Study on Application of Viscous Damper in Hybrid Structure

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Summary

Hybrid structure consists of steel frame and reinforced concrete core tube. The steel beams are welded or anchored to the embedded steel parts in concrete wall, and then concrete slab is cast at the floor level. These stiff joints are easily damaged under earthquakes. This paper describes a comparative study on the seismic behaviour of hybrid structure with stiff connection and with viscous damper connection by using lumped storey model for structural analysis. Numerical results show that proper viscous damper connection can significantly improve the seismic performance of the structure.

Keywords: seismic energy dissipation; hybrid structure; connection; viscous damper

1. Introduction

In the system of hybrid structure, concrete core tube has strong lateral stiffness and relatively low strength, but steel frame is quite the opposite. The vibration frequency of concrete core tube is usually higher than that of steel frame when they are separated to be two single units at the floor. When connecting them with viscous damper, the different displacements of them makes viscous damper dissipate energy efficiently and reduce the dynamic response of the structure as a result.

2. The description of building structure for analysis

The building, 100 meters tall with 24 stories, locates at Shanghai, including 24-story high central reinforced concrete core tube and exterior 23-story high steel frame. The floor is composed of composite metal deck slab. The connection between steel frame and concrete core tube, existing only in story 1 to story 22, is anchoring frame beams to the embedded parts of core tube and casting slab at floor level.

3. Selection of the parameters of viscous damper

Mechanical performance of dampers of this kind can be expressed as follows:

$$F_d = C_v Sign(V)\left|V\right|^{\alpha} \qquad (1)$$

Where C_v =damping coefficient ($kN/(mm/s)^{\alpha}$).

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V =velocity of damper curst relative to damper piston (mm/s).

α =constant value, range from 0.1 to 1.0.

Total damping force of each floor is selected according to formula (2):

$$F_i = (\Delta X_{i1} F^1_{ki} \sum F^1_{ki}) / A_1 \qquad \text{(i=1, 2,..., n)} \tag{2}$$

Among which $A_1 = \sum (F^1_{ki} \Delta X_{i1})$

Where F_i =total damping force at floor i .

F^1_{ki} =calculated earthquake force of the fundamental translational mode at floor i of steel frame under rare earthquake.

ΔX_{i1} =the fundamental translational normalized modal differences in x -direction at floor i of the steel frame and the concrete core tube.

4. The establishment of simplified model

The building model can be simplified as a lumped storey model. And restoring force characteristics of steel frame can be modelled with *Wen* model and concrete core tube can be modelled with *Pivot* model.

5. Analysis of seismic performance of hybrid structure under different connections

The acceleration time history along the x -direction was inputted to analyze the dynamic behaviour of the structure under the condition of stiff connection and viscous damper connection between steel frame and concrete core tube respectively. The peak values of 35cm/s^2 and 220cm/s^2 were selected according to the peak values of frequent earthquake and rare earthquake defined in China respectively.

5.1 Structural response under frequent earthquake

Connected with viscous damper, most of inter-story drift and story shear of structure are decreased comparing with stiff connection. The largest displacement decrement of steel frame and concrete core tube reaches 27% and 30% respectively.

5.2 Structural response under rare earthquake

Connected with viscous damper, most of inter-story drift and story shear of structure are decreased comparing with stiff connection. The largest displacement decrement of steel frame and concrete core tube reaches 32% and 36% respectively.

5.3 Energy dissipation of viscous damper

The energy dissipation of viscous damper is efficient.

6. Conclusion

The following conclusions can be drawn from the above research:

(1) The analytical method for getting the parameters of viscous damper takes both the effect of earthquake and the differential vibration of steel frame and concrete core tube into consideration.

(2)When connected with viscous damper, the seismic performance of the structure is optimized. The value of story shear decreased or approach uniformity and the inter-story drift is also reduced.

(3)The energy dissipation of viscous damper is efficient. And the deformation of viscous damper is not more than 72 mm in this study, which can be settled easily in construction.