Structure selection and analysis of tower 6a and 6b in weihai civic center

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Abstract: Weihai civic center covers an area of 193,100 square meters and consists of four high-rise buildings and large podium buildings. The building is divided into two parts through structural joints, with two towers forming a frame-core tube structural system and the lower podium as a frame structure. Through the selection of different structural systems, the selection and structure of the structural system are analyzed.

1. Project Overview
The project is located in the east of tashan road, weihai city, east of the qunyi library and library. The project covers an area of 27,300 square meters and is used for commercial and financial purposes. The total floor area is 193,100 square meters, of which the floor area is 144,100 square meters. The main functions are office, commercial facilities, civil service hall, underground garage, equipment room, etc. The project site is high in south and low in north. The absolute elevation of 19.60 meters is plus or minus zero elevation. There are three floors underground, one to five floors above ground are podium buildings, and above the six floors are divided into four high-rise buildings: 5A, 5B, 6A and 6B. Among them, there are 16 floors on the ground of 5A and the building height is 71.00 meters. 5B has 22 floors above ground and the building height is 93.70 meters. There are 18 floors on the ground of 6A, and the building height is 86.20 meters. 6B is 22 floors above ground and the building height is 99.90 meters. The architectural effect is shown in figure 1.

Figure 1. Architectural renderings.
The design life of the project is 50 years, the safety level of the building structure is grade 2, the fire level of the building structure is grade 1\[1\], and the design level of the foundation foundation is grade a. According to the "Code for Seismic Design of Buildings" (GB50011-2010) (2016 edition) \[2\], the aseismic group 2 in the area where the project is located, the site category is category II, the aseismic grade is 7degrees 0.1g, and the office area is general fortification category (category c).

2. Structure selection and classification
This project is located in the seismic fortification intensity zone of 7 degrees, which belongs to the standard fortification type building. The project 6A, 6B consists of 2 towers, with the structural height of tower 6A 86.20 (18 floors) and tower 6B 99.90m (22 floors) respectively. The main structure adopts the concrete frame-core tube structural system. As the main lateral force resistance system, shear walls not only provide resistance to wind load and horizontal seismic action, but also bear the additional torsion effect caused by the mass center and stiffness center not coincide. The outer frame mainly bears the vertical load and the second seismic line.

Each tower has different degrees of core tube bias, which makes the center of mass and the center of stiffness of the floor structure more eccentric, and easy to cause torsion under horizontal action. Among them, tower 6A has a 20-meter cantilevered structure on floors 3-5, which aggravates the torsion effect of the structure under external load. In order to ensure that the structure has good lateral stiffness and strong torsional resistance, the layout of the shear wall and the stiffness of the core tube are adjusted, and the stiffness of the frame on the side away from the core tube is appropriately strengthened. Meanwhile, in order to resist the additional torsion effect brought by the cantilever structure, a thick shear wall is set at the proximal end of the cantilever end of tower 6A. Due to the high height of the first layer and the requirements of the seismic structure, the thickness of the shear wall in the reinforced area at the bottom is 400mm and 300mm, and the thickness of the shear wall at the top is reduced to 300mm and 200mm. The seismic bearing capacity and ductility of the shear wall are improved by increasing the stirrup ratio of restrained edge members. The outer frame column is reinforced concrete column, and the cantilevered frame column is steel concrete column. The load refers to Load code for the design of building structures\[3\].

2.1. Layout of high-rise structure
According to the function and shape of the building, the tower at the northwest corner and the tower at the southeast corner are proposed to adopt reinforced concrete frame-shear wall structure system, with 73.5m and 69.9m stories, which belong to grade A high-rise building structure. The frame - shear wall structure is adopted to form the reinforced concrete structure system with good ductility. Combined with the building function, shear walls are set in the elevator of the building, and elevators, elevator halls and equipment rooms are arranged internally to make the plane layout of shear walls as uniform as possible and reduce the torsion effect of the structure. The column spacing of the external frame columns of the building is 8.4m to 12m, and the reinforced concrete columns are used to gradually reduce the section of the external frame columns as the height of the floors changes.

Floor and roof structure with good overall performance, large floor stiffness, good for aseismic, simple and economic construction of cast-in-place concrete beam slab structure, in order to reduce the span of floor slab thickness, reduce weight, this project setup times between frame girder beams, and trabecular high reduction, increasing beam breadth, in order to make the use of space, building a higher facilitate equipment line passage and layout. Seismic grade of this area: the superstructure and the frame and shear wall on the first underground floor are first grade; The frame and shear wall of the second and third underground floors are two grades.

