Analysis on the Seismic behavior of 12 - story X - shaped central support - RC frame structure under rare earthquakes

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Abstract: Based on the actual project, this paper analyzes the seismic behavior of a 12-layer pure reinforced concrete frame, a reinforced concrete frame with steel pipe support and a reinforced concrete frame structure with concrete-filled steel tube supported by SAP2000. The results show that in the pure frame structure, Setting the hinged support can effectively improve the lateral stiffness of the structure, reduce the horizontal displacement of the structure, increase the energy dissipation capacity and seismic performance of the structure, and play a multi-channel fortification effect.

Keywords: Reinforced concrete frame; support; seismic performance;

1. INTRODUCTION

This section analyzes the main building part of a 12 storey complex in Yantai. The first floor of the building is 5.1m high and the other floors are 3.9m high with a total height of 48m. The plane dimensions of the net are 6.0m × 8.7m. The plane is shown in Figure 2.1 (a), the standard value of additional permanent load on the floor is 1.4kN / m2, the standard value of variable load is 4.0kN / m2, the standard value of additional permanent load on roof is 1.89kN / m2, and the standard value of variable load is 2.0kN / m2; wall load of 2.25kN / m, daughter wall load of 0.94 kN / m; seismic fortification intensity of 7 degrees (0.1g), the design of earthquake group as a group, Ⅱ site (Tg = 0.35s, In the event of an earthquake, Tg = 0.40s), SAP2000 was used to analyze the transverse seismic behavior of reinforced concrete frame structure, steel tube center support structure and steel tube concrete center support structure under strong earthquakes of 7, 8 and 9 degrees.

2 ANALYSIS MODEL

The project uses three different structural solutions, M1 is a reinforced concrete frame structure, column cross-sectional dimensions are 850mm × 850mm, transverse frame beam cross-section of 300mm × 800mm, longitudinal frame beam cross-section of 300mm × 600mm, secondary beam cross-section of 250mm × 500mm, thickness of 120mm, concrete grade strength are C30. M2 is a steel pipe center support-RC frame structure, vertical continuous X-shaped center support is arranged on the dotted line position shown in Fig. 2.1 (a), the support is Q235 steel pipe with a diameter of 150mm and a wall thickness of 6mm,), The remaining structural parameters are the same as M1. M3 is the CFST center-RC frame structure, filled with M230 concrete in the M2 steel tube support.

The pushover method is used to analyze the nonlinear spatial structure. In the analysis, membrane elements are used to simulate the horizontal slab, the spatial beam element simulates the beams, columns and supports, and both ends of the support are hinged with the frame.

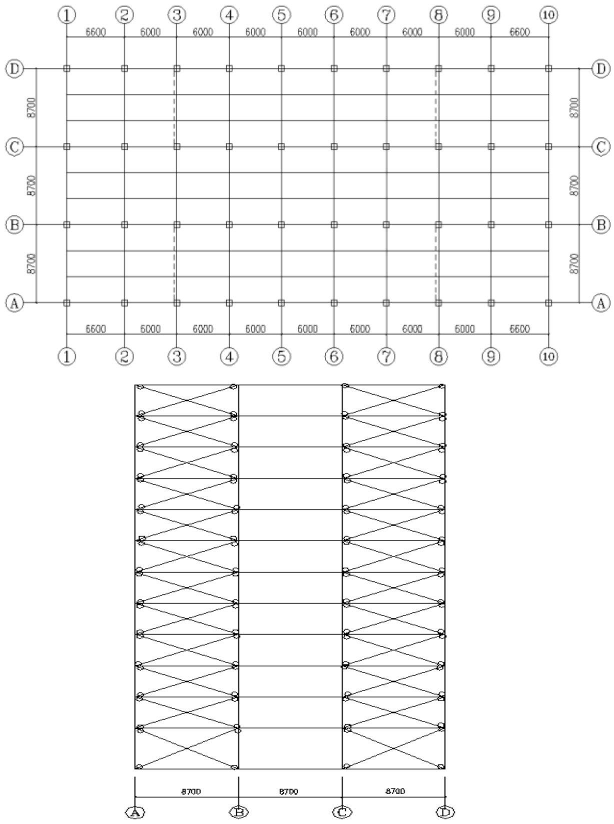

Figure.1 Model Details

3 BASED ON ATC-40 ABILITY SPECTRUM

ANALYSIS

(1) Plastic Hinge Installation To analyze the nonlinearity of the structure, it is necessary to provide plastic hinges on the components. Reference is made to FEMA-273 and ATC-40 of the United States to set the bending moment (M) and shear force Hinge (V) with bending hinge (PMM) at each end of the column.

