

Development of Advanced EuroSID-2 and EuroSID-2re Radioss Dummies

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ABSTRACT

EuroSID-2 and EuroSID-2re are among the most frequently used side impact dummies in vehicle crash safety. Radioss is one of most widely applied finite element codes for crash safety analysis. To meet the needs of crash safety analysis and to exploit the potential of the Radioss code, a new generation of EuroSID-2 (ES2) and EuroSID-2re (ES2_RE) Radioss dummies was developed at First Technology Safety System (FTSS) in collaboration with Altair. This paper describes in detail the development of the ES2/ES2_RE dummies. Firstly whole dummy meshes were created based on CAD data and intensive efforts were made to obtain penetration/intersection-free models. Secondly FTSS finite element certificate tests at component level were conducted to obtain satisfactory component performances. These tests include the head drop test, the neck pendulum test, the lumbar pendulum test and the thorax drop test [1, 2]. Successful FTSS finite element certificate tests at full-dummy level followed, which consists of the shoulder pendulum test, the thorax pendulum test, the abdomen pendulum test and the pelvis pendulum test [1, 2]. In addition, an extra set of tests, the WSU sled tests, were integrated into dummy development to enhance the fidelity and robustness of dummy performances. Finally a EuroSID-2 and a EuroSID-2re dummy have been successfully developed, which have greatly facilitated virtual vehicle development and the design process of vehicle and occupant safety in the automobile industry.

INTRODUCTION

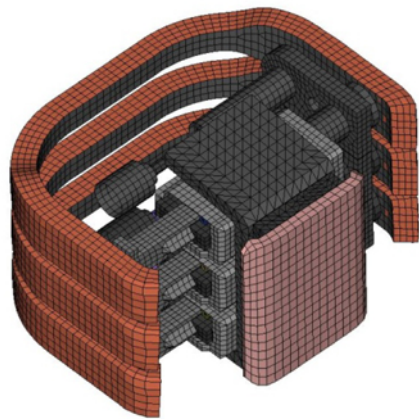
The ES2 dummy is an improved EUROSID-1 (ES1) dummy with increased injury assessment and measurement capabilities that address the main concerns expressed with EUROSID-1. The EEVC recommended the use of the ES2 dummy in 2002, and the dummy was adopted by EuroNCAP

in 2003 and by ECE R95 in 2004. The ES-2re dummy is a variant of the ES-2 dummy proposed by NHTSA for the new FMVSS214 standard and it was developed to completely eliminate the back plate seat interference that may exist with the standard ES-2 [3]. To comply with safety regulations in their own regions with least cost, OEMs in both Europe and North America have used the Radioss code for their vehicle crashworthiness and occupant safety analysis. Development of bio-fidelity and robust ES2/ES2_RE dummy models is highly desired.

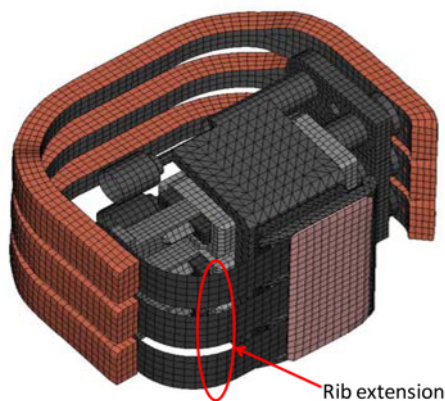
DIFFERENCES BETWEEN ES2 AND ES2-RE DUMMIES

There are two major differences between ES2 and ES2_RE.

- a. ES2_RE is equipped with the shoulder loadcell;
- b. ES2_RE dummy has a rib extension kit, which is specifically designed for overcoming serious interaction issues with airbag and seat revealed in a NHTSA test program for the ES1 dummy. Fig. 1 shows the structure differences in the thorax area between the ES2 and ES2_RE dummies.



ES2 thorax



ES2_RE thorax

Fig. 1. Structure differences between ES2 and ES2_RE thorax

The ES2 and ES2_RE dummies developed by FTSS have different structures in the thorax area as per the physical dummies. However both dummies are constructed the same in all other areas, even having the same shoulder loadcells.

BASIC PROCEDURES IN THE ES2/ES2_RE DUMMY MODEL DEVELOPMENT

The procedure for developing the ES2/ES2_RE FE dummies consists of a few important steps. First, correct dummy geometries have to be obtained so that the FE dummies will resemble their physical counterparts. The whole dummy meshes were created based on CAD data and intensive efforts were made to obtain penetration/intersection-free models. Second, correct material models in the chosen FE code have to be applied based on physical material tests. Third, after the dummy components were created, serial validation tests at component level were conducted to make sure all components will perform well. Fourth, a suite of full dummy certificate tests were accomplished to make certain that the full dummies behave similarly to the physical dummies.

Finally, additional full dummy sled tests were performed to further validate the dummy models.

