Integration of Structure and Enclosure System (Large Span Curtain Wall Structure) Monitoring Technology and Linkage Analysis

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Abstract. The integrated monitoring technology and linkage analysis of the structure and enclosure system (large span curtain wall structure) are studied by studying the impact of deformation of the main structure on the stress and deformation performance of the curtain wall structure, as well as considering the impact of the load transmitted by the curtain wall structure to the main structure on the main structure. Conduct research on three scenarios: pure large-span curtain wall structural model, pure main body structural model, and collaborative work between large-span curtain wall structural model and main body structural model. Compare and study indicators such as period, deformation, and interlayer displacement angle. The analysis shows that the load transmitted by the large-span curtain wall structure to the main structure has very little impact on the deformation of the main structure; The deformation of the main structure has little impact on the relative deformation of the large-span curtain wall structure.

Keywords: Main Structure · Large Span Curtain Wall Structure · Monitoring · Overall Analysis

1 Project Overview

Due to the difficulty of monitoring the main structure, such as high-altitude operations, structural components being covered by decorative layers, etc. In order to achieve the monitoring task of the enclosure structure and the main structure, data collection is carried out by arranging monitoring points on the inner side of the building enclosure structure room or the outer surface of the enclosure structure; Using mature calculation software, establish a calculation model for the enclosure structure and the main structure. By comparing and analyzing their respective periods, displacements, stresses, etc., determine the mutual influence and loading form of the enclosure structure and the main structure; Calculate the enclosure structure and main structure by applying loads obtained from monitoring data; And compare with the corresponding monitoring results to identify the reasons for the differences in results, and modify the calculation model and assumptions to achieve the goal of matching the final calculation results with the monitoring results [1–3].

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As a part of the building, the large-span curtain wall structure needs to be considered in collaboration with the main structure (overall analysis or simplified analysis). The load, deformation, and stress of the curtain wall structure are linearly distributed. It is necessary to study the impact of the deformation of the main structure on the stress and deformation performance of the curtain wall structure, and also consider the impact of the load transmitted by the curtain wall structure to the main structure on the main structure.

This article conducts research on three scenarios: pure main structure model, pure large span curtain wall structure model, and collaborative work between large span curtain wall structure model and main structure model. It mainly compares and studies indicators such as period, deformation, and interlayer displacement angle, analyzes the mutual influence between the main structure and large span curtain wall, determines the loading method between them, and explores the feasibility of separate calculation between large span curtain wall structure and main structure, By simplifying the model for analysis, the purpose of monitoring is achieved.

Project situation: A rectangular building with a podium length of 92 m and a width of 42 m; The tower is 63 m long and 23 m wide; The span of the large-span curtain wall structure is 10.4 m, with one frame every 2 floors (i.e. 7.8 m); The large-span curtain wall structure is a steel structure, with the main structure being a steel frame structure. The analysis software is Midas Gen.

In order to simplify the calculation, the long-span curtain wall structure only considers dead load and wind load, DL (dead load): 7.8 KN/M, W + (wind load): 13.3 KN/M, W - (wind load): 13.3 KN/M [4–6].

2 Comparative Analysis of Models

2.1 Analysis Model

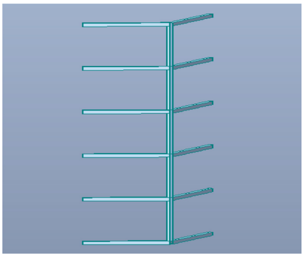

Fig. 1. A Structural Model of Pure Long Span Curtain Wall

2.2 Analysis Ideas

Step 1: The initial model support of the pure large-span curtain wall structure is a rigid joint support, and the support reaction forces F1i and M1i (i taken as x, y, z) are calculated and analyzed in Fig. 1, Fig. 2 and Fig. 3;

