The Design of Chengdu Railway South Station Hub Urban Complex Project

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Abstract. The hub city complex project of Chengdu railway south station is a large multi-function complex. The plane size of the two way maximum structure is 220m*146m, the main body of the structure is super long structure and the crack control is strictly required. This project uses the cast-in-situ unbonded prestressed concrete two-way ribbed floor system in the roof with high crack resistance, which greatly facilitates the construction, reduces the cost of the project and shortens the time limit. This article will introduce related contents of the project design for designers.

1. Introduction
The hub city complex project of Chengdu railway station integrates architectural, commercial, office, catering, exhibition, leisure and other functions in one building. The effect picture is shown in Figure 1, and the structural partition diagram is shown in Figure 2. The total construction area is 265905.2 m², which mainly consists of new-built parts and expansion parts: Commercial Podium in Area A, Office Building in Area B, New high-rise residential building in Area C, and Area D Steel structure. The new building has a three-story basement, with high-rise residential buildings, office buildings and large commercial podiums integrated into the underground. Between the high-rise residential buildings and commercial podiums above the ±0.000m, structural seams are provided between office buildings and commercial podiums, each of them is an independent structural unit.

The plane size of the commercial podium (Area A) is 220m*146m. The height above the ground is 31.875m, a total of nine floors, three underground floors, and six floors above ground. The height of the basement is 4.5 meters, 4.2 meters and 4.5 meters respectively. In addition to the first layer on the ground, the first layer is 6.0m, and the remaining standard layer is 5.1m high. The main column net is 9.0m*9.0m.
2. Structural analysis

2.1. Design Parameters
The structural design working Life of this project is 50 years. The basic wind pressure is 0.30kN/m² (once in 50 years), the ground roughness category is Class B, and the wind load shape coefficient μs is 1.4. The basic snow pressure is 0.1kN/m² (once in 50 years), the snow distribution coefficient is 1.0, the quasi-permanent value of the snow load is partitioned into III Area. The earthquake fortification intensity is 7 degrees, the basic earthquake acceleration value is 0.10g, and the design earthquake grouping is the third group. The site category is II Class, structural elastic damping ratio of 0.05, the characteristic period of the site seismic response is 0.45s, and the multi-site seismic influence coefficient is 0.08.

The commercial podium in Zone A is an extremely long structure. The maximum size is 220m*146m underground and 140m*145m above ground. It is necessary to calculate the temperature effect. We choose 12 °C ~ 25 °C as the range of closing temperature, temperature changes: the second floor and above, temperature +10 °C, cooling -15 °C; basement roof, temperature +7 °C, cooling -10 °C; underground floor, Warming +5°C, cooling -7°C.

2.2. Building Classification Level
Safety grade of building structure: According to "Unified standard reliability design of building structures" (GB50068-2001), it is Grade II. Foundation design level: According to the "Code for design of building foundation" (GB50007-2002), Grade A. Seismic fortification of buildings: According to "Standard for Classification of Seismic Protection of Building Constructions" (GB50223-2008), it is a key type of fortification (Group B). Structural earthquake-resistant grades: According to "Code for Seismic Design of Buildings" (GB50011-2010) and "Technical specification for concrete structures of tall building" (JGJ3-2002), Frame Level II and Shear Wall Level I.

The main materials used in the structure are as follows:
2.3. The main analysis results
The structure analysis uses the SATWE:2008 version. The basement roof is chosen as the fixing part. The data in this paper come from the calculation model containing the basement.

2.3.1. Maximum effect of vibration mode, period, and earthquake effect

The steel bar is HRB400, Steel strand with 1860MPa grade with 15.2 low relaxation steel strand.
The most unfavorable direction of the earthquake: 85.64 degrees; the first torsion period/first translational period = 0.8815/1.0039 = 0.887 < 0.90, meeting the specification requirements.

2.3.2. the displacement angle between floors
According to the "Technical specification for concrete structures of tall building" (JGJ3-2002), the interlayer displacement angle limit of this project is 1/800. The interlayer displacement angle diagram of the floor is shown in Figure 5. The displacement ratio of the floor under the accidental eccentric earthquake of Y-5% is the largest, the calculated value is 1.28, the floor displacement ratio is shown in Figure 6 ~ 7, and the displacement ratio of all floors is within 1.40, which meets the requirements of the code.

2.3.3. the frame withstands earthquake overturning force checking
Under the action of earthquakes, the seismic overturning moment of the bottom frame part is greater than 50% but not greater than 80% of the total earthquake overturning moment. See Figure 8 ~ 9. According to JGJ3-2002, the structure system is frame shear wall structure, the limit of the seismic grade and axial compression ratio of the frame structure is adopted according to the framework of the frame structure.
3. Design Features

3.1. Design of two-way ribbed floors for GRC shells

The choice of floor plan is a comprehensive science, which is influenced and constrained by many factors. To measure the economic benefit of a building, we should not only look at the unit price of the slab or the structure cost of the floor, but rather focus on the overall economic indicators and functions of the whole building, and choose the floor plan reasonably. In modern high-rise buildings, the total height of buildings is generally limited by urban planning. Under the condition that the floor height is limited and the building area can not be reduced, the reasonable floor plan should have comprehensive factors such as reducing the thickness of the structure layer, reducing the weight of the structure, the function of the building does not affect, and good comprehensive economic effect.

