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Analysis of Shear Wall Structure with One-way and Small Wall

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The X-direction frame, which is composed of Y-shear wall and floor, is involved in the anti-side and floor of the X-way shear wall structure by the simplified model. It should be designed and strengthened as a bending member in the anti-side frame system. In this paper, the internal force of the floor design and the conventional design is compared with that of the conventional design. The floor is only considered in the vertical structure in combination with the performance target. In addition, the relationship between the shear rate of the outer wall or the shear wall and the actual model can be verified with the results of the simplified model analysis

1. Introduction

Based on the concept of seismic design, shear wall and frame - shear wall structure should be arranged in both directions shear wall, which should be the direction of two main axis of the lateral stiffness (Zhu and Tan, 2011; Matsusaka and Yasuda, 2017). Due to the need of ventilation and lighting, some residential buildings are arranged in the north-south direction of the shear wall, which resulting in the east and west shear wall is less. Thus, the wall is shorter or even completely degraded into the end column, the structure of the two directions has significant different characteristics (Kui, 2013).

Engineering experience shows that the direction of the structure of such a small wall tend to have a considerable lateral stiffness, and then to meet the norms of the deformation limit. However, the direction of the wall structure of the overall stiffness is how the formation of horizontal force to pass (Miao et al., 2012). And whether there is a conventional design cannot envelope the insecurity, which is the urgent need to be studied and solved.

The shear wall is mainly responsible for the vertical force and the level of horizontal shear, which are the key components of the structure (Qiao et al., 2006). At present, the commonly designed software only takes into account the stiffness of the shear wall, but does not check the outer bearing capacity, while only the internal bearing capacity is reinforced and checked. The conventional two-way evenly arranged shear wall structure is small with wall surface force, and the design does not consider that the conventional design can envelop the unfavourable factors, which will not affect the structural safety (Loo et al., 2015).

Due to the direction and the layout of the in-plane shear force single-direction wall structure, the other side effect of the shear wall surface cannot be ignored, such as according to the general structure of the shear wall, thus wall structure design may have greater security risks. Standard layer plane and build number map can be seen in Figure 1.

In general, the floor bears and transmits vertical loads, while coordinating the deformation of the vertical members and distributing the seismic action. Conventional structure level load is small under the floor of the outside of the bending effect (Dejoan and Leschziner, 2006). However, the contribution of the uniaxial wall structure to the shear wall in the "weak axis direction" is relatively small (Adebar and Mahmoodi, 2014).

The anti-side effect of the outer shear wall and the floor may not be overlooked, and its damage may affect the safety of the structure. Combined with simplified cases and practical engineering cases, this paper will focus on single-way low-wall structure of the floor stress and seismic design problems.

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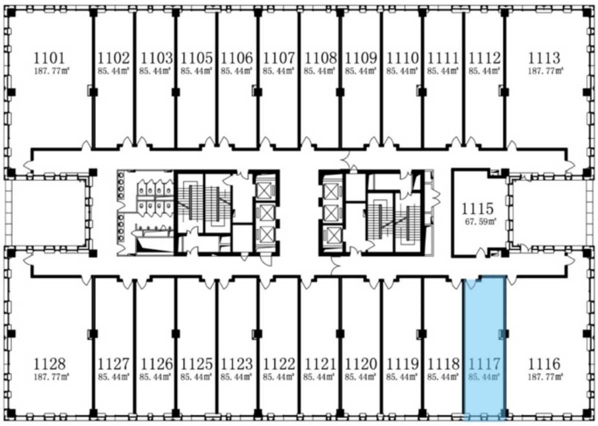

Figure 1: Standard layer plane and build number map

2. Simplified model

2.1 Basic information

The X-ray length is 42m, the length of Y is 15m, and the number and length of the structure X-shear wall are much less than that of Y-direction (The direction of the wall are X-direction). The use of ETABS can establish the analysis model, the shear wall and floor using shell unit, the floor by finite element way guide, and beam rod unit (Zander et al., 2013). Fortified intensity of 7 degrees (0.1g), the characteristic period of 0.35, the basic HE0.75kpa, floor additional load and live load of 2.0kpa, thickness 100mm, 1F ~ 10F wall concrete grade C40, 11F-32F for the C30, and beam , board concrete are C30, component size is detailed in Table 1.