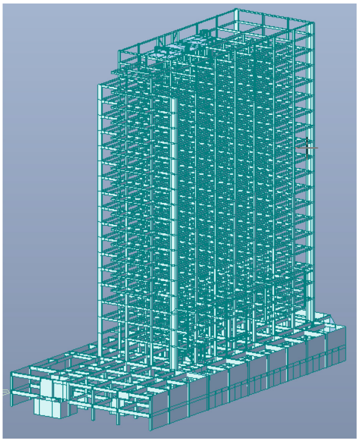

Fig. 2. Pure subject structure model

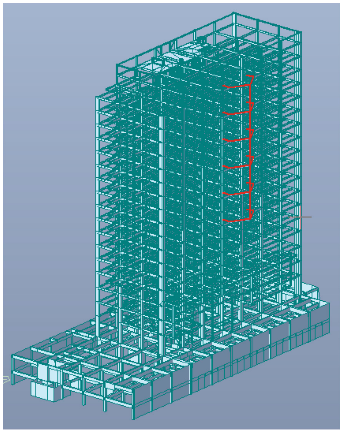

Fig. 3. Final assembly model

Step 2: Apply the calculated support reaction force of the large-span curtain wall structure to the pure main structure, obtain the displacement values Di and Ri (i takes x, y, z) of each support, and calculate the stiffness of each support through Ki = F1i/Di and Ki = M1i/Ri (i takes x, y, z). This stiffness value is the stiffness value after considering the deformation of the main structure;

Step 3: Add the stiffness value Ki after considering the deformation of the main body to the pure main body structural model for calculation and analysis, and obtain the support reaction forces F2i and M2i. This analysis result is the result after considering the influence of the main body;

Step 4: Re add the support reaction forces F2i and M2i from the previous step to the pure main body model for calculation and analysis;

Step 5: Collaborate between the large-span curtain wall structure model and the main structure model, and compare the calculation and analysis results with the pure main structure model and the pure large-span curtain wall structure model analysis results;

2.3 Cycle Comparison

Through modal comparison analysis, the pure main structure model T1 = 4.7805 corresponds to the final assembly model T1 = 4.766, with a very similar period. The periods of other corresponding modes are also very similar, and the modal trend is consistent. The pure curtain wall structure has minimal impact on the main structure (Table 1).

2.4 Comparison of Deflection Between Pure Main Structure and Final Assembly Model

When the stiffness of the main structure is considered in the large-span curtain wall structure, the generated reaction force is applied to the pure main structure. At this time, the pure main structure model (considering the influence of the load transmitted by the curtain wall) is analyzed, and compared with the final assembly model analysis.

Table 1. Period comparison

Model	Vibration mode	Cycle
Pure main structure model (considering the influence of curtain wall structure)	1	4.7805
	2	3.5343
	3	3.3238
Mold assembly model	1	4.766
	2	3.5418
	3	3.336

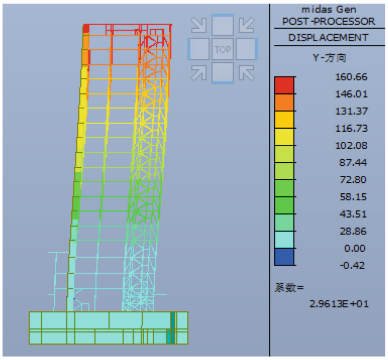

Fig. 4. Pure main body (considering the influence of curtain wall) Y-direction deflection

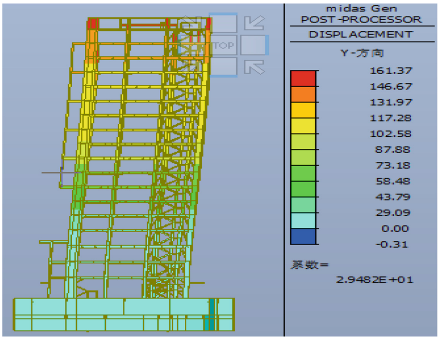

Fig. 5. Y-axis deflection of the final assembly model

Under 1.0 constant + 1.0 wind conditions, the deflections of the pure main structure model (considering the influence of the load transmitted by the curtain wall) are DY = 160.66 mm and DX = 119.24 mm, respectively; The deflections of the final assembly model are DY = 161.37 mm and DX = 118.14 mm, as shown in Table 2 for comparative analysis. From this, it can be seen that the deflection difference in the Y direction is 0.44%,

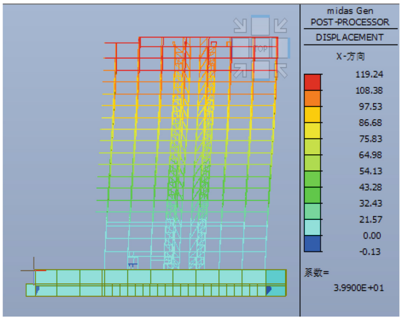

Fig. 6. Pure main body (considering the influence of curtain wall) X-direction

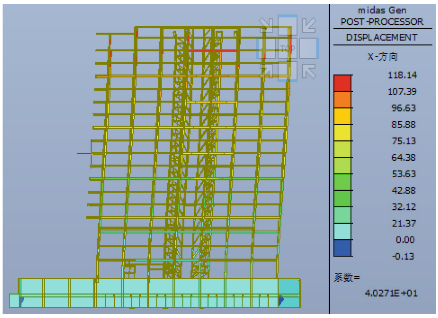

Fig. 7. Final assembly model X-direction deflection

the deflection difference in the Y direction is 0.93%, and the deflection differences in the X and Y directions are very small. According to this simplified method, the deflection of the pure main structure analysis and the deflection of the final assembly mold are basically consistent in Fig. 5, Fig. 6 and Fig. 7 (Fig. 4).