2.2. Podium structure arrangement
The podium building has 5 floors, with a structural height of 23.3m and a local height of 27.5m. There is no joint between the podium building and the main building, which constitutes a large chassis multi-tower structure. The podium building structure system is a frame-shear wall structure. Shear walls
should be added in the range of the podium to ensure the seismic performance of the podium, so as to prevent serious damage to the podium itself after the failure of the connection with the main building. In order to enhance the torsional stiffness of the large chassis, the toilet of the podium building and the elevator room of the building are arranged with shear walls.

2.3. **The setting of structural joints and post-cast belt**

2.3.1. **Shrink post-cast strip**

The plane size of the basement of this project is 145.4mX150.4m, and the plane size of the main building and the podium is 138mX52m, which is an ultra-long structure. In order not to affect the use function of the building, expansion joints are not set in this project, and construction measures of shrinkage post-pouring belt are set at intervals of every 30m ~ 40m to reduce the adverse impact of early concrete shrinkage on the structure. The width of the post-pouring belt is 0.8m. The post-pouring belt adopts non-shrinkage concrete one grade higher than the concrete strength grade of the two side members.

The following structural measures and construction measures are adopted in the design to reduce the adverse effects of temperature action and later concrete shrinkage on the structure:

1. The reinforcement should be as close as possible, and the proportion of the reinforcement should be increased appropriately.
2. Strengthen the insulation measures of the skirt roof layer and the top floor of the main building, and set the outer insulation layer on the outer wall.
3. Use of low shrinkage, low hydration heat of cement, appropriate to reduce the amount of cement. Add proper amount of fly ash to concrete.

2.4. **Settlement joint**

There are many different layers and loads between the main building, basement and podium, which makes the foundation settle unevenly. In order not to affect the use function of the building, settlement joints are not set in this project. The construction measures of setting settlement post-pouring belt are adopted in the design to reduce the adverse impact of foundation differential settlement. The post-settlement pouring belt is located at the junction between the main building and the podium, and at one side of the podium, with a width of 0.8m. It should be filled after the structure is topped and the foundation settlement is basically stable. The post-pouring belt adopts non-shrinkage concrete one grade higher than the concrete strength grade of the two side members.

3. **Calculation and analysis**

According to the technical code for concrete structures of high-rise buildings (JGJ 3-2010) [1], the 3d analysis and design software YJK (version 2.0.3) and the integrated 3d structural analysis and design system MIDAS Building 2019 were used for the structural analysis and design [5]. The influence of floor cavity is considered in the analysis. The superstructure is embedded in the basement roof of the first floor, The earthquake action and the wind load act in two main directions and the torsional effect under the two-way earthquake action is taken into account.
This project uses YJK as the main tool for structural design and calculation. Table 1 shows the main data of the northwest high-rise building:

### Table 1. Two types of software modal cycles and vibration types

| Vibration model | Period (s)  | Vibration type | period ratio |
|-----------------|-------------|----------------|--------------|
|                 | YJK MIDAS   |                | [0.90]       |
| 1               | 2.06 2.03   | Y              |              |
| 2               | 1.97 1.94   | X              |              |
| 3               | 1.67 1.74   | torsion        |              |
| 4               | 1.52 1.53   | Y              |              |
| 5               | 1.37 1.39   | X              |              |
| 6               | 1.13 1.13   | torsion        |              |

### Table 2. Interlayer displacement Angle comparison of software

|                      | YJK result | MIDAS result |
|----------------------|------------|--------------|
|                      | X          | Y            |
|                      | X          | Y            |
| small earthquakes    |            |              |
| 6A Maximum interlayer displacement Angle | 1/1526 | 1/1910 | 1/1589 | 1/2138 |
| 6B Maximum interlayer displacement Angle | 1/1538 | 1/1655 | 1/1617 | 1/1682 |
| Specification limits | 1/800 | 1/800 | 1/800 | 1/800 |
4. Conclusion
Main indicators contrast can be seen by the software, as the main computing software YJK structure analysis, the two high-rise s than 0.85, the first translation cycle meet specification requirements, structure in two directions at the bottom of the shear heavier than also meet the requirements of the resistance to gauge is not less than 1.2%. Both directions are less than the standard limit of 1/800. The two software calculation models are basically consistent, and the structural dynamic characteristics are basically consistent. The self-vibration period, inter-layer displacement Angle, displacement ratio and other indicators of the structure are similar, and all of them are within a reasonable range and meet the requirements of the current specification.

References
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