Table 1: Component size table

Component name	Section height (mm)	Section width (mm)
Wy1~Wy4	300\250\200	6000
Wx1-1~Wx1-4	300\250	600
Wx2-1~Wx2-2	300\250	2300
L1/L2/L3	500\500\600	250

2.2 Force characteristics

The overall calculation results of the simplified model are given, and the displacement curves of each layer are shown in Figure 2.

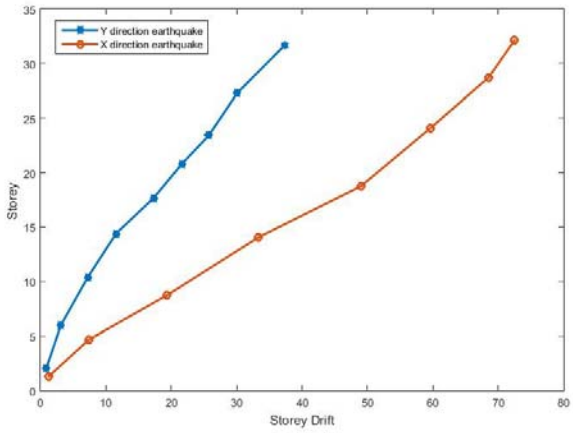

Figure 2: The displacement curve of each layer under earthquake

The deformation curve of Figure 2 shows the "curved shape" characteristic of the Y-shear wall structure, the X-direction of the frame-shear wall structure and the shape of the shear wall structure (Namgung et al., 2011).

It can be seen from Table 2 that although the X- In order can explain the reasons for the formation of X-direction stiffness, and a 6m long shear wall (300mm thick) is extracted from the whole model (Park and Ang, 1985). In this paper, a column with a rod spacing of 6m (beam 250mmx500mm, column 300mmx600mm), is used to establish a layer, 8 layer, 16 layer and 32 layers of the plane anti-side structure. In addition, the application of 100kN level nine vertex lateral displacement on the top has the results in Table 2.

Table 2: Comparison of lateral displacement of plane structure

Floor number	Roof displacement	Frame top displacement	Frame/wall
1	0.05	3.56	79.4
8	4.43	55.5	13.2
16	33.6	154.7	5.3
32	234.5	568.3	3.2

It can be seen from Table 2 that the lateral displacement of the frame and the vertex of the wall are getting closer and closer with the increase of floors (Wei et al., 2012). This is because the lower shear wall is useful for the shear deformation, when it reached a certain height, the bending deformation is more obvious, and then the shear stiffness advantage of the shear wall is relatively weakened (Schanderl and Manhart, 2016). Extended to the overall structure, X is set to as long as you have enough plane length or as long as there are enough "lattice" frame unit, and then weaker force direction can seemingly shape the side stiffness.

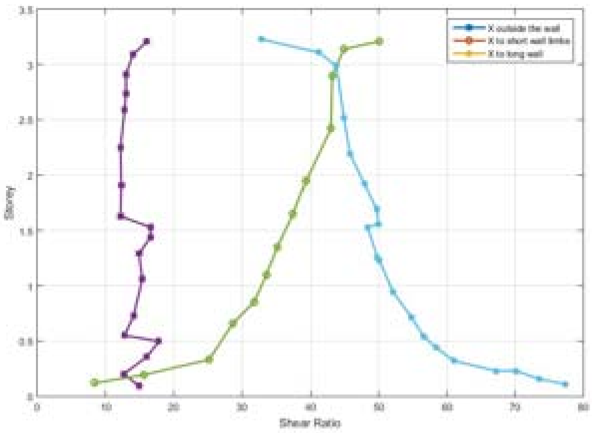

Figure 3: Shear rate

Figure 3 shows that the bottom X to the long wall shear force has the sharing rate of 77.3%, X to short wall limbs 8.7%, Y to outside the wall is near 14%. The sharing rate of the long wall gradually decreases, and the "short wall" share increases gradually with the increase of the floor, which is consistent with the characteristics of the frame-shear wall structure. And the share rate outside the wall fluctuations along the floor smaller, which is basically between 12% and 16%. It is clear that the structure of the X-way anti-side system consists of the following three parts: 1) long wall limbs, 2) short walls and floor beams constitute the frame, 3) shear wall and floor composed of weak frame. In the case of weak sight, the size of the contribution of the wall is outside the shear wall.

