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Multibody and Finite Element models of a leaf-spring suspension for vehicle dynamics applications: numerical model, tests and correlation.

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Abstract

This paper presents a comparison of different modeling techniques for leaf spring suspensions (namely Multibody Dynamics and Finite Element method) and the results of model correlation against static and dynamic tests. Leaf spring suspensions are very common suspension systems for ground vehicles and their usage ranges from passenger cars to light utility vehicles to heavy trucks. They are characterized by a simple structure and thus an ease of constructions that makes them cheap and effective suspension systems. However, despite these important properties, they pose serious challenges to the modeling engineers because of the complexity of the physical phenomena involved in their static and dynamic behavior. In fact, a leaf spring suspension is composed by a number of curved leaves packed into an assembly, bolted in the middle part (see Figure 1) whose extremities are in general connected to the vehicle frame by means of rubber bushing. The difference in curvature and the assembly process causes the introduction of a pre-load into each one of the leaves. During the application of a load, each leaf is in contact with one or two other leaves providing in this way a mechanism for load transfer and dissipation of energy. The presence of an additional stage as shown in Figure 1 provide a dramatic change in stiffness when its leaves are actively in contact with the primary spring. These phenomena are not straightforward to model (contact detection, friction, structural damping, non-linear stiffness and damping characteristics, rubber materials, ...) therefore special modeling techniques are needed. In literature it's possible to find several models from the simple SAE 3-links model, to Multibody to Finite Element models [1][2]. They represent different level of complexity and accuracy and therefore computational time that will make them suitable for different application and at different stages of the vehicle development process. In particular this paper is focused on the Multibody and Finite Element approaches with the goal of finding a good compromise between accuracy and computational speed bearing in mind the final target of vehicle dynamics performance evaluation for handling and ride comfort. The spring under examination is part of the rear suspension of the pick-up truck Ford F-250 Super Duty. It has been tested in the laboratories of the Mechanical Engineering Department of Politecnico di Milano both in static and dynamic conditions (harmonic loading at different frequency up to 10 Hz and with different preload levels). The test rig arrangement is show in Figure 2. The multibody model is built in LMS Virtual.Lab Motion [3] using a discretization of each leaf in rigid bodies connected by linear elastic beams. The contact is modeled as a simplified sphere-to-extrude contact that has the advantage of being computationally efficient and it's suited for this type of application where the contact areas are known a priori. The model is shown

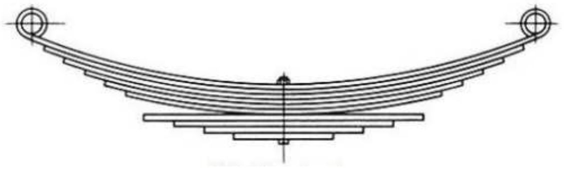

Figure 1: Variable rate leaf spring suspension.

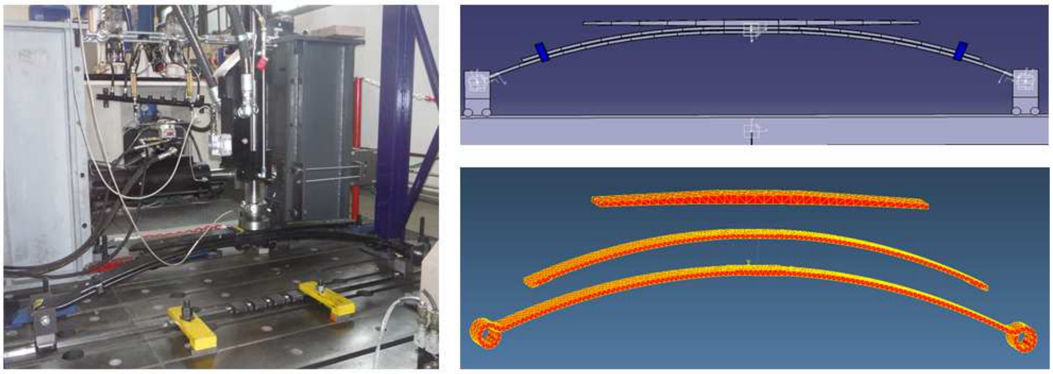

Figure 2: The test rig arrangement and the MBS and FEA model.

in Figure 2. The model is build by means of a special tool developed for this purpose and that allows to create directly an assembly of the suspension, ready to be used in a more complex vehicle model. The Finite Element model is built in Samcef Mecano [4] and uses tetrahedron parabolic elements and a viscoelastic formulation for the material (Kelvin-Voigt model). In this case the model needs to be built from the geometry of each individual leaf and a quasi-static analysis needs to be performed in order to simulate the assembly process. The model is shown in Figure 2. Static and dynamic simulations have been performed according to the test procedure and the results for the MBS model are shown in Figure 3. Similar results have been obtained from the FEA model. The two main conclusions that could be drawn from this modeling activity are the fact that from the computational point of view the MBS model overperforms the FEA one (7s vs. 1600s for the static analysis) but the MBS model lacks in accuracy when nominal geometrical and material properties are used with the consequence that the user needs to tune the model parameters to match the test results.

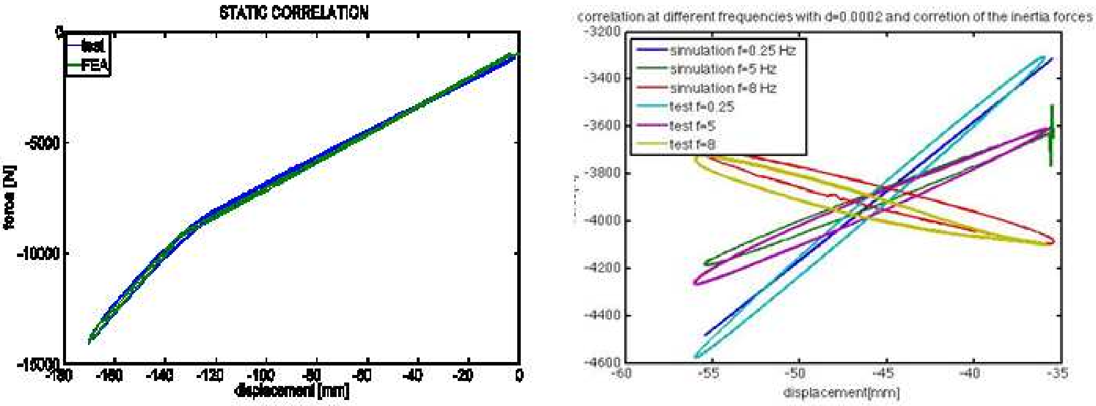

Figure 3: Static and dynamic results for the MBS model.

References

[1] Spring design manual AE-11. Society of Automotive Engineers International. [S.l.]. 1990.

[2] Kumar, K., Aggarwal, M. A Finite Element Approach for Analysis of a Multi Leaf Spring using. CAE Tools. International Journal of Advanced Engineering Research and Studies, (p. Vol. 1(2) 92-96). (2002).

[3] LMS Virtual.Lab 13.2 Online Help. LMS International. (2014).

[4] Samcef Field User Guide LMS Samtech. (2014).