Due to the similarity of the ES2 and the ES2_RE dummies and their validation tests, all validation tests presented in this paper are referred to the tests for the ES2_RE dummy and FE tests results for the ES2 dummy are basically similar to those for the ES2_RE dummy. As the material models in the previously developed dummies (i.e. Euro-SID1) are used for the ES2/ES2_RE dummy model development with necessary fine-tuning, validation tests at the material level will not be discussed in this paper. The methodology for the material level validation is detailed in [4].

VALIDATION TESTS AT COMPONENT LEVEL

During the course of ES2/ES2_RE model development, a variety of certificate validation tests at component level were conducted. These include: head drop test, neck pendulum test, lumbar spine pendulum test, thorax drop test (different speeds) [1, 2].

HEAD DROP TEST

Head injury criteria (HIC) is one of most important dummy injury criteria in all related safety regulations, and is an acceleration based parameter. To ensure that the dummy model can capture acceleration responses accurately, a head drop test was conducted. In this test, the head was falling freely from 200 mm onto a horizontal rigid plate with its mid-sagittal plane at 35 deg with respect to horizontal, achieving an impactor velocity of 1.98 m/s [2, 3], as shown in Fig. 2, which also shows the excellent correlation of the FE simulation against the physical test.

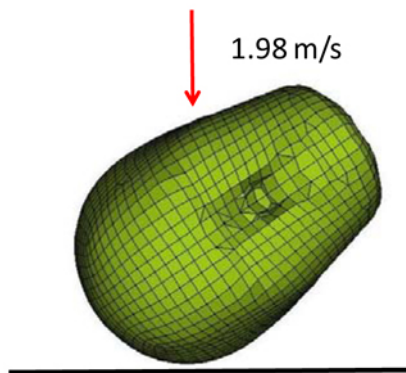
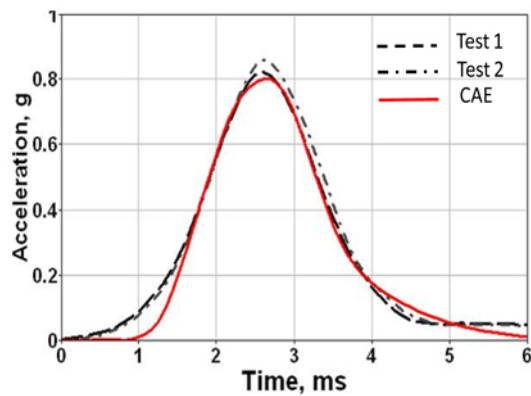


Fig. 2. Head drop test correlation and the model

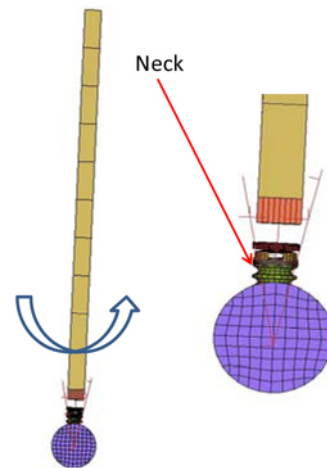
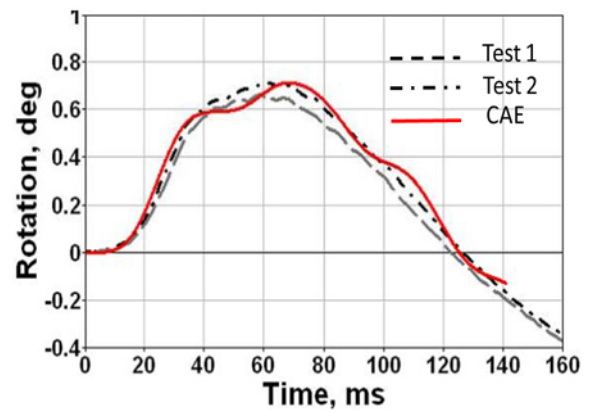


Fig. 3. Neck pendulum test results and its FE model

NECK PENDULUM TEST

The dummy neck is made from rubber material and its responses under different loading conditions contribute to not only neck behaviors but also to head performance. The neck assembly is attached to a pendulum and a headform is connected to the other end of the neck. The physical neck pendulum test employs the Part 572 subpart E pendulum, which is released and falls freely from a height designed to obtain an impact velocity of 3.4 m/s, measured at the centre of the accelerometer, 1657.4 mm from the pendulum axis [2, 3]. A FE neck pendulum test was carried out to make sure the FE dummy neck resembles its physical counterpart. The simulation result is illustrated in Fig. 3, and reveals very good correlation to the physical test results.

LUMBAR SPINE PENDULUM TEST

As the lumbar spine is an important load path between the thorax and the pelvis, full dummy kinematics relies heavily on lumbar spine performance. Similar to the neck pendulum test, one end of the lumbar spine is attached to the free end of the pendulum, and the other end is attached to a headform. The pendulum is released and allowed to fall freely from a height chosen to achieve an impact velocity of 6.05 m/s, as measured at the centre of the accelerometer, 1657.4 mm from the pendulum axis. The head flexion angle is monitored and compared against physical test data. The comparison shows an excellent result, as depicted in Fig. 4.