(2) Lateral Loading Mode In this analysis, the influence of transverse support on the seismic performance of the structure is mainly analyzed. Therefore, the loading mode of "gravity + inverted triangular lateral loading" is adopted. According to the Code for Design of Seismic Design of Buildings, Earthquake, 8 degree rare earthquakes and 9 degree rare earthquakes are 0.50, 0.90 and 1.40, respectively, and the coefficients in ATC-40 are adjusted according to the seismic correlation coefficient of our country (see Table 1)

Table 1 ATC-40 coefficients

seismic intensity	CA	CV
7 degree rare earthquakes	0.2	0.2
8 degree rare earthquake	0.36	0.36
9 degrees rare earthquakes	0.56	0.56

① The structure of the capacity curve is approximately three sections of the line, the first stage structure is in the elastic stage, the second stage of the structure there are some plastic hinge, load capacity curve slowed down, is the energy beam yield stage, the third stage is the plastic hinge To the ultimate bearing capacity development. (2) The energy consumption section of the frame structure with concrete-filled steel tube is obviously increased. ③ Under the same spectral displacement, the frame structure with support can resist the earthquake of higher intensity.

2) Evaluation of seismic performance of structures under rare earthquake of 7 degrees

Structural capacity spectrum and demand spectrum curve, structural displacement at the performance point and interlayer displacement angle are shown in Figure 2.

It can be seen from Figure 3.2: ① The performance point of each structure is in the second paragraph of the capacity curve, indicating that the structure has a strong carrying capacity. (2) Spectral displacement, floor displacement and interlayer displacement angle at the performance point with support frame are obviously reduced. The displacement angles of the model layers all satisfy the stipulation that the displacement angle between the layers of the structure in the Elastoplastic Stage is 1/50.

