Vibration Frequency Analysis of High-Speed Wobble Mode

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The history of research on straight-line stability of motorcycles is long, and discussions of stability using mathematical models had already begun by the end of the 19th century. However, in the 1970s, Sharp initiated practical research, which led to a dramatic advance in the study of straight-line stability.

According to him, there are three modes of motion that affect the straight-line stability of motorcycles, and their stability changes as vehicle speed increases. Of particular importance are the wobble mode, which is a steering system vibration, and the weave mode, which is a multi-degree-of-freedom organization.

In this paper, the energy flow change calculation method is applied to four known vehicle models to ascertain the factors that cause the vibration frequency of the wobble mode to decrease at high speeds.

After ascertaining, it is examined whether the contribution is due to a change in the magnitude of the force or a change in the phase. By proceeding in this way, the degree to which the obtained results are universal is examined for different vehicle specifications.

Eigenvalues and eigenvectors are calculated by eigenvalue analysis using the 4-DOF model. Substituting the obtained eigenvectors into the dynamic variable part of the 4-DOF model, equations to be satisfied by the eigenvectors are obtained.

In the case of the eigenvalues of the wobble mode, the stability and frequency of the wobble mode can be calculated by substituting the eigenvectors of the wobble mode into the equations of motion for the steering system.

The substitution of the eigenvector information is called a force configuration diagram, in which each term is represented by a two-dimensional vector (Fig. 1).

As a result, the following conclusions are obtained.

(1) As a factor acting on the steering system, the front tire lateral force reduces the frequency of vibration.
(2) Among the tire forces, the steering angle coefficient contributes to the decrease in vibration frequency.
(3) The coefficient of the steering angle factor decreases.
This is attributed to the decrease in cornering power and camber stiffness due to load transfer (Fig. 2).
(4) The reduction in cornering power is due to aerodynamic load transfer (Fig. 3).
(5) The results described here are common to the four existing vehicle models.

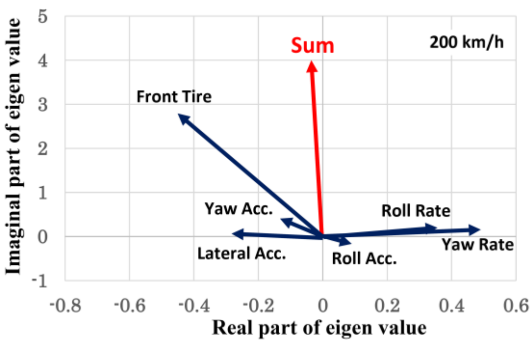

Fig.1 Configuration of Torques Acting on Steer System (Wobble)

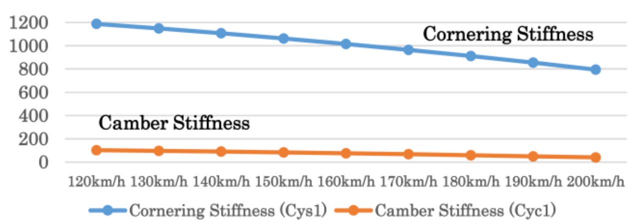

Fig.2 Tire Coefficient of Front SF (Vehecle C)

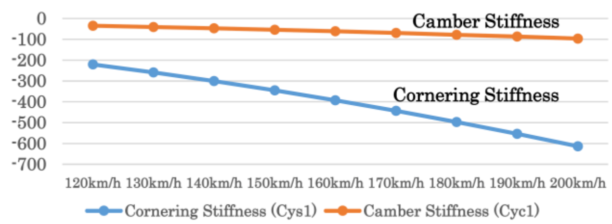

Fig.3 Tire Coefficient of Front SF (Vehecle C)