Table 2. Comparison of Deflection Between Pure Main Structure and Final Assembly Model

Model	Maximum deflection in Y direction (mm)	Maximum deflection in X direction (mm)
Pure main body (considering the influence of curtain walls)	160.66	119.24
Final assembly model	161.37	118.14

2.5 Comparison of Deflection Between Pure Large-Span Curtain Wall Structure and Final Assembly Model

When analyzing the pure large-span curtain wall structure, the influence of the main stiffness was considered, and compared with the final assembly model analysis, only the Y-direction deflection was studied, as shown in Table 3. According to the analysis in the previous section, the deformation of the pure main structure in the Y-direction is 160.66 mm. When considering the stiffness of the main structure, the Y-direction deformation of the large-span curtain wall structure is 0.16 mm, and the relative deformation of the pure main structure in the Y-direction is 161.37–0.16 = 161.21 mm, which is 0.34% different from the deformation of 160.66 mm when analyzing the pure main structure alone, and the difference is very small. According to the analysis, the main structure has a linear relationship with the deformation of the large-span curtain wall structure, and the deformation is coordinated from top to bottom. Therefore, the main structure has little impact on the large-span curtain wall structure, and this simplified model method is feasible.

Table 3. Comparison of Deflection Between Pure Large-Span Curtain Wall Structure and Final Assembly Model

Model	Maximum deflection in Y direction (mm)
Pure large span curtain wall (without considering the deformation of the main body)	0.16
Final assembly model	161.37
relative deformation	161.21

2.6 Comparison of Interlayer Displacement Angles Between Pure Main Structure and Final Assembly Mode

Taking 16F as an example, when considering the influence of curtain wall load transfer, the interlayer displacement angle of the pure main structure is 1/3075 < 1/550; The inter story displacement angle of the main structure of the final assembly model is 1/3153 < 1/550, with a difference of 2.5%, which is relatively small. Analogy analysis of other layers shows that the differences are relatively small. From the analysis results, it can be seen that the main structure considers the influence of load transfer from the large-span curtain wall structure, and the interlayer displacement angle is very close to the calculation results of the final assembly model, indicating that this simplified model method is feasible.

3 Conclusion

By comparing the pure large-span curtain wall model (considering the main stiffness), pure main structure model (considering the influence of large-span curtain wall), and final assembly model on the period, interlayer displacement angle, and deflection of large-span curtain wall structure and main structure, it can be seen from the period that the modal trends of the sub model and final assembly model are consistent, and the interlayer displacement angle and deflection are also very close. The main conclusions are as follows:

1) The most accurate way to monitor various indicator data of the main structure is to use the final assembly model of the main body and large-span curtain wall structure for analysis and monitoring. However, in actual projects, many models are relatively large in size, and if we want to use the final assembly model for calculation and analysis, both configuration and efficiency requirements are relatively high. So it is necessary to simplify the model for analysis and processing to achieve the goal of improving efficiency.
2) The pure large-span curtain wall structural model is a simplified method of applying a large-span curtain wall structural reaction force to the main model, calculating and analyzing the lateral stiffness of the main structure, and then adding it back to the large-span curtain wall structural model for analysis and calculation. This simplified method greatly improves the efficiency of calculation and analysis. By comparing and

analyzing the results of the combined model calculation, it is found that the cycle and modal trends are consistent, and the differences in interlayer displacement angles and deflections are also very small. Therefore, the pure large-span curtain wall structure model can be analyzed separately in this simplified model method. However, in actual projects, comprehensive consideration needs to be given to the actual situation and engineering requirements.

3) The pure subject model is a simplified method of directly applying the reaction force obtained from the separate analysis of the pure large-span curtain wall structure to the subject, which takes into account the stiffness of the main structure. This simplified method also greatly improves the efficiency of calculation and analysis. By comparing and analyzing the results of the combined model calculation, it is found that the cycle and modal trends are consistent, and the deformation difference is also very small. Therefore, the pure main structure model can be analyzed separately in this simplified model method. However, in actual projects, comprehensive consideration needs to be given based on the actual situation and engineering requirements.

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