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Analysis of High-level Transformation Structure Design

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Abstract: *With the rapid development of architecture, the design form become different with the traditional architectural design, among which the beam-type high-level conversion layers is a typical example. This article mainly discusses some differences between the structural design of high-level transformation buildings and the design of general tall building in combination with actual construction projects. Through work experience, put forward some principles on the design of high-level transformation structure.*

Keywords: *Tall Building; Beam Type Transformation; Conversion Layers Structure; Design Principle*

1. Introduction

At present, the development of tall building rapidly in the world, with the requirements for building functions and appearance are getting higher and higher, modern of the tall building are also getting taller and more complex. From the perspective of architectural functions, it is required that the lower part of the building needs as much free and flexible space as possible. For example, in order to increase the parking space and driveway space in the basement, the ground floor and related floors also need a large space for business operations, which requires building The column network of the lower structure is larger, and the shear walls are as few as possible; the upper floor is for residential use, in order to meet the requirements of residential functions, the axis network needs to be denser and more walls are installed. A simple understanding is that the building function requires the lower structure of the building to be a frame structure and the upper part to be a shear wall structure.

From the perspective of structural force, if the lower part of the building is relatively force and the upper part is less force, it is necessary to reduce the column net and increase the number of shear walls in the lower part to improve the rigidity of the lower structure; while the upper part should increase the column net and reduce shear walls to reduce stiffness. Obviously, that from the perspective of structural force, the layout and the requirements of building functions are deviated from each other. Now, in order to meet the building function, the structure must be "unreasonable" design. However, in order to realize this kind of structural system, it is necessary to set up horizontal transformation components on the transformation floor, which is the conversion layers structure.

Display of currently constructed tall building with conversion layers, the forms of it generally include: beam type, thick plate type, truss type, box type, etc. Among them, the beam type conversion layer used frequently for compared with other forms, the layer has the advantages of clear force, clear force transmission path and convenient construction.

In the code, the calculation methods and requirements for the structural system are different according to the location of the conversion layer. When the floor where the conversion layer is located on the third floor or above, we usually call this conversion structure a high-level conversion structure. In this paper, combined with a high-level conversion tall residential building (the conversion floor of this building is located on the third floor), according to the problems encountered in the process of project model calculation and construction drawings and the treatment methods, the design difficulties and design principles of the high-level conversion structure was analyzed.

2. Project Overview

The project is located in Shenzhen. One of the tall residential buildings is a high-level transformation structure. The specific overview is: 7-degree area, the main seismic grade is Level 2, and part of the frame-supported shear wall structure system. There are 21 floors above the transformation floor. With a

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total height of 88.25, the conversion level is located on the third floor.

According to "Technical specification for concrete structures of tall building", there are certain requirements for the section size of frame beams. For example, the beam width is greater than the upper shear wall, and the beam height is greater than 1/6 of the beam span. However, in real projects, the dimensions of the transformed beams far exceed these minimum limits. The force form of frame beams is different from other ordinary frame beams. The force situation is mainly affected by the stiffness of the upper wall transferred to the load, the stiffness of the transformation beam itself, and the stiffness of the transformation column supporting it. In particular, some conversion beams with a large number of supporting layers have a particularly large shear force. It is obviously that the section size of the conversion beam is large for the requirements of the standard shear-compression ratio.

Through the model calculation, the final structural plan of the conversion layers is designed as follows (Fig1):

