VEHICLE RIDE STUDY WITH FLEXIBLE BODIES IN ADAMS

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1. BACKGROUND

Automobile engineers use commercial code, such as ADAMS, to perform vehicle dynamics simulations for ride, handling, energy management and NVH analyses. Because of the complexity of body flexibility, a rigid body assumption is often made in a full vehicle dynamics model with suspension systems. This assumption provides a quick solution to a complicated issue, but it also introduces significant error in predicting component interactions during dynamics simulation.

Several attempts were made in the past to circumvent this deficiency; they all faded for the reason that the structural dynamics characteristics of vehicle body can not be accurately translated into vehicle dynamics systems. The "compliance method" introduces additional stiffness to the vehicle body at the connection points. Although the tested compliance is applied, the lack of mass distribution in the formulation makes it a static representation only. The "lumped mass" method assumes multiple rigid masses connected with spring elements, which reasonably represents the mass distribution and structural compliance across the structural body. This approach is sufficient for representing simple structures, such as beams or plates, with reduced mass and stiffness matrices. However, it becomes very cumbersome and very difficult to accurately translate dynamic structural characteristics into vehicle dynamics system models.

The modal formulation available in ADAMS v8.2 provides a reliable tool to bridge the sophisticated structural finite element model in NASTRAN with a dynamic vehicle system model in ADAMS. This presentation discusses a successful application of this new approach for the vehicle ride and handling analyses. This technology marks a key advancement of vehicle dynamics simulation for integrated chassis system development.

2. INTRODUCTION

The modeling of a flexible vehicle body structure in a multibody dynamic system is crucial for providing accurate ride and handling analyses for ground vehicles. Several formulations have been developed for the computation of flexible multi-body dynamics. They all adapted the "assumed mode" approach, in which the body flexibility is assumed to be small. The deformation stays within the linear elastic range, to approximate the displacement field within the structural body.

$$R = r + u + u_l$$

$$u_l = \sum_{1}^{n} \phi\eta$$

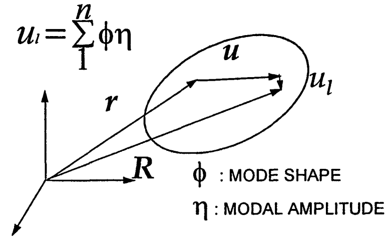

Figure 1. Modal Displacement

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With the above new definition for displacement representation at any point within the structural body, the computation of dynamic response becomes very complicated. In ADAMS v8.2, the complication of modal characteristics of structural body is described with 14 invariant matrices; these can be computed from NASTRAN with appropriate DMAP provided by MSC. The integration of structural FEA models with vehicle dynamics systems can be achieved via standard steps with *careful* engineering judgment. The current study, with joint efforts among NAO Chassis Center, Small Car Group and Delphi Chassis engineers, is the first successful attempt at using flexible bodies in the vehicle ride and handling analyses. It is considered a major breakthrough technology for improving vehicle dynamics simulation.

3. APPLICATION

A vehicle trimmed body NASTRAN model is used for the study of flexible body effects on vehicle handling analysis. Table I shows how the flexible bodies progressively improve the prediction of lateral compliance. The static results signify the critical role of structural body flexibility in the dynamic systems.

DESCRIPTION	LATERAL COMPLIANCE
RIGID BODY MODEL	7000 N/mm
FLEXIBLE CROSSMEMBER	5500 N/mm
FLEXIBLE C.M.&BODY	1930 N/mm
LAB TEST	2220 N/mm

* Static Results Obtained Via ADAMS v7.2

Table I. Static Compliance Results

The vehicle system model was generated through SLAM (Suspension Linkage ADAMS Modeler - a pre-processor written by Delphi Chassis). The GM modal tire was also used in the study. The vehicle trimmed body model, was tied to the dynamic system through appropriate connections. The 30 body modes under 50 Hz were selected to represent body structural characteristics. Four constraint nodes were defined at the strut tower connections to the body. Table II shows the first 20 modes of the Vehicle body.

MODE	Frequency (Hz)
1	17.96
2	18.16
3	24.45
4	25.78
5	26.81
6	28.98
7	29.84
8	30.11
9	30.58
10	31.12

MODE	Frequency (Hz)
11	31.43
12	32.65
13	33.97
14	34.90
15	35.70
16	36.63
17	37.64
18	38.40
19	39.26
20	40.18