In the weak frame composed of the shear wall and the floor, the flexural rigidity of the floor and the influence of the bending stiffness on the self-vibration period of the structure are 3.57% and 11%, respectively. In the actual project for the simplified calculation, using the membrane unit to simulate the impact on the overall structure of the target may be small, and the floor bearing capacity may cause significant impact, thus the floor design only considers the vertical load bending moment, while it do not consider horizontal bending of the floor under the floor. In addition, the one-way low wall structure of the floor may bring insecurity.

3. Floor stress analysis

3.1 The stress analysis of the floor under the action of X direction with small earthquakes:

In order to examine the normal stress in the middle of the floor, the stress difference of the upper and lower surfaces, which is caused by the bending of the floor, should be eliminated, and the shell element with the outward bending stiffness is modeled (Zander et al., 2013). The stress floor of typical floor under X - shaped earthquake can be seen in Figure 4.

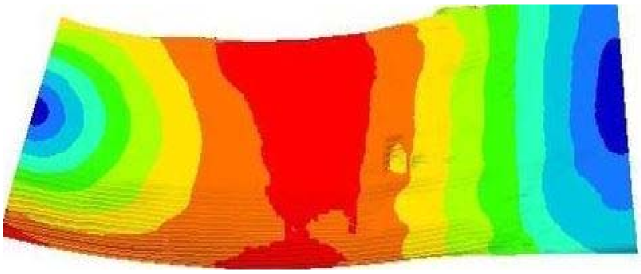

Figure 4: The stress floor of typical floor under X - shaped earthquake

Figure 4 shows that the tensile stress of the floor is small under the action of X-direction, and the tensile stress of the left and right ends of the plane is relatively large at 0.05MPa, which is much lower than the concrete tensile strength of 1.43MPa. The maximum shear stress of the same floor is about 0.04MPa, which is much smaller than the floor shear bearing capacity. The impact of the floor on the bending capacity can be ignored according to pure bending components design.

3.2 The distribution law of bending moment along the floor

In order to quantitatively grasp the relative size of the bending moment and the distribution along the floor, the bending moment and the bending moment per millimeter are given respectively in the following Figure 5, while they are under the vertical load and the earthquake,

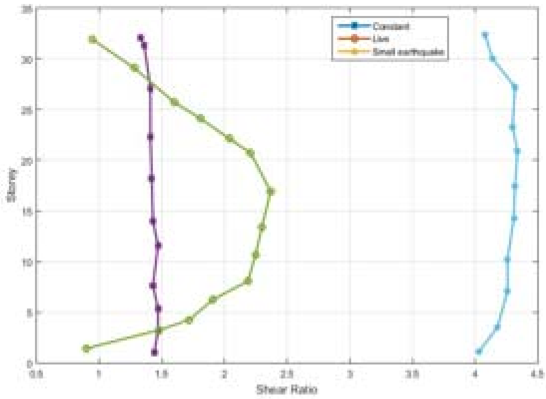

Figure 5: Typical Curve of Layers

Vertical load under the floor bearing design is about between 6.5kN.m/m~7.5kN.m/m, when bending along the floor of the basic uniform distribution. In the small earthquakes, B1 and B2 single bearing moments are close to each other, which are shown as the distribution pattern of small fish in the middle, low and high floor of the middle area with a maximum of 2.4 kN.m/m. And 35% of the design bending moment is under the load. While under the vertical load, the design bending moment is more uniform about 3.9kN.m/m.

