Longitudinal Vibration Control of Long-span Railway Cable-Stayed Bridge

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Summary

As the floating tower cable-stayed bridge has no constraint between the main girder and the pylon, it may cause larger longitudinal displacement of main girder, and larger longitudinal bending moment at the root of tower, and it also could affect the normal use and safety of the bridge under the affection of earthquake and train braking. It is an important part of the design to select an appropriate vibration control scheme. Taking a long-span railway bridge for example, this paper presents the finite element model and discusses the damping effect in the view of train braking. Moreover, the present study also examines the dynamic behavior with focus on two parameters of damping coefficient C and damping exponent α of the viscous dampers through dynamic time-history analysis. The results show that setting viscous dampers with reasonable parameters can reduce the vibration and the response of the bridge caused by train braking and have a good energy dissipation effect.

Keywords: railway steel truss bridge, viscous damper, dynamic response, train braking

The longitudinal swinging is permitted for the float-type cable-stayed bridge under the action of external loads, and the energy is dissipated because of this kind deformation, so there are more and more applications in the real bridge engineering project. However, there are not longitudinal constraints in the floating type cable-stayed bridge, a relatively server structural dynamic responses are inevitable under a strong dynamic load, such as seismic load, wind load and train baking, so it is vital to control the longitudinal vibration of the main girder. As one of vibration control technologies, damping technology in concerning with the low damping property of bridge structure has been widely applied in bridge engineering for it can improve the damp of bridge structure dramatically.

The current study on the damper for controlling the longitudinal vibration of the main girder in the floating type cable-stayed bridge is mainly focused on the vibration control under the action of seismic and wind load. As for floating type railway cable-stayed bridge, the dynamic loads must include moving train load as well in addition to the seismic and wind load. If the moving train is braking on the bridge, a larger longitudinal braking load will be raised, and large longitudinal dynamic displacements and longitudinal bending moments at the bottom of pylon will be resulted, then the operation and safety of the bridge will be affected, so it is necessary to control the longitudinal vibration of floating type railway cable-stayed bridge caused by the train braking. There are a few studies on the longitudinal vibration control of the floating type cable-stayed bridge under the train braking, the vibration of Tianxinzhou Yangtze bridge carrying both highway and railway under the longitudinal seismic and train braking loads is investigated by Qin Shunquan, Weilian Qu, Jia Liu etc., then the intelligence vibration control scheme of combined MR dampers and fluid viscous dampers is figured out. The MR dampers is used to control the vibration caused by train braking load and the fluid viscous dampers is utilized to control the vibration caused by seismic load, and the purpose of vibration control is achieved effectively.

In this paper, the fluid viscous dampers are used to control the vibration caused by train braking load, and one certain double-line floating type railway cable-stayed bridge is taken as the example to

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investigate the damping effect of fluid viscous damper in the view of train braking aided by the nonlinear time-history analysis. Moreover, the parameter sensitivity of damping coefficient C and damping exponent α is analyzed, and rational. Damping parameters of fluid viscous dampers are obtained, and the vibration control scheme of the railway bridge is carried out. The obtained rules of the variable parameters and vibration control scheme have been already applied to the longitudinal vibration control of the bridge.

With the analysis and discussion in this paper, the following conclusions can be drawn:

1) As the train braking load is one of the common loads for railway bridge, the structure vibration of key position caused by the train braking load should be reduced effectively by introducing viscous dampers on the longitudinal direction of main girder, then the structural mechanical behavior is improved, moreover the structural damage caused by collision is also avoided or mitigated, and the normal operation and service life of bridge is ensured.
2) The variable rule of displacement is basically contrary to that of the internal force with the damping parameters variation. The result shows that viscous dampers have great impact on the maximal longitudinal displacements of girder and the top of pylon which decrease with damper parameters C increasing and increase with speed exponent α decreasing; and it has certain influence on the internal forces of girder and pylon which increase with damper parameters C increasing and decrease with speed exponent α increasing. So an optimal parameter is figured out to obtain the best effect on the control of both the displacements and internal forces.
3) With the damper parameters C increasing, the damping force increases. Nevertheless, with the speed exponent α increasing, the damping force decreases.
4) As specific situations of practical engineering are different, the selection of optimal damping parameters is also various. Because of the greater damper output force, the higher cost, a comprehensive consideration of the optimal damping effect and damper output force is engage finally to determine the damping coefficient, and it is favorable when C is 2e6 and speed exponent α is 0.2 for the railway cable-stayed bridge.

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References and Notes

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