Table II. Vehicle Body Modes

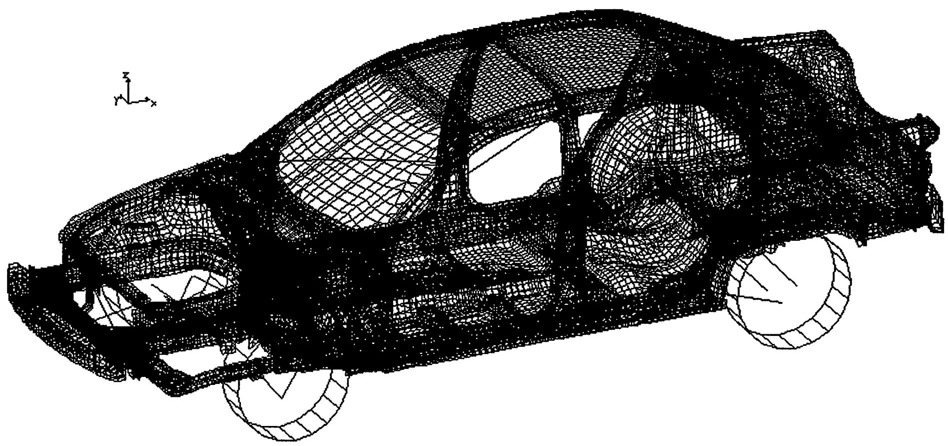

Figure 1. Vehicle Body Model in ADAMS

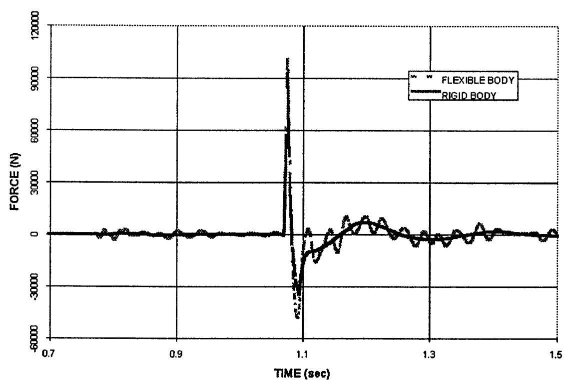

Figure 2. Left Rear Spindle Acceleration

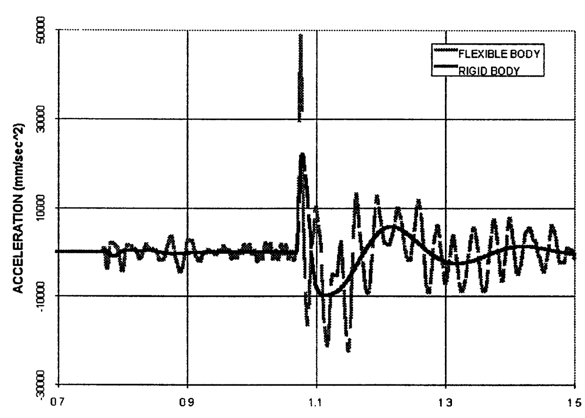

Figure 3. LR Upper Spring Acceleration on Body

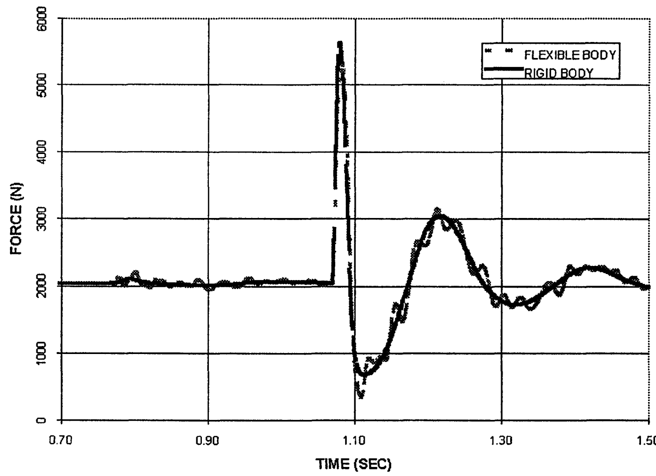

Figure 4. LR Upper Spring Force to Body

Figure 1 shows the vehicle body FEA model in ADAMS, Figures 2 through 4 show the simulation results of vehicle driving over the AES bump at 20 mph. Figure 2 shows the left rear spindle acceleration along the vertical direction, Figure 3 shows the acceleration at the strut mount attachment to the body along the vertical direction, and Figure 4 shows the force at the spring attachment to body. Preliminary comparison with vehicle test data (not shown) looks promising; acceleration response magnitudes due to the flexible body effects are consistent with test data. Further correlation is now underway.

4. CONCLUSION

The capability of integrating high fidelity NASTRAN structural models with vehicle dynamics systems in ADAMS provides engineers the opportunity to improve vehicle dynamics analyses in ride, handling, energy management and NVH. This technology marks a key milestone toward the advancement of vehicle dynamics simulation for integrated chassis system development.

5. ACKNOWLEDGMENT

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