Structure selection and structure analysis of China publishing creative center

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Abstract. The China publishing creative center covers 100,000 square meters, which is composed of two towers and one podium. The building is divided into three parts through structural joints. The structural system of the two towers is the frame-core tube, while the podium is the frame structure. Through the selection of different structural systems, the selection and construction of structural systems are analyzed. Through structural calculation and optimization, the consumption of concrete and steel bars should be reduced as much as possible to reduce the impact on the environment.

1. Project Overview
The project is located at no. 30, honglian nanli, 28 honglian south road, xicheng district, Beijing, with a total construction area of 107154.63 square meters, including 71094.33 square meters above ground and 36060.3 square meters underground. High-rise building A (north building) 16 floors, 80 meters high, high-rise building B (south building) 16 floors, 80 meters high, podium 2-4 floors, underground 3 floors. The architectural effect diagram 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 8 degrees 0.2g, and the office area is general fortification category (category c).

2. Structure selection and classification

This project is located in the Beijing area, general situation is: the underground three layer (layer is 6 m, 4.8 m, 4.8 m), The elevation of the podium building is 19.50m. There are two main towers in the northwest corner and southeast corner of the building. There are 16 floors in the northwest corner tower (73.5m on the roof) and 16 floors in the southeast corner tower (69.9m on the top floor). According to characteristics of architectural function, the skirt building and separated by aseismatic joint between the main building, the building is divided into three regions, and the structure of the buildings have become independent units. The three underground floors ~ the three above ground floors are the reinforcing zone layer at the bottom of the shear wall, and the height is 14.90 meters. As the fixed part of the superstructure, the first floor roof is 180mm thick. The load refers to Load code for the design of building structures[3].

2.1. Northwest corner tower and southeast corner tower

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 building

The skirt floor is 4 stories high, with a height of 19.5m. It adopts a reinforced concrete frame structure system and a small amount of shear walls to increase the lateral resistance of the structure. 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 of the underground layer are first grade; The frame of the second and third floors underground is the second level.

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

Due to the large size of the underground garage (the total length of about 165m), therefore, every 30 meters or so set 800 wide anti-shrinkage post-pouring belt (a total of 7 in the vertical and horizontal directions); The above-mentioned post-cast belt shall be reinforced with micro-expansion concrete one
grade higher than the concrete strength grade of the corresponding component parts one month after the construction of the structure on both sides. The underground garage is an ultra-long building. In order to reduce the adverse effect of concrete shrinkage and temperature stress on the structure caused by the ultra-long building, the setting of expansion joints is cancelled. In order to solve the adverse effects caused by the excessive length of the structure, it is proposed to adopt the temperature stress analysis for the main structure, and effectively reduce the shrinkage stress by setting the post-pouring zone of temperature, controlling the temperature of concrete entering the mold and adopting appropriate additives to limit the development of structural cracks.

According to the code for design of concrete structures (gb50010-2010) [4], the space between expansion joints of reinforced concrete structures should not be more than 50m. And the dimension of basement plane of this project exceeds the limit value. In order to ensure the use of functions, the basement is designed to be undivided structural form, which belongs to the ultra-long structure, the temperature stress and concrete shrinkage deformation can not be ignored. In the design, the effect of temperature stress and shrinkage creep equivalent temperature stress are considered in detail, and according to the environmental conditions of different parts of the structure, corresponding structural measures are taken to solve the problem of concrete shrinkage may produce cracks. The following measures are proposed:

