

Study of the Optimization of Structural Designs in Residential Buildings

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ABSTRACT The building structural design which has met both functional and quality assurances could no longer meet the demands of human life and spirit, especially with the continuous improvement in living standards and increasing in public needs. Therefore, there is necessary to optimize the design of building structures. This study will give a brief introduction to the optimization theory of structural design, present some optimization measures and theoretical reference for future structural design optimization.

KEYWORDS

Building structure design
Optimization method
Housing structure design

1. Introduction

Building, as a solid art, is a result of joint action of aesthetics, architecture and design. For the construction of residential housing, the design should be applicable and economic, safe and beautiful. In the aspect of construction, it should be easy to operate, etc., we should maximize the utilization of space and limited resources, achieve the affordable goal. The application of optimization method in design not only can make the beauty of the shape prominent, but also focus on structural safety, so that the completed construction is economic, rational and affordable.

2. Theory reflecting structural design optimization methods

In the project design process, we not only need to consider the aesthetics and practicality, but also pay attention to safety and reliability. That is to hold onto the link of aesthetics while projecting its application, e.g. the optimization of structure. The optimization method is divided into the optimization of project division structure and project overall structure. The overall project optimization includes system protocol design, envelope structures protocol and detailed design of the structure, which also includes the

selection, overall structural arrangement, force and cost analysis and others. Hence, during the construction project, we must base on the principle that everything must be realistic and consider benefit as the first principle to conduct design optimization [1].

3. Application and practical value of building structure design optimization method

3.1. Application of structural design optimization methods

The structural design optimization is divided into the optimization of project division structure and project overall structure. Among them, the division structure optimization includes foundation plan, room cover system, envelope part and detail design. The above section also contains the shape, force, cost analysis and others. We should maximize the economic benefits through a combination of on-site construction based on meeting design specifications and functionality.

3.2. Practical value of structural design optimization method

In this paper, through research and field visits, it is concluded that as a building, it will not only meet the long-term economic needs, but also minimize expenses in construction investment and make long-term planning for building structure, rationality and security. The adoption of structural design optimization project can greatly reduce the project cost, generally 15% to 30% lower than the original budget [2]. Based on reasonable material and performance, to achieve the purposes of harmonization and security in each structural level and space. Meanwhile, with the optimization program, making decisions for the whole building and so on. Therefore, the optimization of

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engineering structures is the only way for us to achieve economy, safety, aesthetics and practicability.

4. Relationship between housing construction structural design and economy

In the aspect of land use, we should focus on land area. In general, the land area and housing design structure have a great relationship, especially for high-rise buildings, its total construction area can be counted as the sum of the area of each layer. According to an increase in the number of layers, the distance must be increased, a certain proportion must be followed to perform increments.

The impact on construction area is also great due to the relationship of number of layers, but the degree of impact is different with different structures. With increasing in housing layers structure, the requirements for contact load capacity is increased, due to security considerations, in the aspect of load-bearing structure, wall thickness, columns and beams thickness and others will be increased accordingly in bearer class and seismic aspects with the increased number of layers. Furthermore, it will increase the cost of house [3].

The investment in all aspects will increase correspondingly due to the increased number of layers, as for its structural design and economy, not only focusing on safety, but also reasonable design.

5. Structural design optimization methods

Every project should be beautiful and practical, which is the perfect combination of design and architecture. First, the design should be safe and applicable, the construction should be economic and beautiful, at the same time, the construction process should be easy to conduct. This structural optimization design not only solves the problem encountered in architecture from the technical level, but also improves the methods of structural design. So that housing is truly affordable. The optimization of building structure design mainly reflects the design optimization of division structure and overall optimization of engineering structure.

5.1. Structural optimization design model

Structural design optimization method is mainly aimed to find out the main variable parameters from various kinds of influence factors, set up function model based on these parameters and combine with the scientific method, in order to obtain the best result. The establishment of model mainly follows the steps below: first, the selection of main variables. In normal circumstances, the selection of variables is based on the influential factors. All the parameters involved in the project are divided into different grades according to their importance. As for the development of advanced preset parameter, the parameters with small influence are classified as preset parameter, in order to reduce the workload of programming. The second grade is

determination of objective function. Function calculation is used to find out the qualified result. The optimal solution is determined in accordance with the conditions. For the building structure design optimization, the choice of constraint conditions contains many contents, such as the effect of stress, crack width, size and the primary strength level. Under normal conditions, the ultimate limit state to the final state, its elastic binding and constraint condition. All of which must conform to the overall requirements of the design and construction of the project.

5.2. Structure optimization scheme

Since building design and structure optimization involves many variables and constraint conditions, we should simplify the complex situation in the process of this project for the nonlinear issue, transfer constraints to unconstrained conditions, then made all kinds of calculation. The versatile method, Powell method and other methods are commonly used in this aspect [4]. Programming was performed on the basis of the completing calculation scheme, to get the final optimized result.

6. Practical application of structure design optimization technology

At present, building structure design optimization is widely applied due to its wide range. With this optimization method, costs are reduced without changing the performance of housing conditions. This kind of building structure design optimization method can be widely used in the overall design of the projects. It also can be used for the premise design and various links of reconstruction of old house and other project. However, in practical applications, there are few things to note:

6.1. The optimization of structural design should pay attention to early participation

The project design proposal will affect the total investment amount. The affection is more obvious in the premise proposal. However, the early proposal does not comprehensively consider the feasibility and rationality of the structure in the design process. However, the results of design may directly affect the next design of structure, which increases the difficulty to structure design to a large extent. Hence, the overall investment of the project is increased. If the optimization design of structure is introduced when developing the proposal, the structural designers will draw up a reasonable and scientific structure, and present the completed design proposal according to the different categories of construction, thereby forming a good start.

6.2. Design optimization of integration of conceptual design and detail structure design

In the structural design optimization, since some of the conceptual designs lack of specific quantitative indicators, such as aseismicity and anti-cracking degree and so

on, there will be some contradiction between design and actual situation due to the uncertainty of parameter in the process of calculation. Therefore, facing of such problems, we need to adopt the conceptual design, using previous data for reference, give full play to people's flexibility and intelligence to achieve optimal results.

6.3. Foundation structure design optimization of lower foundation

First, foundation design plan of foundation is chosen. If it is a pile foundation, we should choose type according to the geographical environment of construction site in order to save cost. The suitable solution will be selected for the pile end bearing layer due to influencing of the perfusion pile length.

7. Practical significance of structural design optimization

7.1. Optimization design

The optimization design can reduce the cost and floor space of high-rise buildings and multi-storey building. For example, a building only needs one roof, nothing to do with the layer numbers. For foundation, although it is common and its investment will increase with the increased number of layers due to the increase of the tolerance, it is not obvious than the overall effect of housing is related to the overall cost [5].

7.2. Lowering layer

Lowering layer not only can save material, but can also enhance the seismic performance. In addition, when designing the plane shape of house, we will choose circular design or the design of close to square when designing the shape of house. Therefore, the perimeter of periphery, its foundation and surface decoration will be reduced accordingly. At the same time, the force and efficiency will be also

increased significantly.

8. Conclusion

Buildings should be not only practical but also need to be strong and beautiful, further optimization of design method of building structure is very important when perfecting the construction technology. Through optimizing design method, the building design becomes more practical, more secure, more beautiful and economic. At the same time, the building design becomes more conducive to the construction of construction unit, improving the quality of the buildings, realizing the maximization of resource utilization and ensuring the economic benefits of construction unit.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work.

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