Research on the Influence of Vehicle Model on the Aerodynamic Force Coefficients

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Abstract: Shape and size of vehicle model in numerical wind tunnel model have a great influence on aerodynamic coefficients of vehicle. A bus running on the steel box girder bridge was used to establish numerical wind tunnel model to study the influence of the parameters of vehicle model on the aerodynamic force coefficients of vehicle and bridge. In the numerical wind tunnel model, respectively established with and without of wheels and different height of the vehicle model to study the aerodynamic characteristics of vehicle and bridge. The results show that, with and without wheels in the established numerical wind tunnel model has a great influence on the aerodynamic force coefficient of vehicle. The height variation of vehicle chassis plays an important role only for separate aerodynamic force coefficients of vehicle and bridge.

1. Introduction
Research of aerodynamic coefficient of vehicle is the basis of studying the critical wind speed of safety driving, which also is the foundation of comfort of driving research. Wherein, the shape and size of the vehicle, the height of the vehicle chassis from the ground, and the establishment of the vehicle details are all easy to be ignored in the process of establishing the numerical wind tunnel model. The vehicle's shape and size have a great influence on the aerodynamic characteristics of vehicle, which also influence the aerodynamic coefficient difference of vehicle. In this article, the numerical wind tunnel is established to study the influence of with and without wheel and height of vehicle chassis on the aerodynamic force coefficients of vehicle and bridge.

2. The Influence of Wheels
In the numerical calculation and experimental measurement of aerodynamic characteristics of vehicle, if need to consider the influence of with or without wheels for vehicle model, how deep this difference between the with wheels and without wheels on aerodynamic characteristics, how much do aerodynamic force coefficients vary between the two different models. Taking common bus as the investigation subject to establish the numerical wind tunnel of a bus running on a long-span steel box-girder bridge. Respectively research the difference of aerodynamic force coefficients between the vehicle model with and without wheels. The calculated results are shown as follows. Wherein, $C_S$, $C_L$, $C_D$, $C_P$, $C_Y$, $C_R$ respectively represent the side force coefficient, lift force coefficient, drag coefficient, pitching moment coefficient, yaw moment coefficient and rolling moment coefficient.
Figure 1. Aerodynamic force coefficients of vehicle

The results show that, the influence of whether to set up the wheels of the vehicle is not the same on the Six component aerodynamic coefficient of vehicle in the numerical wind tunnel model. Where, it has a minimal impact on the side force coefficients and drag force coefficients of vehicle, which is because that the two coefficients are mainly determined by the body shape and size of the vehicle. Where, it has a maximal impact on the lift force coefficients which can be well understood. Because that if a wheel established is direct influence the air flow state of the bottom of vehicle, so it has the most impact on the lift force coefficients of vehicle. The influence of vehicle model on the rolling moment coefficients are mainly displayed around the wind angle of 45 degrees.

Figure 2. Aerodynamic force coefficients of bridge
Where, the influence of whether to establish the vehicle wheels are mainly present on the side force coefficients of bridge. Because the existence of vehicle wheel leads the difference on the flow status over the bridge surface. Whether to establish the vehicle wheels has the less influence on the lift force coefficients and rolling moment coefficients of bridge. Where, the value of rolling moment coefficients of bridge is mainly decided by the shape and size of bridge section. But in the research on the influence of vehicle wheels on the aerodynamic force coefficients of bridge, only one bus running on the bridge is used to establish the numerical wind tunnel. So, it needs to further research the influence of vehicle wheel on the aerodynamic force coefficients of bridge for different number of vehicles running on bridge.

3. The Influence of Height of Automotive Chassis

Vibration of vehicle will generate in the process of driving, which will lead the height between vehicle chassis and road surface will change. Take the bus as the investigation subject to respectively to study the influence on vehicle aerodynamic force coefficient in the process of driving which generate the vibration of vehicle. The model of a bus stationary on a bridge with chassis height of 0.01m, 0.0125m, 0.015m, 0.0175m, 0.02m, 0.024m is establish to study the influence of chassis height on the aerodynamic force coefficients of vehicle.

![Figure 3. Aerodynamic force coefficients of vehicle](image)

It is obvious can be seen from the calculated result, there is larger effects of vehicle chassis height on the aerodynamic coefficient of vehicle. Where, that has less influence on the side force coefficients and drag force coefficients of vehicle, which is similar to the influence of vehicle wheel. This because that the two aerodynamic force coefficients of vehicle are mainly decided by the shape and size of vehicle, so the variation of vehicle chassis height has a less effect on the side force coefficients and drag force coefficients of vehicle. But the rolling moment coefficients of vehicle changes biggest, because the different height of vehicle chassis lead the difference of flow status between the vehicle chassis and bridge surface. The flow status up on the bridge surface lead the value of rolling moment coefficients of vehicle change from negative to positive. The height of vehicle chassis has greater effect on the pitching moment coefficient and yaw moment coefficient when the height of chassis is larger.

![Figure 4. Aerodynamic force coefficients of bridge](image)
It can be seen from the change law of aerodynamic force coefficients of bridge in the process of height variation between the chassis and bridge surface, there basic is not large difference of side force coefficient and rolling moment coefficient of bridge. That is because that the side force coefficients and rolling moment coefficients of bridge mainly is decided by the shape and size of bridge itself. There is small range difference between the lift force coefficients of bridge when the height of chassis changes, which is because that the flow status up on the bridge surface is affected by the height of chassis. But, this research results mainly are obtained based on the model a bus stationary on the bridge. So, it needs to further study the influence of height of chassis on the aerodynamic force coefficients while there are more vehicles running on bridge with different spatial position.

4. Conclusions
The analysis model of fluid domain and solid domain of wind-vehicle-bridge is respectively established to study the characteristics of wind-vehicle-bridge coupling system. Study the influence on the aerodynamic force coefficients of vehicle and bridge according to the difference of shape and size of vehicle. This following results conclusion can be obtained.

It needs to consider the influence of wheel and height of chassis to study the aerodynamic force coefficients of vehicle and bridge while vehicle running on bridge. It is not the same for the influence of height of chassis on the six-component aerodynamic force coefficients, which has little effect on the drag force coefficients of vehicle and on the lift force coefficients of bridge, and it has the most importance influence on the rolling moment coefficients of vehicle.

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