1. Concrete with a certain amount of fly ash (can also be mixed with fly ash and mineral powder) and efficient water reducer. The levels of fly ash should be not less than (ore powder level for the S95 II level).
2. Later concrete strength (60d) instead of 28d strength was used for mix ratio design to reduce cement consumption.
3. 25 ordinary Portland cement with lower hydration heat was selected. Under the premise of ensuring the design strength of concrete, the amount of cement should be strictly controlled. Reduce water-cement ratio, strictly control concrete slump.
4. Using 5mm~40mm continuous gradation of coarse aggregate, strictly control the mud content of sand within 1.5%, control the mud content of coarse aggregate stones within 1.0%.
5. For basement floor, roof, exterior wall and other parts that are greatly affected by temperature, the ratio of reinforcement should be increased appropriately, and the reinforcement should be smaller in diameter and spacing. The ratio of unidirectional long reinforcement is not less than 0.35%.
6. Adopt storehouse construction method
7. During the construction, the construction management of the post-pouring belt should be especially strengthened, and the moisture and maintenance of the post-pouring belt should not be less than 14 days after the construction.
8. During the construction, we should consider the concrete itself and construction technology, and design the proportion of concrete scientifically and rationally. When using commercial concrete, we should cooperate with commercial concrete mixing plant to make reasonable concrete construction plan.
9. Ensure sufficient curing of concrete and formulate concrete curing and moisturizing measures.

2.4. Settlement joint
The number of floors and loads between the main building, basement and podium of this project are different from each other, resulting in uneven settlement of foundation. In order not to affect the use function of the building, the construction measures of setting settlement post-pouring belt are adopted in this project design to reduce the adverse effect of differential settlement of foundation. The settlement post-pouring belt is located at the junction of the main building and the podium, with a width of 0.8m on one side of the podium. It should be refitted after the structure is capped and the foundation settlement is basically stable. Non-shrinkage concrete with a strength grade one grade higher than the concrete constructed on both sides is adopted for the post-pouring zone replacement.
3. Calculation and analysis

According to the technical code for concrete structures of high-rise buildings (JGJ 3-2010)\(^1\), YJK is adopted as the main tool for structural design and calculation in this project\(^5\). The following is a typical layout of the northwest and southeast high-rise buildings.

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. main calculation results of the northwest high-rise building

| Mode of vibration(s) | YJK |
|----------------------|-----|
|                      | T1  | 2.12 |
|                      | T2  | 1.95 |
|                      | T3  | 0.62 |
| T3/T1                | 0.29|
| Maximum inter story displacement angle | | |
|                      | X-direction earthquake | 1/1147 |
|                      | Y-direction earthquake | 1/879 |
| Ratio of maximum displacement to average displacement | | |
|                      | X-direction earthquake | 1.24 |
|                      | Y-direction earthquake | 1.31 |
| (Shear weight ratio) | | |
|                      | X-direction unidirectional earthquake | 3.948% |
|                      | Y-direction unidirectional earthquake | 4.19% |

Table 2 shows the main data of the southeast high-rise building:

| Mode of vibration(s) | YJK |
|----------------------|-----|
|                      | T1  | 1.63 |
|                      | T2  | 1.53 |
|                      | T3  | 1.27 |
| T3/T1                | 0.78|
| Maximum inter story displacement angle | | |
|                      | X-direction earthquake | 1/1139 |
|                      | Y-direction earthquake | 1/987 |
| Ratio of maximum displacement to average displacement | | |
|                      | X-direction earthquake | 1.07 |
|                      | Y-direction earthquake | 1.32 |
| (Shear weight ratio) | | |
|                      | X-direction unidirectional earthquake | 5.15% |
|                      | Y-direction unidirectional earthquake | 5.02% |

Main indicators contrast can be seen by the software, as the main computing software YJK structure analysis, the two high-rise buildings, the first, second cycle for translational cycle, the third cycle to reverse the cycle, the structure of the two direction stiffness were similar, and the structure of the first/reverse cycle is less 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. Considering the accidental eccentricity, YJK results show that the maximum floor displacement/average floor displacement (floor maximum inter-floor displacement/average inter-floor displacement) is 1.3. Meet the requirement that the specification should not be greater than 1.4.

4. Conclusion
Measures taken in this structural design for overruns:

1. The overall structure is divided into three parts through the reasonable setting of seismic joints, and designed separately, which effectively reduces the construction cost.
2. The overall calculation index of the structure is good, with good anti-seismic performance, meeting the performance design index of the structure and is not bad for small earthquakes.
3. The structure is located in the 8-degree seismic zone. Under small earthquakes, the seismic load is the control load for the overall stiffness of the structure.

4. Through structural calculation and optimization, the consumption of concrete and steel bars should be reduced as much as possible to reduce the impact on the environment.

References
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