Innovative Design and Practice Research of Large-Span Space Structure

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Abstract: At the present stage, China's large space structure has the phenomenon of low bearing capacity. Once the bearing capacity of the space structure is overloaded, it will lead to the deformation of the spatial structure, resulting in bad building safety impact. In order to effectively solve such problems, this paper on the structure design across space innovation and practical application of practice, structural innovation design analysis from three aspects, respectively, for the large across space actual structure design system, material selection and space structure stability to find shape, through practical research to prove after innovation of space structure can effectively improve the actual bearing capacity of large across the space, improve the building quality and ensure the building safety.

Keywords: Large Span Space; Structural Innovation Design; Practical Research

Introduction

Large across space structure can be divided into three categories, respectively is rigid, flexible and rigid and flexible combined with space structure, large across space has the unique advantages and design style is other kinds of building structure, most famous building is reference across the space diversification design structure and architectural design development. At present, China's architectural design style is constantly optimized and innovated. Most public buildings have successfully built many landmark buildings based on large-span space structures. The building built on the basis of large-span spatial structure design has the architectural beauty of magnificent appearance and novel and unique appearance, but the appearance of the building presents irregular shape. Based on this, the architectural designer needs to consider the feasibility and rationality of the design structure in a full way when carrying out such spatial structure design. This paper mainly explores the building projects of large-span space structure through practical cases.

1. Project overview

The large-span space design structure building project explored in this paper is based on the entertainment building in a certain area as an example. This building mainly relies on the unique deep foundation pit in the environment, and the panoramic shape of the foundation pit is presented in a U-shaped way. The free boundary in this project can cross the maximum length of 200m. After the completion of the coin construction project, it is expected that the actual height of the above-ground building can reach 37m, and the actual building area can reach 120500m^2, If the construction of this space building is successful, it will provide the best space experience place for people's leisure and entertainment. The panorama of the deep foundation pit in its architectural design project is shown in Figure 1.

Figure 1 Panorama view of the deep foundation pit where the construction project is located

In the communication with the architectural designers, the expected effect drawing of the structural design and the 3 D structure model after the construction of this project are specifically shown in Figure 2.

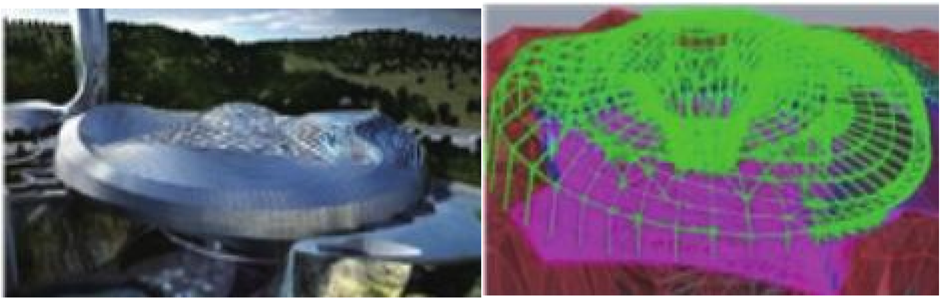

Figure 2 Actual expected model and 3 D structure model after the end of the building

As shown in the figure above, in order to improve the visual experience of construction project, the design of the building structure design is free streamline modelling, the overall design structure is mainly composed of upper and lower two parts, in the building above the structure design of steel shell network with significant across space characteristics, and the substructure is a hole plate, the bearing capacity of the building space is mainly carried by flat. Based on the irregular appearance of the architectural design under the large-span space structure, in order to improve its space design innovation, the in-depth research will be conducted below.

2. Innovative research on structural design for large-span space

2.1 Large-span spatial structure mechanism design

Large span spatial structure has unique spatial advantages, and its structure types and design forms are more rich and diverse. At present, the types of large span spatial structure include hybridization and Zhang string. From the perspective of spatial structure, the spatial system can be divided into four structures, which refers to the grid system, reinforced concrete thin shell, tensioned whole and hybrid combination structure[1]. Different structural systems can be selected according to the actual situation. In the spatial structure design, it is necessary to calculate the unknown design structure, the initial design domain, and the calculation formula is as follows.

Type 1 $V_0^x = \varphi V_0 = \frac{C_0}{C} V_0$

V_0 C_0 C In Equation 1, it represents the actual structural volume of the large-span space in the initial design domain, and refers to the total strain energy in the initial structural design, which represents the ultimate strain energy. When the architect optimizes and updates the design domain of the large span space, he can use the iterative structure optimization volume formula, which is as follows.

$$\text{Type 2 } V_i^x = \frac{C_i}{C} V_i$$

V_i i C_i In formula _ 2, it represents the total volume of the large-span space structure at the first iteration, which refers to the total strain energy. In addition, the existing spatial design topology can be changed by using the specific relationship between the strain energy and the actual design domain volume in the structure of the performance index.

