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Road restraint systems - Guidelines for computational mechanics of crash testing against vehicle restraint system - Part 2: Vehicle Modelling and Verification

Dispositifs de retenue routiers - Recommandations pour la simulation numérique d'essai de choc sur des dispositifs de retenue des véhicules - Partie 2: Composition et vérification des modèles numériques de véhicules

Rückhaltesysteme an Straßen - Richtlinien für Computersimulationen von Anprallprüfungen an Fahrzeug-Rückhaltesysteme - Teil 2: Fahrzeugmodellierung und Überprüfung

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Foreword

This document (CEN/TR 16303-2:2012) has been prepared by Technical Committee CEN/TC 226 "Road equipment", the secretariat of which is held by AFNOR.

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This document consists of this document divided in five Parts under the general title: Guidelines for Computational Mechanics of Crash Testing against Vehicle Restraint System:

— *Part 1: Common reference information and reporting*

— *Part 2: Vehicle Modelling and Verification*

— *Part 3: Test Item Modelling and Verification*

— *Part 4:Validation Procedures*

— Part 5: *Analyst Qualification*[1]

[1] In preparation

Introduction

This part of CEN/TR 16303 is informative. It gives general information for the development of a vehicle model for crash test simulation against vehicle restrain system.

Two different categories of vehicle models can be identified. The first category consists of a detailed model (usually finite element) of a vehicle or of a portion of it, typically used in the automotive industry to assess the structural performance and properties of the vehicle. A second type of vehicle model (finite element or multi-body), instead, is typically used to assess the barrier performance in the simulation of full-scale crash tests. In this case, a less detailed model is required, in order to obtain a computationally cost-effective tool for the analysis of several different crash scenarios. At the same time, it is mandatory to reproduce faithfully the correct inertial properties and outer geometry of the vehicle.

This Part of the guideline is meant to provide the user with all the information necessary to develop a complete and efficient numerical model of a vehicle in order to properly simulate a crash event (second category of vehicle above). It is not convenient to use a very detailed model, because of the unaffordable increase in the computational costs. In this perspective, the vehicle model can be regarded as a tool for the analysis of a crash event.

1 Scope

The aim of this Technical Report is to provide a step-by-step description of the development process of a reliable vehicle model for the simulations of full-scale crash tests giving the reader a first synthetic summary of problems encountered in the different steps of the vehicle modelling process.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

N/A

3 General considerations on the modelling techniques of a vehicle

3.1 General

Particular attention shall be paid on the modelling of vehicular kinematics and of the components that realize it: front and rear suspensions, wheels, steering system, etc. The geometry of the vehicle shall be reproduced correctly to simulate the interaction with the barrier. The model shall include only significant parts and few details (internal parts should be modelled only regarding their inertial properties, etc.) in order to reduce the computational cost of the model.

3.2 Finite Element and Multi-body approaches

Two main modelling approaches can be considered, using two different analysis tools: the Finite Element Method (FEM) and the Multi-Body (MB) approach. Both methods are widely known and broadly used in many fields of engineering, including the Automotive Industry.

The first method allows the user to build a very detailed vehicle model and to assess global results such as the barrier or vehicle performance in a crash test as well as the stress data in a local area of the vehicle. As a counterpart, a FEM analysis requires significant computational costs, thus proving less valid for parametric studies where a large number of simulations may be required.

Crash tests finite element (FE) simulations are usually run with a dynamic, non-linear and explicit finite element code. Computer runtime is usually significant, with the order of 30-40 hours on a 2,4 GHz personal computer for the simulation of a full-scale crash test with an effective simulated time of 0,25 second. In fact, the model must include not only the vehicle model, but also several meters of roadside barriers (depending on the barrier type, up to 80 meters of barrier) to faithfully reproduce the interaction between the vehicle and the barrier and the boundary conditions. The integration time step is controlled by the minimum dimension of the smallest element of the FE mesh, therefore, the mesh size shall be a trade-off between the need for geometrical and numerical accuracy and computational cost: large elements guarantee a high time step but poor accuracy of the model and possible instabilities, while small elements give a better accuracy but a smaller time step. General criteria for the mesh can be identified. The most significant parts of the vehicle shall be modelled explicitly with a detailed mesh (vehicle body, wheels, etc.). Other parts can be modelled implicitly, reproducing their inertial properties (engine) or their function and kinematics (suspension and steering systems).

On the other hand, the MB approach consists roughly in modelling the vehicle as a number of rigid bodies connected by means of joints with specified stiffness characteristics. The method is particularly suitable to assess the kinematics of the vehicle, while less applicable to determine data about levels of stress and strains. When reliable and validated data are available, the MB approach is very useful to perform parametric