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Effect Analysis of Damping Characteristics Using Rear Frame Flexibility Model of Motorcycle

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In past, Sharp reported his analysis results of straight driving stability using a 4-DOF (degrees of freedom) model. As a result of his study, there was a leap in the advancement of studies on handling stability of a two-wheel vehicle.

The study has revealed that there are three types of unstable modes by natural frequency analysis using a 4-DOF model.

More specifically, the modes are a capsize mode that comprises non-oscillatory body leaning motion; a wobble mode that primarily comprises 5 to 10-Hz oscillatory motion of a steering system; and a weave mode that comprises a coupled motion of lateral, yawing, rolling and steering systems.

From Sharp's studies, as well as a number of studies done after Sharp, it was revealed that the weave mode and the wobble mode of a two-wheel vehicle are unstable in the expressway speed range, and once the speed is higher than a certain speed, the vehicle has more chance to fall. As a matter of safety, it is necessary to stabilize those modes, and for this purpose, we need to understand how those two modes are generated. It has been believed, however, that natural frequency analysis, which has been conventionally employed, is not effective enough to reveal the mechanism of the generation.

In the 1980s, a new method - energy flow method - which enables us to understand the cause of generation of the two oscillatory modes, was proposed. According to this method, we can understand the cause of generation of the modes by computation of energy flow by the force (torque) included in an equation for the primary DOF of the respective modes.

The latest energy flow method has allowed us to obtain more detailed statistics than the method proposed about 40 years ago. More specifically, with the latest method, we can understand the reason of the change in the straight driving stability in the light of an equation of motion.

In this paper, we investigate the effect of the damping terms in the frame stiffness model on the weave modes. The components of the relevant degrees of freedom are then analyzed in detail to determine whether the change is due to a change in the magnitude of each term in the eigenvector equations or a change in phase. By proceeding in this manner, the main mechanism will be clarified and the effect of the frame damping characteristics on the weave mode of the motorcycle will be analyzed.

The conclusions are summarized as follows

(1) Weave modes are stabilized by the tire system for both small and large damping coefficients.

(2) When the damping is small, the magnitude of the front tire lateral force vector is small and stabilized.

(3) In the case of large damping, the phase of the rear swing arm torsional angle is delayed, and as a result, the phase of the rear tire lateral force is advanced and stabilized.

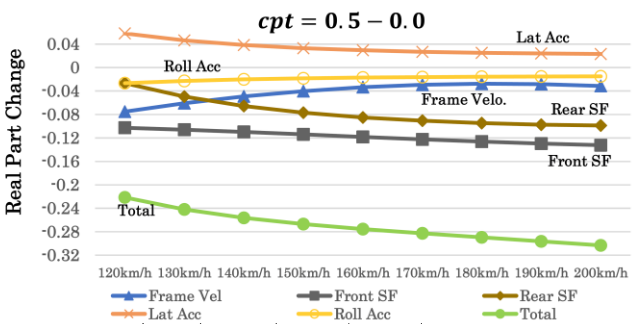

Fig.1 Eigen Value Real Part Change
(Damping coefficient is small)

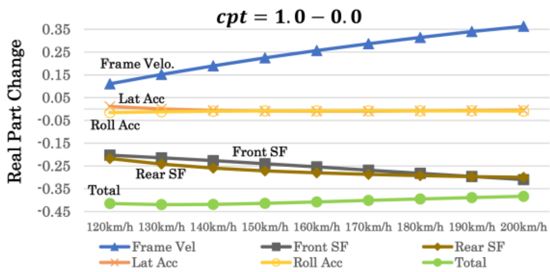

Fig.2 Eigen Value Real Part Change
(Damping coefficient is large)

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