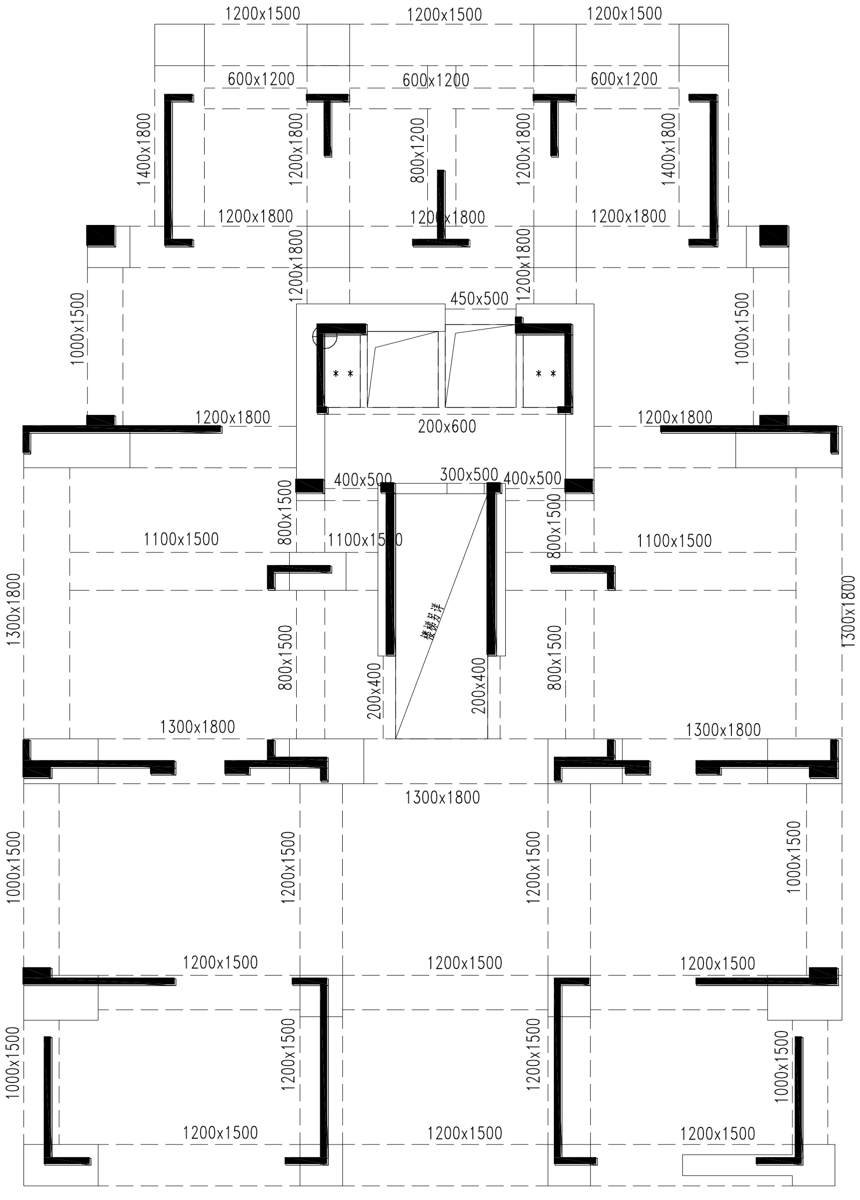

Figure 1: Structural layout plan

3. Control Points of High-level Transformation Structure Design Specification

In the high-level transformation structure system, for vertical irregularity, the conversion layers and the adjacent floors below are relatively usually turn to weak layers. In the code, the control of this structure type is more strict than other general tall building. Including structural regulations, seismic

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grades and calculation indicators.

3.1. In Terms of Structure Regulations

The thickness of the conversion layer should be at least 180mm, use double-layer and two-way reinforcement, and the reinforcement ratio should not be less than 0.25%. The floors on the upper and lower floors of the conversion layer should be properly strengthened, and the thickness of the floor greater than 150mm.

In the seismic design of the transformed beam, the minimum reinforcement ratio of the longitudinal reinforcement shall be not less than 0.6%, 0.5% and 0.4% for the first, first and second grade respectively; at least 50% of the longitudinal reinforcement of the upper longitudinal reinforcement of the transformed beam under eccentric tension shall be along the full length of the beam. Through, the lower longitudinal reinforcements all go straight into the column, along the beam web height should be equipped with waist reinforcement with a spacing of not more than 200 and a diameter of not less than 16; the stirrups in the encrypted area should not be less than 10 mm directly.

The transformation column shall use compound spiral hoop or well-shaped compound hoop, densified along the full height of the column. The diameter of the stirrup shall not be less than 10mm, and the spacing of the stirrups shall not be greater than 100mm and the smaller value of 6 times the diameter of the longitudinal steel bar; The characteristic value of stirrups should be increased by 0.02 compared with the value required by ordinary frame columns, and the volume of stirrups should not be less than 1.5%.

3.2. In Terms of Seismic Grade

The seismic grade of the main body of the structure is Level 2. In the high-level transformation structure, the seismic grades of components (including beams, columns and walls) at different structural positions are different, and the specific seismic grades of the components need to be specially defined in the model.

For this project, for some frame-supported shear wall structure types, the shear wall at the bottom reinforcement area is first-class, the frame-supported frame is first-class; in the high-level transformation structure type, the frame column and the reinforcement area at the bottom of the shear wall are classified as first class. The earthquake resistance level of the equipment should be increased by one level on the basis of the regulations (Table 3.9.3 and 3.9.4 of the technical specification for concrete structures of tall building), and it may not be increased when it is already in first-class. Therefore, in this project, the seismic grade of the converted beam is grade 1, the converted column is graded special grade, and the floor-to-ceiling shear wall in the reinforcement area at the bottom is graded special grade.

In actual projects, in addition to the issue of the seismic grade of components clearly stipulated in the code, designers should combine theoretical knowledge and understanding of the code to appropriately strengthen the seismic grade of components within the relevant scope.

3.3. Calculation Indicators

Compared with general tall building, the calculation indicators of high-level transformation structure mainly has some differences in lateral stiffness ratio and earthquake overturning moment ratio.

