Research on the Influence of Pavement Roughness Level on the Driving Comfort

WANG Gui-hua1*, ZHOU Ji-guo1

1 School of Civil Engineering, Baicheng Normal University, Baicheng Jilin, 137000, China

*Corresponding author’s e-mail: 466124747@qq.com

Abstract: The car-bridge pavement roughness level has a great influence on the vibration of the coupled system and on the driving comfort. Numerical simulation model of vehicle-bridge coupling vibration analysis is established to study the vehicle-bridge system while vehicle running on a long-span bridge. The vibration characteristics of vehicle-bridge system and the driving comfort of vehicle are studied while vehicle running on a long-span bridge under different pavement roughness level. The results show that, the vertical impact coefficient and the comfort evaluation index both gradually increase with the improving level of roughness.

1. Introduction

Roughness level of bridge deck pavement plays an important role on the vertical vibration of vehicle-bridge coupling system while vehicle running on a bridge. The vibration of vehicle-bridge system has a big effect on the vertical acceleration of vehicle, which is concerned to the driving comfort. In this paper, vehicle-bridge coupled vibration numerical model is set up to analyze the vibration characteristics of vehicle running on different pavement roughness level. Meanwhile, two vehicle comfort evaluation methods Sperling and ISO2361-1 are applied to calculating the vehicle comfort index.

2. Road surface roughness

For the pavement power spectral density for all kinds of road and off-road ground, the “vehicle vibration input road flatness representation” suggests using $G_d(n)$ which represents the unilateral power spectral density of vertical displacement to describe the per unit pavement flatness statistical properties. The ordinate and abscissa in the graphic are expressed with logarithmic. The curve fitting is needed to get the expression of power spectral density. he recommended type of fitting formula of displacement power spectral density are as follows.

$$G_d(n) = G_d(n_0)\left(\frac{n}{n_0}\right)^{-w} \quad n > 0$$

According to the power spectral density, the road will be divided into eight level, among which the roughness coefficients value range and the geometric average value of the roughness of grade A, B, C flatness are shown in table 1 below. In this article, it mainly studies the impact of A, B, C different levels of surface roughness on the vehicle bridge coupling vibration.
Table 1. Road roughness classification

| Road level | Road roughness coefficients Gd(no) 10-6m²/m | Minimum | Geometric average | Maximum |
|------------|---------------------------------------------|---------|-----------------|---------|
| A          | 8                                           | 16      | 64              | 32      |
| B          | 32                                          |         | 128             |         |
| C          | 128                                         | 256     | 512             |         |

3. Vehicle-bridge system coupling vibration

To study the change rule of the vehicle-bridge system vibration while vehicles running on a large span cable-stayed bridge with the different road surface, the coupling vibration are analyzed while a bus running at the speed of 120km/h on a long-span cabled-stayed bridge with the road conditions is the smooth and road surface roughness is class A, B, C.

It can be obtained from the generated road surface roughness samples that the greater the roughness of road surface the higher road level is, which have a greater influence on the coupled vibration of vehicle-bridge system. It can be seen from the change rule of vertical vibration of car body with the vehicle driving, vertical vibration is relatively stable when the road surface is smooth and the higher grade of road surface roughness the greater range of the vehicle vertical vibration. Especially when the road roughness is class C, the value of the vehicle vertical vibration generates the positive, which show the pavement roughness has an important effect on the vertical vibration.
The vertical vibration of bridge change is slightly smaller than that of vertical vibration of vehicle. That is because that the research object is a car driving on the large span cable-stayed bridge. If there are too many vehicles running on the bridge, the bridge of the vertical vibration fluctuation value will increase. It can be seen from the calculation results, the higher level of road roughness the larger range of vertical vibration of bridge is when driving a vehicle on the large span bridge to long-span cable-stayed bridge across. So the road roughness has an important influence on vertical vibration of bridge which also has an important effect on the impact coefficients.

4. Driving comfort evaluation
To study the influence of bridge pavement roughness on the vehicle driving comfort while the vehicle running on a long-span cable-stayed bridge. Based on the two different evaluation method of Sperling and ISO2361-1 method to study the characteristics of vehicle driving comfort while a bus running on a long-span cable-stayed bridge with different road roughness. While the vehicle running at the speed of 90km/h with the bridge pavement roughness level condition respectively is A, B and C, the variable schedules of vertical acceleration of vehicle are shown as follows.

![Graph](image1)

a) Road roughness of grade A

![Graph](image2)

b) Road roughness of grade B
c) Road roughness of grade C

Figure 3. Acceleration process of vehicle

The obtained evaluation value of vehicle driving comfort respectively based on the evaluation method of Sperling and ISO2361-1 evaluation method for the vehicle driving comfort are shown in table 2.

| Evaluation method | A    | B    | C    |
|-------------------|------|------|------|
| Sperling          | 0.4321 | 0.545 | 0.723 |
| ISO2361           | 0.045  | 0.093 | 0.183 |

The calculated value of comfort index both are less than 1.0 based on the Sperling comfort evaluation method, which can illustrate passengers can feel a slight vibration while a vehicle running on the bridge. The calculated value of comfort index both are less than 0.315 based on the ISO2361-1 comfort evaluation method, which can illustrate passengers can not feel uncomfortable while a vehicle running on the bridge. It can be obtained from the calculation result based on three different grade of pavement roughness, the higher level of road roughness the larger value of vehicle driving comfort index is.

5. Conclusion

Three-dimension space numerical model of vehicle-bridge coupled vibration is established to study the vibration characteristics of vehicle running on long-span cable-stayed bridge with different pavement roughness level. The results can be obtained.

The level of road roughness has an important influence on the vehicle vertical vibration of vehicle-bridge coupling system, which also plays an importance role on the impact coefficients. It can be seen from the results of comfort index calculated based on the comfort evaluation method of Sperling and ISO2361-1 method that the level of road roughness has an important effect on the vertical acceleration of vehicle which will also play an important role on the comfort index of vehicle.

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