Structural design and analysis of Yanqi Lake ecological development Demonstration Area in Beijing

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Abstract: Beijing lake yanxi ecological development demonstration project, a total of 60 square meters, consists of eight 50 tower and garage, tower, a total of seven family, layer number ranged from 8 to 15 layers, structure with shear wall structure, garage mainly adopts frame structure, through the choice of different structure and introduction, the structure system is analyzed.

1. Project Overview
This project is located in the yanqi lake ecological development demonstration area of Beijing (phase II), with a total construction area of about 637,000 square meters, divided into 9 plots, including 50 residential buildings, 8 underground garages, 2 supporting public buildings, 2 kindergartens and a nine-year school. The upper floors of each residential land are 9~15 stories, and the underground floors are 1~3 stories. Shear wall structure and raft foundation are adopted. The project has a total of 8 garages, each plot has an underground garage, the garage has two floors, most of which are level 5 civil air defense and level 6 civil air defense, a few of which are non-civil air defense, the underground first floor is an ordinary garage, the thickness of the garage roof is 2m thick. The garage adopts frame structure, independent plinth + waterproof board.
The design life of the project is 50 years, the safety level of the building structure is level 2, and the design level of the foundation foundation is level a. [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 and the aseismic grade is 8 degrees 0.2g, and the office area is general fortification category (category c).

2. Structure selection and classification

2.1. Structural system analysis
This project is located in Beijing, with a total of 50 residential buildings, which are 1-3 floors underground and 8-15 floors aboveground, all of which adopt shear wall structure. Concrete strength grade: wall, beam, slab, foundation are C30. There are 8 underground garages, all with 2 floors underground and frame structure. Concrete strength of the garage: wall, column, beam, board, foundation for C35, stairs C30; The roof of the garage is 2.1 meters thick, and the civil air defense of the basement is level 5 and 6. The roof of the civil air defense and the roof of the overlying soil layer all adopt the frame structure-beam and plate structure system. The thickness of civil air defense roof is grade 5 350, grade 6 250, and the thickness of overburden roof is 250-300. Foundation plan: garage adopts independent foundation + waterproof board, high-rise residence adopts flat raft board foundation and public construction adopts independent column foundation. There are 7 different apartment types in the 50 residential buildings. In the structural design and drawing, the unit apartment type is taken as the basic unit, and the floor plan is formed by combining different unit drawings. Figure 2 is the unit diagram, and figure 3 is the layout diagram. The load refers to Load code for the design of building structures [3].
2.2. The setting of structural joints and post-cast belt

Because underground garage area is very long structure. Therefore, it is necessary to set 800 wide anti-shrinkage post-pouring belt every 30-40 meters in the garage. 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 [4] (gb50010-2010), the space between expansion joints of reinforced concrete structures should not be more than 50m or so. 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.

2.3. Settling post-cast belt
This project's main building garage load difference is more, causes the foundation to produce the uneven settlement. 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. A settlement post-pouring belt with a width of 800mm is set between the sunken garage and the main building, and a settlement joint or post-pouring belt is set between the garage, ramp and underground passage. 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.

2.4. The connection between the garage and the foundation of the main building
The bottom floor of the garage is -9.42m, and the elevation of the bottom floor of some main buildings is -6.3m, with a height difference of 3m between the two. The foundation of the main building is raft foundation, while the foundation of the garage is sole foundation + waterproof board. In order to solve the problem of height difference between the two, the waterproof board of the garage and the main building used to release the slope step by step through the steps before, the Angle of releasing the slope is 60 degrees, and the ratio of releasing the slope is 1:2. Figure 4 is the layout of slope relief.

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]. Three of the seven apartment types are calculated and analyzed.
Table 1. main calculation results

| Mode of vibration(s) | (X+Y) | coefficient of torsion | Modal type | Period ratio Tt/T1 |
|----------------------|-------|------------------------|------------|-------------------|
| Z4+Z4               |       |                        |            |                   |
| T1                  | 1.29  | 1.0 (1.0+0.0)          | X          | 0.7               |
| T2                  | 1.25  | 0.98 (0.00+0.98)       | Y          |                   |
| T3                  | 0.91  | 0.03 (0.03+0.00)       | torsion    |                   |
| Z5+Z5               |       |                        |            |                   |
| T1                  | 1.25  | 1.0 (1+0.0)            | X          | 0.6               |
| T2                  | 1.09  | 0.98 (0.0+1)           | Y          |                   |
| T3                  | 0.75  | 0.00 (0.00+0.00)       | torsion    |                   |
| Z6+Z6               |       |                        |            | 0.65              |
| T1                  | 1.17  | 1.0 (1+0.0)            | X          |                   |
| T2                  | 1.06  | 0.98 (0.0+1)           | Y          |                   |
| T3                  | 0.76  | 0.00 (0.00+0.00)       | torsion    |                   |

Main indicators contrast can be seen by the software, as the main computing software YJK structure analysis, general design index is better, 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 case of accidental eccentricity, YJK results show that the maximum displacement/average displacement (maximum inter-storey displacement/average inter-storey displacement) of the floor is 1.15, which meets the requirement that the specification should not be greater than 1.4.

4. Conclusion
This paper introduces the structure design of yanqi lake ecological development demonstration zone in Beijing and introduces the structure system, basic form and split way. The feasibility of the project is verified. Through structural design and structural calculation analysis, the seismic performance of the tower is good and meets the requirements of the code study.

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