Verify the Performance Levels of Vehicle Restraint Systems with Multibody System Dynamics

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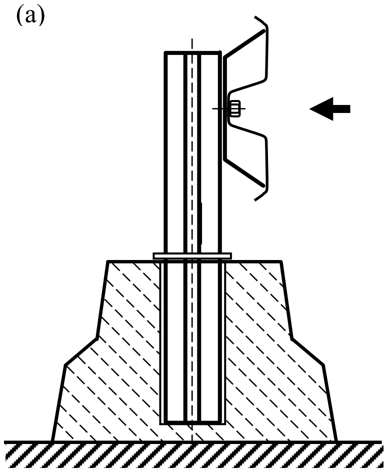
Vehicle restraint systems (VRS) make a significant contribution to road safety. Modern vehicle restraint systems are further developed in such a way that, in the event of a vehicle crash, the greatest possible portion of the impact energy is absorbed by the system, while at the same time reducing the intensity of the vehicle deceleration. However, a conflict of goals often arises between the available space and the necessary deformation path, which is why such a protection system should be optimized carefully.

There are a variety of construction parameters for the design of a vehicle restraint system. These include in particular the geometry of the profiles, the plate thicknesses used, connection configurations, post distance and the choice of material. The loading on the other hand depends in case of an impact on the vehicle design, the vehicle velocity and the impact angle. To investigate comparable conditions, vehicle types and associated impact loads are standardized in the European code EN 1317 [1].

For the classification and certification of a vehicle restraint system, a real full scale test has to be carried out according to EN 1317. A certification of a VRS on the other hand using only computational simulations, without a real full scale test, is according to EN 1317 permitted only for minor modifications of an already tested and certified VRS. However, of course, simulation calculations can help in the development of VRS to find the optimal design parameters.

(a)



(b)

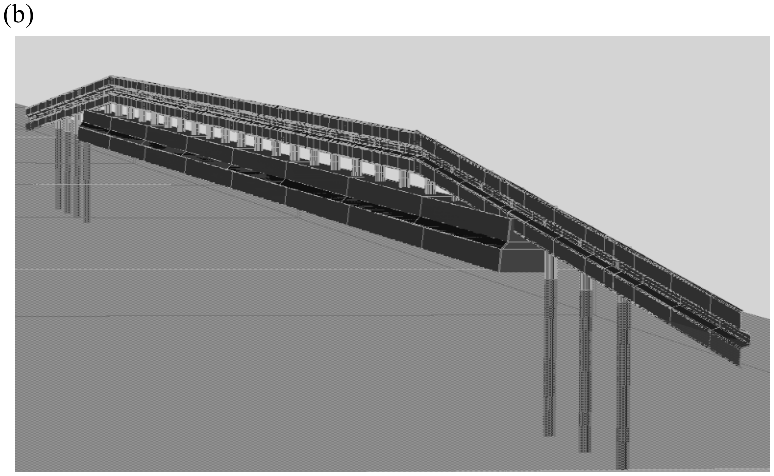


Fig. 1: One variant of the vehicle restraint system currently developed
(a) Section view of the restraint system
(b) Isometric view of the multibody system model

Multi-body system (MBS) models have the advantage over the continuum and finite element methods, that the mechanical properties such as inertia, elasticity and viscosity can be described directly via internal force elements. Each of these parameters can be changed easily and directly. Often however several parameters are to be optimized. In addition to the traditional "one-factor-at-a-time-approach", the design of experience (DoE) methods offer various more effective methods, where different factors may be included and investigated with a reduced number of computational simulation runs. The DoE also offers the possibility to determine interactions between the factors. By using the Principal Component Analysis (PCA) in combination with the DoE method, it is possible to quantify the influence of the factors on the classification criteria (as response) and further to show dependences between the criteria (responses).

The simulation calculations using multibody systems together with the evaluation of the results by means of the different procedures of DoE allow an efficient verification of the responses. In addition, in order to determine the optimal configuration, the influencing factors together with their extent of tolerance can be derived.

For a current development of a VRS (Fig. 1), the use of the MBS in combination with the DoE is to be shown for the determination of the optimal design parameters. The VRS is a combination of a steel guardrail system with a base made of prefabricated concrete elements. It is demonstrated that both the modelling as well as the controlling mechanisms of the elastic plastic deformation behavior of the steel structure and also the modelling and controlling mechanisms of the dynamic behavior of the concrete base due to the vehicle impact can be carried out directly, efficiently and with high accuracy using the method of MBS. It is shown how the optimal design parameters are determined and verified to comply with previously defined limit values of the classification criteria.

References

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