role in land conservation on the premise of ensuring the residential function and environmental quality.

The impact of residential community layout on land utilization

For residential building design, the methods of front-back stagger arrangement, point-strip combination or corner units or others may be adopted to achieve the purpose of land conservation.

Construction Cost Index System

The constituent ratio of construction cost is the proportion of the construction cost of different parts of the project to the total cost.

The Proportion of the Construction Cost of the Partitioned Project /%

	Foundation	Wall	Column	Ground	Doors and windows	Roof	Others
Post and penal structure	8-10	30-35	2-6	8-10	6-10	15-25	4-6
Steel-concrete structure	5-10	30-40	10-20	4-7	5-11	10-18	3-5

The above table indicates that the wall takes the largest share of the cost, followed by the roof. So the wall should be the focus of researching the economic issues of multi-storey residential building, followed by the roof.

The impacts of the plane layout and spatial organization on construction cost

As most residential buildings are multi-layer, the area coefficient of the wall is a very important parameter. When this coefficient is reduced, the construction cost can be significantly reduced accordingly. The wall area coefficient is relevant to all the factors such as the bay width, depth, layer number and storey height. So residential building designs should (1) favor a regular planar shape, which can effectively reduce the external wall perimeter, and also the interior and exterior surfacing. Then accordingly, the construction cost is decreased as well; (2) reasonably increase the depth of the building, which can effectively reduce the exterior wall perimeter and the construction cost.

The impact of the storey height on the construction cost

Storey height directly affects the cost of residential building, because if the story height is increased, the cylinder volume and wall area also will be increased, and the pipeline will be lengthened. According to statistics, the construction cost can be reduced by 1.2% to 1.5% if the storey height is lowered by each 10cm. At the same time, reducing the storey height can also reduce indoor engineering cost, and save heating cost in the region with heating provision. Therefore, reducing the storey height can effectively save energy and material, and reduce the construction cost.

The impact of the number of layers on the construction cost

To reasonably determine the number of layers is an important topic to reduce the construction cost. For multi-layer residential buildings, to increase the number of layers may reduce the construction cost for each household by 1%. However, as for the high-rise housing, if the number of layers is increased, and the factors of elevators and pressure pumps are taken into account, the cost will be increased accordingly.

The techno-economic evaluation methods of residential design scheme

A single index evaluation method

The so-called single indicator method is to adopt a single indicator as the standard for the scheme selection. A single indicator can be efficiency indicator or cost index. During the comparison and selection of schemes, if other indicators of different schemes are close to each other, or one of these indicators is very important, a single indicator can be adopted. The cost index is most widely used for the single index evaluation. There are two different ways: one is to only count the initial cost of the project, namely the construction cost or investment; the other is to calculate the whole life-cycle cost of the design scheme, including the initial investment of the project, the daily expenditure after delivery, the cost of demolition after the expiration of the project, and other

expenses. The whole life-cycle cost is a more reasonable evaluation indicator. However, when the daily expenditures of some design schemes after their completion have few differences or are unable to be predicted, these schemes can be directly evaluated by investment.

Multi-index comprehensive evaluation method

Multi-index evaluation of design scheme means to achieve an optimal overall design on the basis of evaluating every part, every stage and every level of the scheme. The evaluation methods include scoring method and index method. There are two problems needing to be solved when multi-index evaluation method is adopted. First, the issue of comparability of the evaluation index, that is the necessary conditions for comparing the two schemes, should be resolved. Second, the index should be divided into the main index and the secondary index. Multi-index comprehensive evaluation method is usually adopted for selection of design schemes and tender design schemes.

Value Analysis Method

Value analysis, namely value engineering, is a very effective method of management analysis, by which all the schemes concerning expenses can be compared and selected. This method seeks to reliably achieve the necessary functions of the product by the lowest life-cycle cost. It is widely applied in the field of engineering design. In practice, value engineering method is mostly adopted for analysis of individual design scheme and for the improvement and optimization of the original design scheme.

Conclusion

Architectural engineering design not only determines the investment cost but also, to a great extent, determines the use cost and service life of the building. Consequently, it will necessarily exert a significant and direct influence on the building's techno-economic effects. Therefore, for the residential building which accounts for a large proportion of civil buildings, it is very necessary to make a techno-economic analysis of its design scheme.

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