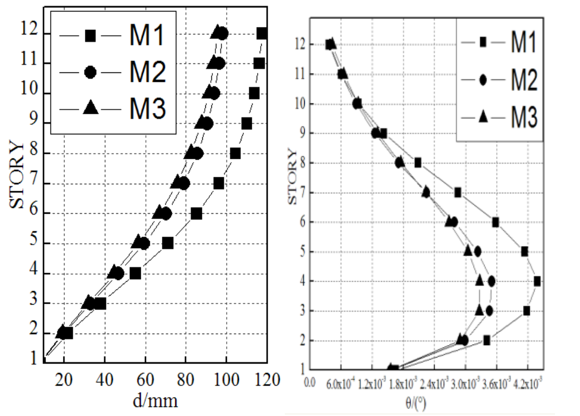

Figure 2. Seismic performance analysis of structures under rare earthquakes

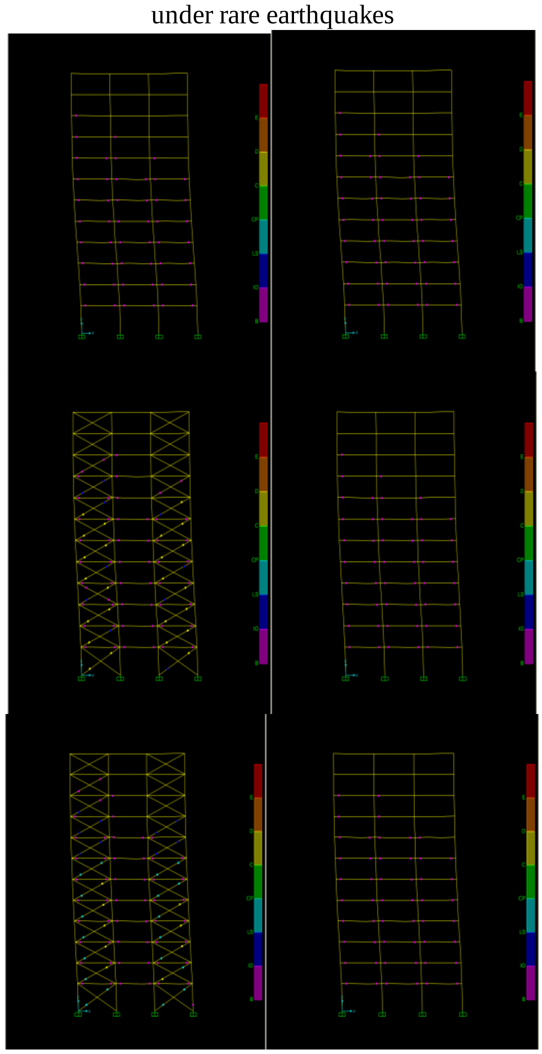

Figure 3. Plastic Hinge Distribution of Performance Points at Severe Seismic Seism

① The performance point of M1 is at the end of the second paragraph of the ability curve, indicating that the plastic hinges have started to develop towards the ultimate carrying capacity and will no longer be suitable for continued bearing. However, the performance points of M2 and M3 are still in the second stage of the ability curve, indicating that the additional support can improve the structural resistance to earthquakes. (2) Spectral displacement, floor displacement and interlayer displacement angle at the performance point with support frame are obviously reduced. The displacement angles of the model layers all satisfy the stipulation that the displacement angle between the layers of the structure in the Elastoplastic Stage is 1/50.

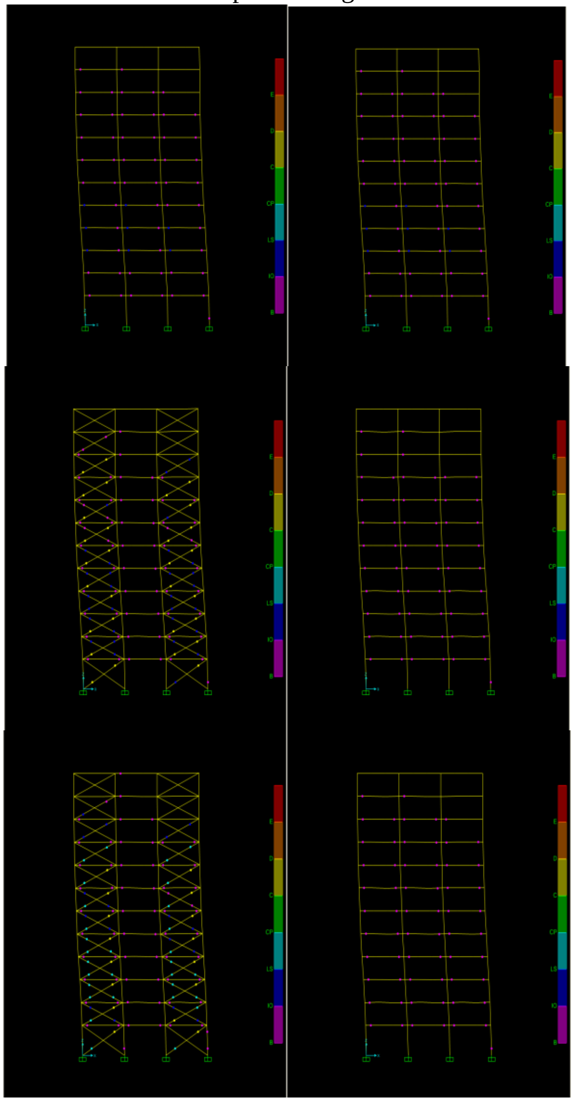

Figure 4. Plastic hinges for each model at the performance point for a rare earthquake of 8 degrees

Through the plastic hinge state in Fig. 4, we can see that ① the plastic hinges begin to appear at the bottom column of the three models, and the plastic hinge part at the beam end of M1 exceeds the IO stage. ② M2 and M3 appear only in the bottom edge of the plastic column hinge, plastic hinge is still in the beam end IO segment. ③ Comparing the development of plastic hinges between M1 and M2 and M3, it can be seen that the brace has played a significant role in energy consumption, demonstrating the effect of its first fortification.

