Vehicle Dynamic Analysis Using Simplified Calculation Method for Compliance Steer

K. Morihara*, **M. Tsushima#**, **T. Shiiba***

* Department of Mechanical Engineering
Meiji University
1-1-1 Higashi-Mita, Tama-ku, Kawasaki, Kanagawa, Japan
[ce42084, shiiba]@meiji.ac.jp
#Vehicle Test Technology Development Department,
Nissan Motor CO.,LTD
560-2 Okatsukoku, Atsugi, Kanagawa, Japan,
masashi-tsushima@mail.nissan.co.jp

Abstract

In recent years, the progress of the computer performance has improved the calculation speed of a vehicle dynamic analysis, and has enabled some applications of a real-time simulation such as a driving simulator. By applying a multibody vehicle model to a real-time simulation, the accuracy of the analysis result can be enhanced.

In a multibody vehicle model, several stiff elements such as a rubber bush are usually contained. A rubber bush is an important element for the ride comfort and the driving stability of an automobile. When a vehicle runs, a rubber bush is deformed by a lateral force of a tire. The alignment of the tire changes depending on this deformation. The compliance steer that uses this alignment change positively enables to improve the driving stability. For this reason, it is important to consider the characteristic of a rubber bush in a vehicle dynamic analysis.

The relation between the applied force to the rubber bush and its deformation is non-linear and shows a feature of viscoelasticity [1]. When the vehicle dynamic analysis with considering the deformation of a rubber bush is performed, rubber bush is usually defined as a force element in the multibody vehicle model. In this case, the multibody vehicle model contains the element that has high natural frequency, and the vehicle dynamic analysis requires small step size.

The purpose of this study is to realize a vehicle dynamic analysis considering the influence of the compliance steer by using a simplified calculation method. In this method, the compliance steer was calculated by using a stiffness matrix and a force of a tire instead of considering the deformation of each rubber bush. The characteristics of the rubber bushes included in one suspension were merged in one stiffness matrix. In order to construct the stiffness matrix, the multibody model of the front suspension with rubber bushes was developed. The multibody suspension model for the front suspension with rubber bushes is shown in Figure 1. The suspension model was consisted with five elements: a vehicle body, a knuckle, an upper arm, a lower arm and a steering rack were defined as independent bodies. The stiffness matrix was calculated from the result of static calculation using the suspension model with rubber bushes by adding the external force.

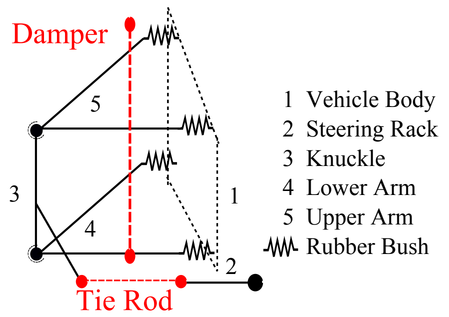


Figure 1: Suspension model with rubber bushes.

The dynamic analysis of the multibody vehicle model with rubber bushes defined as the stiffness matrix shown in Figure 2 was conducted. In this analysis, the rubber bushes were replaced by using revolute joints. The body component of the vehicle model was described in Table 1. In the multibody vehicle dynamic analysis, the compliance steer of the front wheel was obtained by using the stiffness matrix considered in tire force calculation. In order to confirm the validity of the proposed method, the dynamic analysis of the multibody vehicle model with rubber bushes defined as the force elements was conducted. The result of vehicle dynamic analysis with rubber bushes defined as the force elements and the stiffness matrix are shown in Figure 3 and 4 respectively. From these figures, the dynamic analysis using the proposed method could realizes accurate calculation of the compliance steer and the vehicle behavior.

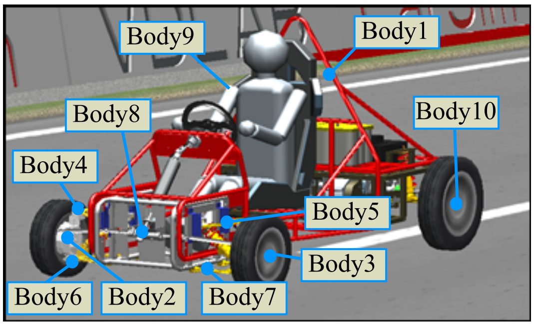
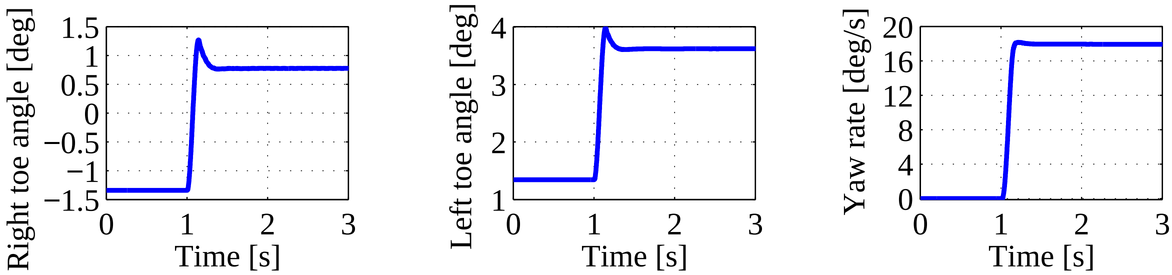


Figure 2: 10 body vehicle model

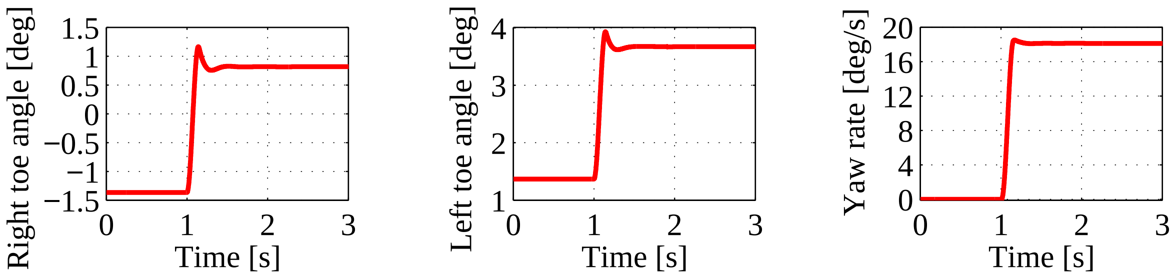
Table 1: Body component

Body Num.	Component
1	Main Frame
2	Front Right Knuckle
3	Front Left Knuckle
4	Right Upper Suspension Arm
5	Left Upper Suspension Arm
6	Right Lower Suspension Arm
7	Left Lower Suspension Arm
8	Steering Rack
9	Rear Right Knuckle
10	Rear Left Knuckle



(a) Right toe angle (b) Left toe angle (c) Yaw angle

Figure 3: Result of vehicle dynamic analysis with rubber bushes



(a) Right toe angle (b) Left toe angle (c) Yaw angle

Figure 4: Result of vehicle dynamic analysis using the proposed method

References

[1] S.B. Lee, A Wineman. A model for non-linear viscoelastic axial response of an elastmeric bushing. International Journal of Non-Linear Mechanics, Vol. 34, Iss. 5, pp. 779-793, 1999.