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VIBRATION ANALYSIS OF A LONG-SPAN BRIDGE WITH A SUSPENDED PAVEMENT SYSTEM (SPS) CAUSED BY THE VEHICLE EXCITATION

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In this research, to figure out the vehicle induced vibration of suspended pedestrian system(SPS), which is designed for pedestrians walking through the road bridge, the vibration analysis method based on vehicle-bridge interaction theory is established. The maximum acceleration responses with different vehicle speeds and road surface roughness are calculated. Some suggestions are given to control the local vibration of SPS. The study shows that with the same vehicle speed and road surface roughness, the maximum acceleration of SPS is much larger than the main girder. The acceleration responses are increased along with the increasing of road surface roughness, but it has weak tendency to increase with the vehicle speed. By increasing the cantilever stiffness and SPS's overall stiffness, the local vibration problems of SPS at the middle span are effectively controlled. However, the method of increasing deck stiffness doesn't have obvious effect for the vibration control of side span.

Keywords: suspended pedestrian system (SPS); vehicle-bridge interaction; parameters analysis; local vibration; frequency-domain analysis

1. Introduction

In this research, based on the vehicle-bridge interaction theory, the method of analyzing the SPS vibration response under the vehicle excitation is established. Then, a long-span extradosed cable stayed bridge with the SPS (Fig.1) is analyzed as an example. Parameter analysis of SPS's maximum acceleration considering the vehicle speed and road surface roughness is studied. The local vibration control measures of the SPS for the bridge are presented and analyzed. This study can provide a reference for SPS design and pedestrian comfort analysis of long-span bridges under vehicle excitation.

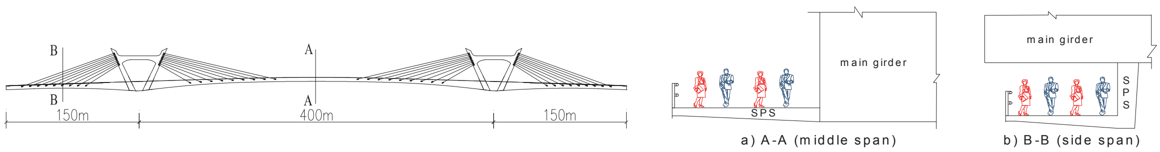

Fig.1 Elevation of the main bridge and its SPS

2. Analysis theory of SPS vibration under vehicle load

To discover the vibration of bridges under vehicle load, it is necessary to establish the axle-bridge interaction equation. In this paper, the separated iterative method is applied which requires the system to satisfy both the displacement relationship and the force coupling equation. The force coupling equation can be expressed as the dynamic vertical force applied to the deck by the wheel, as shown in equation (1). Where F_i refers to the instantaneous force of the i^{th} wheel. y_{gi} refers to the displacement excitation caused by road surface roughness. y_i refers to the instantaneous vertical displacement of the i^{th} wheel. W_i refers to the static axle weight of the i^{th} wheel.

$$F_i = c_{wi}(\dot{y}_{gi} - \dot{y}_i) + k_{wi}(y_{gi} - y_i) + W_i \quad (1)$$

3. Conclusions

(1) The maximum acceleration responses of SPS are much larger than that of the main girder, which indicates that the local vibration effect of SPS is quite obvious. The acceleration responses are consistent with the increase of the road surface roughness, but the acceleration responses have weak tendency to increase with the vehicle speed. As is shown in Fig.2:

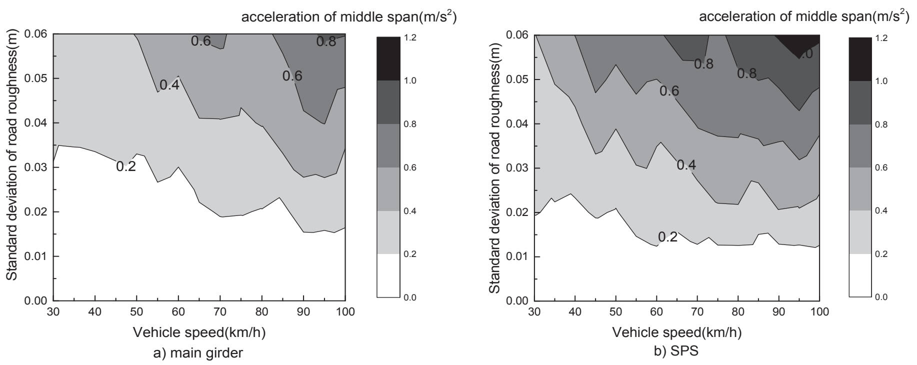

Fig.2 Acceleration results of the middle span with different vehicle speed and road roughness

(2) In terms of the main span structure, improving the cantilever beam stiffness, the deck stiffness and the overall stiffness can achieve similar local vibration control effect. In the case of side span, improving the cantilever beam stiffness stiffness and the overall stiffness can achieve similar local vibration control effect, but improving the deck stiffness only makes the the acceleration ratio increase slightly. As is shown in Fig.3:

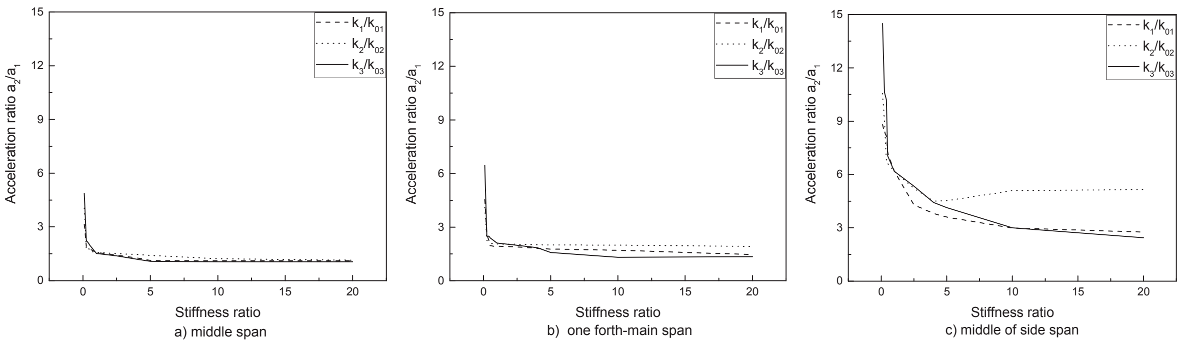

Fig.3 Max acceleration ratio of SPS to main girder with different stiffness ratio