Comparative Analysis of Dynamic Characteristics of Concrete Frames Reinforced with GFRP Bars and CFRP Bars

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Abstract. FRP bars have the advantages of light weight, high strength and corrosion resistance, and it can be used as a substitute for steel bars. There are relatively few studies on seismic performance of FRP reinforced concrete frame structures at home and abroad, so it is necessary to carry out research on seismic performance of FRP reinforced concrete frame structures. In order to analyze the structural performance of FRP reinforced concrete frame, the dynamic characteristics and dynamic responses of CFRP and GFRP reinforced concrete frame model structures under different seismic intensity are analyzed. The finite element model of shaking table test scale model of CFRP and GFRP reinforced concrete frame structures is established. The correctness of the finite element model is verified by comparing the structural dynamic responses of the two models. Then the acceleration response and floor displacement envelope diagram are analyzed and compared to evaluate the displacement response of the model. The results show that the displacement response of the two models under bidirectional seismic wave is obviously larger than that under unidirectional seismic wave, the displacement in X direction is obviously larger than that in Y direction, and the inter-story displacement of FRP reinforced concrete frame structure gradually increases from bottom to top. The lateral deformation of the structure is mainly the bending deformation of the beam and column.

1.Introduction
In recent years, researchers at home and abroad have studied the mechanical behavior of FRP reinforced concrete frame structure specimens under horizontal low-cycle cyclic loading, and analyzed its structural performance. The test shows that it is feasible to apply FRP bars to frame structure design, and the frame can show certain ductility. The shaking table test model of CFRP reinforced concrete frame and GFRP reinforced concrete frame is analyzed by SAP2000 finite element analysis software, and the seismic performance of GFRP reinforced concrete frame structure is evaluated.

2.Model building
Due to the limitation of the size of the shaking table and the effective bearing capacity, the model structure of the scale is usually adopted for the test object. At present, there are relatively few engineering examples of FRP reinforced concrete frame structure, so two prototype structures are designed according to the test requirements. They are all three-storey and two-span "Tian" shaped frame structures. The first storey is 3.75m high, the second and third storeys are 3M high, and the total building height is 9.75m. Column section size 400 mm *400 mm, beam section size 300 mm *400 mm, floor thickness 120 mm. CFRP bars and GFRP bars are used in the beams and columns of the two prototype structures. The stirrups and the distributed bars of the floor are all made of ordinary steel.
bars, and the strength grade of concrete is C35. In order to eliminate the influence of other parameters on the test results, the design parameters of the two prototype structures are the same except that different types of FRP bars are used in the beams and columns.

3. Comparative analysis of dynamic response of model structure

3.1 Acceleration Response Analysis

Through dynamic elastic-plastic time history analysis, the acceleration time history curve of each floor under El Centro wave is simulated. By processing and analyzing the acceleration data, the maximum acceleration of each layer of the model can be obtained, and then the acceleration amplification coefficients of each layer can be obtained. The change trend of the acceleration amplification coefficients can reflect the damage situation of the structure. Based on the data obtained, the envelope graphs of the peak acceleration and the acceleration amplification factor of each layer of the model under El Centro wave are drawn, as shown in the figure.1-4.

![Acceleration peak of model 1 and Acceleration transmissibility of model 1](image1)

![Acceleration peak of model 2 and Acceleration transmissibility of model 2](image2)

Figure 1. Envelope diagram of acceleration peak and acceleration amplification factor of the model under El Centro wave

3.2 Floor displacement envelope diagram

By sorting out the displacement data of each working condition, we can get the maximum displacement of the two models in X and Y directions relative to the platform under the action of different types and different levels of seismic waves, and take the maximum relative displacement of the model structure under the action of different seismic waves, and draw the displacement envelope diagram of the two model floors under the action of El Centro single, double and three-dimensional seismic waves, in which "X" represents the one-way displacement envelope. Seismic wave action, "XY" represents two-way seismic wave action, "XYZ" represents three-way seismic wave action, "1" represents model 1, and "2" represents model 2.
Figure 2. Floor displacement envelope diagram of two models under El Centro single, double and three-dimensional seismic waves.
4. Conclusion

(1) When seismic waves are input in one-way, two-way and three-way, whether model 1 or model 2, the displacement response of structure under two-way seismic waves is obviously larger than that under one-way seismic waves, and the displacement response under three-way seismic waves is also significantly higher than that under one-way seismic waves.

(2) With the increase of input acceleration peak value, the displacement response of the two models increases gradually. When the acceleration peak value is 0.069g and 0.197g, the floor displacement increases gently. When the acceleration peak value is 0.433g and 0.788g, the floor displacement increases significantly, which indicates that the structure is damaged, the stiffness degradation is serious and the deformation increases.

(3) Both models are symmetrical "Tian" shaped structures, and their lateral stiffness in X-direction is the same as that in Y-direction. However, compared with the maximum relative displacement responses in X-direction and Y-direction, it can be found that the displacement in X-direction is obviously larger than that in Y-direction, which is mainly because the energy of seismic wave input in Y-direction is less than that in X-direction, so the displacement response in Y-direction is also smaller than that in X-direction.

(4) From the envelope diagrams of floor displacement of the two models, it can be seen that the inter-story displacement of FRP reinforced concrete frame structure decreases gradually from bottom to top, i.e. shear deformation. It shows that the lateral deformation of the structure is mainly the bending deformation of beam and column, and the lateral displacement of the column caused by the axial deformation is relatively small, so the whole structure presents shear lateral displacement.

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