1) Lateral stiffness ratio

Regarding the lateral stiffness ratio of the structure, the main methods currently used including: the equivalent shear stiffness ratio method (Technical specification for concrete structures of tall building formula E. 3.5.2-1), the floor lateral stiffness ratio method considering the correction of the storey height (Technical specification for concrete structures of tall building formula 3.5.2-2) and the equivalent lateral stiffness method (also called the shear-bending stiffness, Technical specification for concrete structures of tall building formula E.0.3). The calculation methods used to calculate the lateral stiffness ratio are also different for different structural types and structural positions.

For the high-level transformation structure, the lateral stiffness ratio of the conversion layers to the upper layer should not be less than 0.6. In terms of period calculation, it is calculated by the ratio method of the floor shear force and the inter-story displacement; the equivalent side of the lower structure and the upper structure of the conversion layers is calculated. The ratio of longitudinal stiffness should be

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close to 1, not less than 0.5 for non-seismic design, and not less than 0.8 for seismic design.

2) The seismic overturning moment borne by the frame-supported frame should be less than 50% of the total seismic overturning moment of the structure. The main purpose of this specification is to suggest increasing the number of landing walls.

4. High-level Transformation Structure Design Principles

The design calculation of the high-level transformation structure is also a professional technical challenge for the structural designer. Due to the irregularity of the structural system itself, it brings a series of difficulties to the structural designer. Through the accumulation of experience in actual construction projects, the following are some design principles that should be noticed in the design of high-level transformation structure types.

4.1. Symmetrical Arrangement of Transformation Columns and Shear Walls

In the process of arranging the building structure, it must be arranged according to the corresponding technical code. Especially for the arrangement of transformation columns and shear walls, the symmetry of the two must be maintained as much as possible. The position of the conversion column is preferably in the middle of the conversion beam. The purpose is to prevent the conversion beam from having a certain impact on the conversion column when it is seriously deformed, so that it can also find deformation and cause adverse effects on the entire conversion layer.

4.2. Ensure the Rigidity of the Conversion Layer

The rigidity of the transformation beam must reach a certain rigid standard, otherwise the seismic performance of the building will be greatly affected. The height of the conversion beam section can be estimated initially based on 1/8 to 1/6 of the span. The more layers lifted, the higher the conversion beam section; the side length of the conversion column is not less than the width of the connected conversion beam, and not less than 1/12 of the conversion beam span. which subject to the axial compression ratio and reinforcement.

4.3. Define the Lastic Floor

According to the research in this area, for the frame-supported transformation structure, the transformation beam will not only generate bending moment and shear force, but also generate a large axial force cannot be ignored. In the SATWE software, the axial force of the transformed beam can only be generated by defining an elastic floor. Therefore, for high-level transformation structures, elastic floors must be defined for the entire floor of the transformation floor.

4.4. Arrangement of the Shear Wall on the First Floor of the Transformation Beam

When arranging a shear wall on a transformed beam, if the two ends of the wall pier fall under supports of different properties, the internal force calculation result of the shear wall will be abnormal (for example, the axial compression ratio of one end of the wall pier is particularly large, and the axial pressure of one end is very large. The ratio is even 0), in order to reduce this effect, it should be avoided that the two ends of the wall pier fall on the supports of different nature, and the horizontal symmetry and vertical continuity of the wall pier should be maintained.

4.5. The Position of the Conversion Layer Structure Cannot Be Too High

In the design of high-level transformation structures, the height of the conversion layers should be controlled for the height is too high and the rigidity of the conversion layers is reduced, not only the structural design index is not easy to control, but also the internal force of the transformation column and the transformation beam increases, it is easy to find over-reinforced and deformed to destroy, the building cost will also be greatly increased.

4.6. Other Matters Needing Attention

Arrange as many main beam conversions as possible and less secondary beam conversions,

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simultaneously, the regularity of the column network should also be considered. In order to improve the torsion resistance of the conversion beam and its stability, secondary beams can be intentionally arranged outside the plane of the conversion beam. On the basis of taking into account the function of use, try to drop the wall as much as possible. When a choice must be made, the upper long wall should be dropped as much as possible.

Experience has shown that the reinforcement of frame pillars is generally constructed, and the reinforcement of transfer beams is mostly constructed. Otherwise, the rationality of component size should be noticed. The reinforcement ratio of the calculated reinforcement should not be too large in a small amount, control it at a maximum of 1.0%. The main considerations are as follows:

When the calculated reinforcement is too large, the ductility of the component is reduced, and it is difficult to discharge the reinforcement in the construction drawing stage.

5. Conclusion

In the tall structure with conversion layer, due to the discontinuity of the vertical lateral force-resistant members at the position of the conversion layer, the force transmission path changes, and the force on the structure becomes complicated, it is easy to become a weak layer of the structure, which has an impact on the overall stability of the structure.

This paper mainly through a high-level transformation design project, lists the control characteristics of the high-level transformation structure, and summarizes the design principles and precautions in the design of the high-level transformation structure.

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