The Applied Research on Bidirectional energy-dissipating damper in High-rise Building Structure

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Abstract: The bidirectional energy-dissipating damper is applied to the actual engineering structure of a high-rise building. The SAP2000 software was used to establish a three-dimensional model of a high-rise structure, and through the nonlinear dynamic analysis of the structure under the action of an 8 degree earthquake, the effect of the bidirectional energy-dissipating damper on the actual high-rise building structure was studied[1].

1. Introduction

The bidirectional energy-dissipating damper can simultaneously undergo shear deformation, bending deformation and tension and compression deformation. Each of them consumes energy, and has the function of consuming wind or seismic energy input in any direction. Moreover, this kind of damper is easy for people to obtain its materials, simple to manufacture, easy to install, and reasonable in price, which can be used in cast-in-place monolithic buildings, and can also be used in ordinary multi-story, high-rise civil buildings, and prefabricated buildings. Using this damper can improve the seismic performance of the structure, effectively reduce the damage and casualties caused by the earthquake, and provide key technical support and products and services for urban seismic construction.

2. Bidirectional energy-dissipating damper

The bidirectional energy-dissipating damper is shown in Figure 1. It consists of two parts: The first part is three sets of semi-circular BLY160 mild steel rods, which can be sheared, bent and deformed by tension and compression, and are the core part of the damper; the second part is the upper and lower steel plates, which play a role in restraining the movement of the mild steel bars. Using ANSYS software, it is determined that the initial elastic stiffness of the damper is 4.81E+07 N/m, and the shear model is 0.987E+07 N/m. The restoring force model of the bidirectional energy-dissipating damper is shown in Figure 2.
3. High-rise structure and damper layout
The actual engineering structure of a high-rise building has a height of 216 m, 54 floors above ground, and each floor is 4 m high, a fortified area is located at 6 degrees, and the seismic fortification intensity is magnitude 8 [2]. The location of the bidirectional energy-dissipating dampers is shown in Figure 4. There are 8 dampers on the 1st, 9th, 18th, 27th, 36th and 54th floors of the structure, and
there are 48 in total.

4. **Selected seismic waves**
For the nonlinear dynamic analysis under the action of a magnitude 8 earthquake, two rare artificial seismic waves, ART EL CENTRO wave and ART HACHINOHE wave are selected [3]. We selected two seismic waves to compare with the design velocity spectrum in "Code for Seismic Design of Buildings" of China (Figure 5), the fitting degree was good and met the requirements of the code.

5. **Nonlinear dynamic analysis**

5.1. *Optimizing stiffness*
The time history analysis of the actual engineering structure of the high-rise building is carried out by using the compiled nonlinear analysis computer program, and the optimal stiffness of the bidirectional energy dissipation damper is determined as $k=1.0\times10^9$ N/m by comparing the displacement of each layer of the structure (Figure 6: Relationship curve between floor displacement and damper stiffness).

5.2. *Analysis of the effect of shock absorption and energy dissipation*
By using nonlinear analysis computer program compiled by the high-rise building under the action of the chosen two seismic time history analysis, we found that, under the action of bidirectional energy-dissipating dampers, the maximum floor displacement, velocity, acceleration and the maximum inter-story shear force of the practical engineering structure of high-rise buildings are greatly reduced, the dampers lower the input energy of the earthquake to a large extent, and the plastic deformation of the structure is greatly reduced, which can effectively protecting the structure [4].

6. **Conclusion**
Through the nonlinear dynamic analysis of the bidirectional energy dissipation damper applied to the actual engineering structure of a high-rise building [5], the following conclusions are obtained:

- Bidirectional energy-dissipating dampers have good shock absorption and energy dissipation effects, which can provide a good protective effect on high-rise building structures, and improve their overall seismic performance;
- By adjusting the parameters such as the material, section size and arrangement mode of the mild steel of the bidirectional energy-dissipating damper and optimizing the stiffness, the individual needs of different structures can be satisfied. It can be used in ordinary multi-story and high-rise civil buildings and prefabricated buildings to provide a certain foundation for urban seismic construction.
Figure 7. Maximum floor displacement.

Figure 8. Maximum floor speed.

Figure 9. Maximum floor acceleration.

Figure 10. Maximum shear force between layers.
Under the action of ART EL CENTRO earthquake wave
Without damper Add damper
Earthquake input energy (N.m)
Time /s
0 1 02 03 04 05 06 0
-5000000 0 5000000 10000000 15000000 20000000 25000000 30000000

Under the action of ART HACHINOHE earthquake wave
Without damper Add damper
Earthquake input energy (N.m)
Time /s
0 1 02 03 04 05 06 0
-5000000 0 5000000 10000000 15000000 20000000

Figure 11. Earthquake input energy.

Under the action of ART EL CENTRO earthquake wave
Without damper Add damper
Plastic deformation energy (N.m)
Time /s
0 1 02 03 04 05 06
-5000000 0 5000000 10000000 15000000 20000000

Under the action of ART HACHINOHE earthquake wave
Without damper Add damper
Plastic deformation energy (N.m)
Time /s
0 1 02 03 04 05 06
-5000000 0 5000000 10000000

Figure 12. Plastic deformation energy borne by the structure.

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