(1) The performance points of the models all enter the third stage of the capacity curve, but the plastic hinges of M1 and M2 have been developed to the limit state, and the M3 plastic hinge has just entered the third stage. (2) Spectral displacement, floor displacement and interlayer displacement angle at the performance point with support frame are obviously reduced. The displacement angles of the model layers all satisfy the stipulation that the displacement angle between the layers of the structure in the Elastoplastic Stage is 1/50.

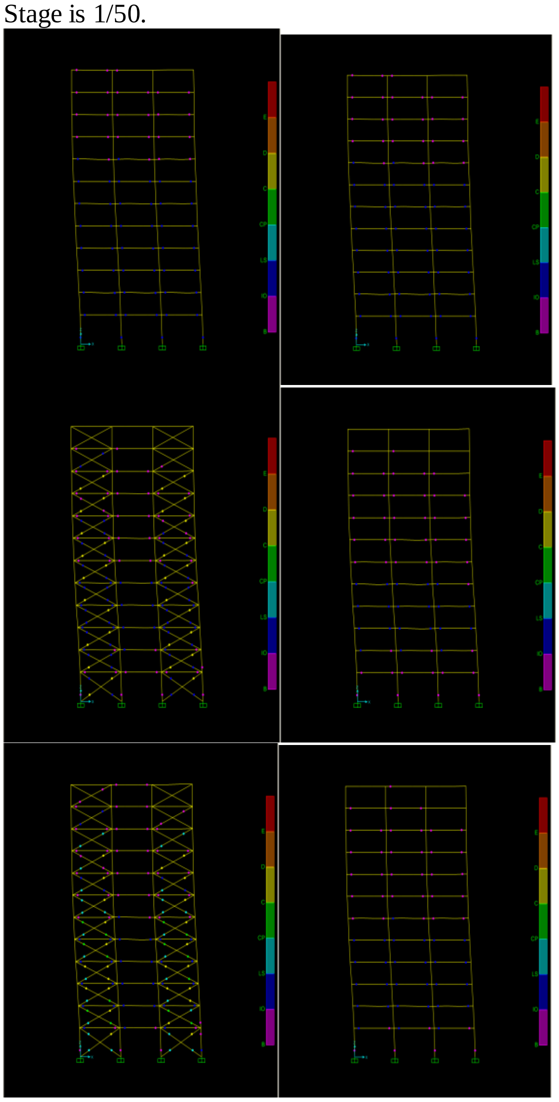

Figure 5. Plastic hinges for each model at the performance point during a rare earthquake of 9 degrees

Through the plastic hinge state in Fig. 5, we can see that: (1) plastic hinges appear at the bottom of the bottom three columns of the three models, but the plastic hinges at the bottom of the three bottom columns have different states of development. Late, damage is also small. However, all the models are not suitable to continue to resist earthquakes. (2) Comparing with the 3-axis 5-axis plastic hinge of M2 and M3, we can see that the frame with one support consumes more energy and plays a protective role on the other frames, which shows the effect of its first fortification. ③M2 and M3 of the plastic hinge at the beam end also significantly less than the degree of development, which also reflects the support of the first fortification effect. (4) From the above analysis, we can see that although the model still meets the specification requirements, the model can no longer resist the earthquake. It shows that in the actual design, whether the structure is damaged can not be completely in accordance with the layer displacement angle Provisions to judge.

4 CONCLUSION AND CONCLUSION

Through the analysis of the seismic response of three different structures of a 12 storey commercial building in Yantai, we can draw the following conclusions:

1) Compared with the pure reinforced concrete frame structure, the lateral rigidity of the structure can be obviously improved, the lateral displacement of the structure can be reduced, and the space stiffness distribution of the structure can be improved, and the effect of multi-channel fortification can be realized.

2) Under the same rare earthquake intensity, the probability of X-type central support-RC frame structure destruction is less than that of pure concrete frame structure. The effect of concrete-filled steel tube support is better than that of steel tube support and can be repaired The use of houses has greatly increased, reducing the rebuilding of the property after the earthquake.

3) In the actual design, for the analysis of elasto-plasticity, whether the structure is damaged or not can not be judged exactly in accordance with the provisions of the layer displacement angle.

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