3.3 Board seismic design and conventional design comparison

Due to the difference between the load of the small earthquake and the mid-earthquake, the coefficient of the initial material and the adjustment coefficient of the seismic bearing capacity are considered to be translated into the reinforcement area by the design force. The ratio of the reinforcement of the B1 and B2 is calculated to the reinforcement under the internal force of the X with the small and medium seismic forces, and then the ratio of the reinforcement to the reinforcement is calculated. In addition, we should also consider that the effect of the reinforcement is in the cross-stitch. The internal force distribution of the frame beam is similar to that in the frame-shear structure. And the internal force of the slab is also seen as a small distribution pattern of the large and low areas. The negative tendons of the middle and lower floors are more than conventional design reinforcement. Besides, B2 board is more serious than the B1 board. For example, small earthquake 11 to 21 layers of reinforcement has an average of 1.1 times, while that of the average earthquake is 1.55 times. The conventional design of the bottom bar can be enveloped small into the bearing, and the B1 and B2 support plate bottom reinforcement under the earthquake. The details of floor seismic design performance objectives can be seen in Table 3.

Table 3: Floor seismic design performance objectives

Earthquake intensity	Performance standards	Specific description
Small	1	No damage
Middle	4	Allows bending or partial bending
High	5	Allows bending, does not collapse

As shown in Figure 6, the ratio of negative beams to conventional design ratio is given. The shear rate of the Y-shear wall is 96.73%, while the shear rate of the outer wall of the X-wall (including the short wall) is 3.27%, which is obviously smaller than the shear rate of the Y-direction shear wall under the X-way earthquake. Therefore, the bending moment of the slab bearing should be small, and the bearing of the B3 north side bearing with relatively large confinement in Figure 6. The bending moment of the typical floor board represents the stress of the floor of a shear wall structure, and it is compared with the bending moment of the wall in the direction of the wall.

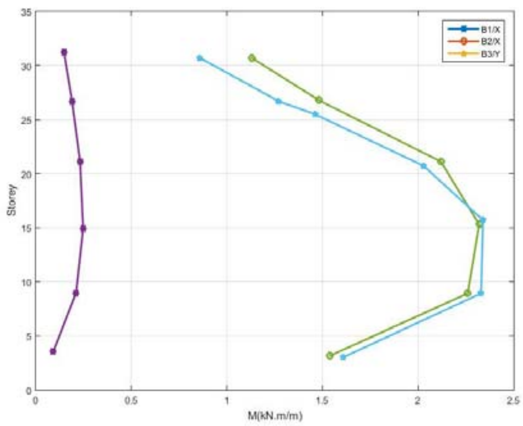

Figure 6: The Ratio of Negative Beams to Conventional Design Ratio

It shows that under the action of the earthquake, the bending moment of the slab bearing on the conventional shear wall structure is much smaller than that of the wall bearing on the wall structure, which is about 10% of the wall direction. And the conventional shear wall structure of the floor bearing small earthquake is with interaction about 1.2D+1.4L combination, and the average earthquake is about 0.84 times, small, medium shock while the floor will not yield.

4. Conclusion

Single-sided wall structure of the anti-side system has the following three parts: long wall limbs, short wall limbs and floor beams formed by the framework of the external force of the composition weak frame. The bearing capacity of the floor bearing has basically proportional relationship with the shear force of the shear wall as the bearing. When the sharing rate reaches a certain degree, the bearing capacity of the floor may not be satisfied under the earthquake. Thus the design should be based on the floor under the action of the earthquake bending calculation. The bending resistance of the floor is recommended to be set for small seismic elasticity. The mid-seismic allows bending yield or partial bending yield. Under the earthquake, the plastic deformation is controlled to prevent falling. Because it is not allowed to bend the yield control, the reinforcement will have a greater degree of increase. In the earthquake, more floor bearing will bend yield and result in increasing bending moment, which can be low appropriate amplification in the floor plate tendons of the low floor, and the bottom bar should be extended into the bearing by the tensile reinforcement. With the architectural requirements, not only the actual structure characteristics, the typical components and the limitations of the selection should be considered, but also the designer should combine the specific circumstances of the building floor seismic design.

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