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STRESS ANALYSIS OF STONE-LIKE CONCRETE HANGING PANEL CURTAIN WALL

Jie Luo[1,2], ZhiCheng Bai[1,2,*], Yang Yang[1,2], XiaoFei Tao[1,2], YongYan Li[1,2], JiaLi Cao[1,2]
[1]China Construction Fourth Engineering Bureau Co., Ltd. Guangzhou, Guangdong 510000, China;
[2]China Construction Fourth Engineering Bureau Sixth Construction Co., Ltd. Hefei, Anhui 230000, China.
Corresponding Author: ZhiCheng Bai, Email: 19822660870@163.com

Abstract: This paper mainly uses the stone-like concrete hanging board curtain wall system of a curtain wall project in Hangzhou to conduct stress analysis on the determined system, mainly making a detailed structural analysis of the stress condition of the main profile. On the premise of ensuring the facade effect and water tightness, it explores its stress distribution and deformation under various loads, tries to simplify the stress system, reduce the weight of the curtain wall, improve the installation accuracy, and shorten the unit assembly period.
Keywords: Construction engineering; Anti-stone concrete curtain wall; Finite element method

PREFACE

With the advancement of construction technology and the diversification of decorative materials, stone-like concrete hanging panels have gradually become one of the preferred materials for building curtain walls due to their unique aesthetic effects and superior physical properties. Imitation stone concrete hanging boards can not only simulate the appearance of natural stone, but also have the advantages of high strength, good durability, and low cost. However, due to its different material properties and construction techniques, its stress characteristics are significantly different from those of traditional stone curtain walls, so it is necessary to conduct a systematic stress analysis.
This article takes a large venue project in Hangzhou as an example to conduct stress analysis on the determined system. It mainly conducts a detailed structural analysis on the stress situation of the main profiles. On the premise of ensuring the facade effect and water tightness, it discusses Its stress distribution and deformation under various loads try to simplify the stress system, reduce the weight of the curtain wall, improve the installation accuracy, and shorten the unit assembly period.

1 PROJECT OVERVIEW

Taking a large venue in Hangzhou as an example, this project is a key project in Zhejiang Province, with a total land area of 49,900 square meters and a total construction area of 175,600 square meters, of which the above-ground construction area is approximately 107,700 square meters and the underground construction area is approximately 67,900 square meters. It includes a mountain-shaped tower and podium, with 2 floors underground and 15 floors above ground, with a total height of 73.5m. Among them, the outer facade of the gable-shaped tower is made of stone-like concrete hanging panel curtain wall, totaling 52,000 square meters, which is installed in a synchronous and staggered manner following the structural setback. Imitation stone concrete hanging board curtain wall can be seen in Figure 1.

Figure 1 Imitation stone concrete hanging board curtain wall

Material characteristics of imitation stone concrete hanging board:
Imitation stone concrete hanging board is made of cement, sand, aggregate, admixture and appropriate fiber reinforcement material, and has the following characteristics: (1) High strength and durability: Imitation stone concrete material has high compressive and tensile strength and can withstand large external forces; (2) Light weight: Compared with natural stone, imitation stone concrete hanging board has a lighter weight, which is conducive to reducing the load

of the building; (3) Good weather resistance: The admixtures and reinforcing fibers added to the material make it have excellent weather resistance and can be used for a long time in various harsh environments.

2 STRESS ANALYSIS OF IMITATION STONE CONCRETE HANGING BOARD CURTAIN WALL

2.1 Stress Type

Imitation stone concrete hanging board curtain wall mainly bears the following loads:
Self-weight load: The weight of the hanging board itself is transmitted to the main body of the building through the supporting structure.
Wind load: The external wind pressure acts on the surface of the hanging board, generating positive and negative wind pressure effects.
Seismic load: Under the action of earthquake, the hanging board and its connecting parts need to withstand horizontal and vertical vibration and impact.
Temperature load: thermal expansion and contraction effect caused by changes in ambient temperature.

2.2 Force Model and Assumptions

In force analysis, it is usually assumed that the imitation stone concrete hanging board is a homogeneous, isotropic elastic material. The finite element method is used for simulation analysis to establish a force model of the hanging board under various loads. The deadweight, wind load, seismic load and temperature load of the hanging board are considered in the model.
Just like Figure 2, taking the highest 8-story slab in this project as an example, the 8-story L-shaped corner slab has a horizontal grid of 3165+1500mm and a height of 6135mm. According to the wind tunnel test report, the wind load here is +1.67kpa/-2.33kpa.