2.2 Selection of large-span space innovative structural materials

In the past, steel and concrete were widely used in large span space structure, but because of the continuous influx of new materials into the market, innovation and optimization on the original basis, new research and development materials such as aluminum alloy, high strength steel cable and rubber wood have been widely used in the existing large span space structure[2]. For example, aluminum alloy has strong corrosion resistance function, and its weight is relatively light. If aluminum alloy is used during the design of large span space structure, it can effectively improve the corrosion resistance of the space structure with more water vapor such as natatorium building, and can better resist the corrosion of water vapor. In addition, in addition to selecting high-quality materials to design a large-span spatial structure, it is also necessary to budget reliable data information to support the design. At the same time, we should fully consider how to build two-dimensional planes of materials with the same properties. At this point, Equation 3 can be used to calculate the requirements, which is as follows.

$$\text{Type 3 } \sigma = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_Y + 2t^2}$$

σ In the above formula, the positive stress between the materials with the same attribute; the lateral stress of the same attribute material; the longitudinal stress; and the actual shear stress of the material. σ_x σ_y t

According to the formula and the maximum stress requirement of the combined structure, the innovative and optimized model of large-span space structure materials can be obtained.as follows.

$$\text{Type 4 } A = \{\alpha_1, \alpha_2, \cdots, \mathrm{n}\}$$

A $\alpha_1, \alpha_2, \cdots, n$ It represents the optimization result, which refers to the actual variables in the design of the structural material, and the value of the calculation process can be calculated from 0 or 1.

When designing the initial area of the spatial structure, the initial area can be discrete to make it a grid structure of finite element, a period during which the required boundary condition and applied load should be determined, and the task can be reassigned to the parameter values in the initial design. Then the rigorous calculation and scientific analysis of the finite elements of the design structure are developed through the relevant formulas, and finally the required stress value can be obtained. Of course, in the selection of materials, the obtained stress value should be corresponding to the optimized model one by one, and the optimal material should be determined after the best matching effect is obtained.

2.3 On the stable shape finding in the design of the large-span space structure

In order to ensure the strong stability of the large-span space structure, it is necessary to develop the design and work. During this period, the most appropriate force conduction geometry structure should be selected to maximize the mechanical properties of the material under the premise of ensuring the cost of the material, so as to achieve the optimal effect. In view of the relatively simple structural modeling system, we should focus on the adverse effects caused by the bending moment, and the design structure itself can bear the gravity and pressure brought by the building[3]. When finding the shape, the dynamic relaxation method can be used to achieve the task of finding the structure, and then determine the target of finding the shape according to the force of the structure, and use the relationship between the geometric figure and the force distribution in the spatial structure design to find the most scientific and reasonable topological structure. Therefore, in the innovative design of the large-span space structure, we should focus on its stability and take the stability as the cornerstone, so as to design the spatial structure with the best stability.

3. Practical study of large-span spatial structures

In order to ensure that the designed large-span space structure can meet the needs of the building, it is necessary to pay attention to the requirements of the investors for the design, and fully consider the necessary conditions for the design of the large-span space[4]. Table 1 refers to the conditions that should be considered when designing for large-span space construction in buildings. The details are shown in Table Table 1.

Table 1 Requirements for the design of a large-span space structure

Structural design project	Prerequisites and related data
Design for service life	In 50 years
Seismic intensity	6 Degrees
Seismic category	C-class
The design structure is safe	two stage
Category of the spatial structure	III class
The seismic grouping of the design structure	a set
Design structure wind pressure setting	0.3-0.4（kN/m^2）
Rough ness of ground buildings	B class
External load value	0.64-0.74（kN/m^2）

After mastering the necessary conditions of large-span space structure design, we should also pay attention to the load distribution and the comparative analysis of the bearing capacity detection in the structure design. The results of the specific analysis are shown in Table Table 2.

Table 2 Comparison data of design bearing capacity and measuring point results in the architectural design of large-span space structure

The area where the point is measured	Test data of measuring point bearing capacity / kN / m^2	Design bearing capacity data / kN / m^2
Area 1	2.94	2.8
Area 2	3.66	3.5
3 District	2.97	2.9
Area 4	3.15	3.1
5 District	3.02	2.9
Area 6	3.37	3.3
Area 7	3.88	3.8

According to the experimental data in Table 2, the design bearing capacity is <the bearing capacity of the measuring point, which proves that the designed large-span space structure can meet the design requirements, and the design structure has certain stability and safety. The scientific calculation design can effectively improve the bearing capacity of the structure and ensure the reliability of the building.

4. Epilogue

This paper, through practice to prove that across space structure development space is huge, so a variety of building structure space, system, design materials and design technology are constantly developing innovation, China has become a space structure construction, but the big cross space structure design innovation technology research is lacking, hope to have more researchers involved in building structure innovation research, to promote the development of the space building structure in our country.

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