This structure is an ultra-long structure. According to “Technical code for waterproofing of underground works” (GB50108-2008), the waterproof grade of the planting roof in the basement power distribution room and the basement is grade I, the crack control is strict. In order to solve the structural stiffness requirements and crack resistance requirements, The cast-in-place unbonded prestressed concrete two-way ribbed floor system is applied to the basement roof of the project with high crack resistance. The two-way multi-ribbed floor system combines the concrete dense ribs with the prefabricated mold technology. It adopts the GRC formwork construction and can be molded at one time without mold removal, which greatly facilitates the construction, reduces the construction cost and shortens the construction period.
3.2. Glass Box and Concrete Connection

At the entrance of the sinking plaza on the southwest side of Zone A, the steel structure "Glass Box" is set up with the height of the podium, which was designed by Liu Peilin. The glass box steel column was connected with the concrete frame of the A area at the basement. We need fine design node the connection node.

The 2000mm thick overburden in the roof of the basement leads to a large amount of steel reinforcement in the roof beam. To avoid excessive steel bars passing through the steel column web, some concrete frame beam is replaced by a steel reinforced beam, the steel section is I-shaped. The 6 axis concrete column has the cross shaped steel bone because of the two-way steel cross. Because the glass box column net is not the same axis as the concrete Frame of A area, the beam with 6 to 1/8 axis on the A axis of the basement roof is designed to be 1550mm. The I-beam is arranged eccentrically, center line of the web is the B axis (node 1 in the figure below), the column is enlarged to 1550mm in the direction of the letter axis, near the steel column 900mm, the steel beam is set with a 1:6 haunch to avoid the steel column (node 1 and node 3 below), the specific node design See below:
3.3. Partially Unsupported Exterior Wall Design of Sunken Square

In the southwestern corner of the project, a sunken square (beside the glass box at the front of the section) is installed. Due to the functional requirements of the building, the structural floor cannot be set. The elevation of the outer wall of the outer wall is -17.0m, and the elevation of the outer wall is -0.365m. The total height is 16.635m. According to the conventional design, the side wall of the concrete wall with a thickness of 600mm cannot control the crack within 0.3mm².

For this purpose, horizontal beams QLa and QLb are added to the floors which without slab, and the force transmission way of lateral walls are transferred from vertical to horizontal. Water pressure outside the side wall of the horizontal beam passed to both sides of buttress column and vertical range wall on the floor. The wall, when QLa and QLb have sufficient stiffness and strength to bear this horizontal force, the exterior wall can be designed in accordance with ordinary floor support. According to this design method, WQ8 added horizontal beams with a cross-section size of 1350*700 at -10.250m and -5.850m elevation respectively. After calculation, the design section of the WQ8 sidewalls was finally as follows (BW expansion waterstop was later modified to Water-proof steel plate); The project has been completed and put into use for more than five years. No water seepage and cracking has been found during the use. It is found that the method is effective and feasible by engineering inspection.
3.4. Shear-ring beams design

Umbrella steel structure \(^3\) is a unique design in this project. The largest umbrella steel structure --1# steel rain shed in this project is set up at the surface of the podium of the A area (6 storey). Inside the steel canopy ring is the core tube where the 11# and 12# stairs are located, and the dense column of the canopy takes root in the 6-storey. According to the flat form of the canopy, the concrete ring beam HL1 is installed on the periphery of the core canal in this area. The section size of the ring beam is 1200*1400. In order to ensure the net height of the substructure, the top elevation of the ring beam needs to be turned up 300mm. Concrete design is shown in the figure. 21.

4. Conclusion

The construction of this project is huge, and the two way are too long. The temperature stress of the structure has great influence on the whole structure. Different design methods should be taken to meet the different needs of waterproof and anti-cracking. According to the way of force transmission, it is a continuous beam calculation model or one way plate model. When the pure vertical force is difficult to realize, it is a good choice to realize the bidirectional transmission of the external wall by increasing the horizontal beam. The two-way multi-ribbed floor cover can reduce the thickness of the structural layer and obtain a good building space. If the traditional wood template is used, not only the construction is difficult, but also the cost of the formwork is high. The GRC model can be used to form the support frame once without disassembly. The model greatly facilitates construction, reduces
construction costs, and shortens the construction period. With the constant renewal of building materials, the appearance of a new type of eco-friendly formwork will more effectively expand the use of this type of floor.

Figure 21. Plan of concrete ring beam reinforcement

Figure 22. Connection of steel structure and area A

Figure 23. Connection of steel structure and A area

Figure 24. Connection of steel structure and A area

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