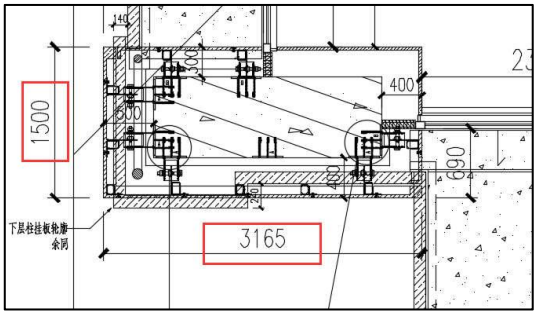

Figure 2 Plan of the highest plate on the 8th floor

3 CALCULATION METHOD

Finite element analysis of the hanging board was performed using ANSYS software. The specific steps are as follows:
1. Modeling: Establish a three-dimensional model based on the actual size and material properties of the hanging board.
2. Apply loads: Apply self-weight load, wind load, seismic load and temperature load respectively, and set reasonable boundary conditions.
3. Solution: Perform static and dynamic analysis to solve the stress distribution and deformation of the hanging board's bearing capacity, crack resistance and deflection under various loads.
4. Result analysis: Analyze the stress characteristics and weak links of the hanging board through stress cloud diagrams and deformation diagrams.

4 RESULTS AND DISCUSSION

4.1 Stress Conditions under Four Types of Wind Loads

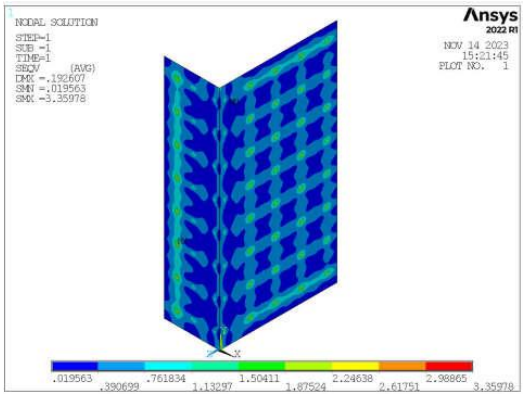

Figure 3. Plate Stress Cloud Diagram under Positive Wind Pressure on Both Sides

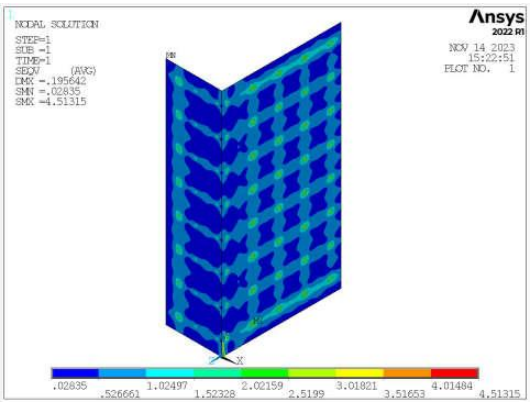

Figure 4 Plate Stress Cloud Diagram under One Positive and One Negative Wind Pressure

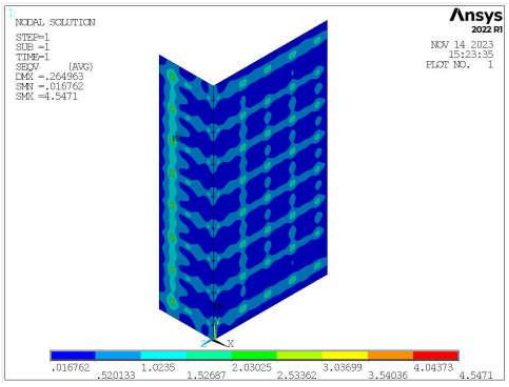

Figure 5 Plate Stress Cloud Diagram under One Negative and One Positive Wind Pressure

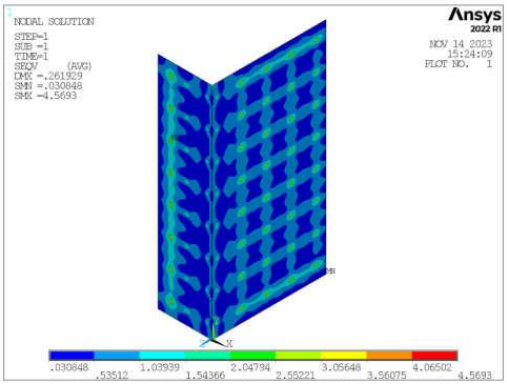

Figure 6 Plate Stress Cloud Diagram under Negative Wind Pressure on both Sides

In Figure 3-6, under the action of wind load, positive and negative wind pressures are generated on the surface of the hanging board, and the maximum stress is concentrated near the edge and fixing point of the hanging board. By strengthening the design of the fixing point and the edge part, the wind resistance of the hanging board can be effectively improved.

4.2 Stress Conditions of Crack Resistance Calculation

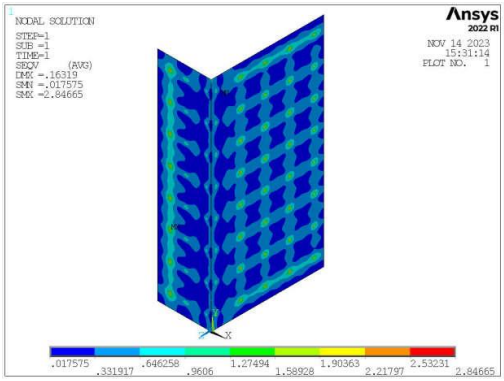

Figure 7 Panel Cross Section Cracking Stress Diagram

In Figure 7, the load causes the hanging board to vibrate in the horizontal and vertical directions, and the stress is concentrated at the connection part of the hanging board. By reasonably designing the connectors and supporting structures, the stress concentration caused by the load can be effectively reduced.

4.3 Stress Conditions of Deflection

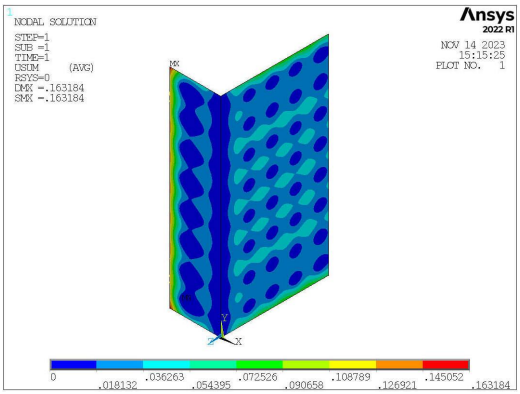

Figure 8 Panel Displacement Diagram

In Figure 8, the thermal expansion and contraction effect caused by the temperature load will cause a large deformation at the edge of the hanging board. By setting the expansion joint and the distance from the hanging board anchor point to the edge, the impact of temperature changes on the hanging board can be effectively alleviated.

5 CONCLUSION

(1) Superior material performance: The imitation stone concrete hanging board has high compressive strength and tensile strength, which can meet the requirements of the curtain wall system for bearing capacity. At the same time, its good weather resistance and durability enable it to maintain stable performance under various climatic conditions.
(2) Reasonable stress distribution: Through finite element analysis, it is found that the stress distribution of imitation stone concrete hanging panels under self-weight load, wind load, seismic load and temperature load is relatively uniform, and the local stress concentration phenomenon can be effectively alleviated through optimized design.
(3) The design of key parts is important: The fixing points and connectors of the hanging panels are the key parts of stress concentration. Reasonable design and installation can significantly improve the safety and stability of the system. The use of high-strength materials and flexible connection technology can effectively reduce stress concentration and fatigue damage.
(4) Strong environmental adaptability: Imitation stone concrete hanging panels show good adaptability under temperature changes and dynamic loads. Through reasonable structural design and construction technology, their durability and reliability can be further improved.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

[1] Technical Specification for Application of Fair-faced Concrete: JGJ169-2009.
[2] Shi Xuewen. On the Construction Quality Control and Application of Special-shaped Hyperbolic Fair-faced Concrete. China Building Materials, 2022(03): 133-135.
[3] Fang Zhongliang. Application of Fair-faced Concrete Construction Technology in Construction Engineering. Popular Standardization, 2019(18): 59+61.