TUC Validation Repository

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Documentation Validation Environment LS-Dyna

Lumbar Intervertebral Disk: Compression

Version:	V01
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1. General

This document is part of the *validation kit* for the validation of a FE Human Body Model (HBM) against the loading condition specified under 1.1. The *validation kit* is composed of the following parts:

1. FE model of **validation environment**

   The following LS Dyna files contain the validation environment:

   a. *main.k*
   b. *bc.k*
   c. *geom.k*
   d. *control.k*
   e. *out.k*

   The HBM to be validated needs to be prepared and integrated into the validation environment according to the validation protocol in section 4.

2. Experimental corridors

   The following experimental corridors are provided as excel-files:

   f. *Fo_M01.csv – Fo_M15.csv*
   g. *Convex_Hull.csv*
   h. *Convex_Hull_FailurePoints.csv*
   i. *Corridor_Mean_Values.csv*
   j. *Corridor_Mean_plusSTD.csv*
   k. *Corridor_Mean_minusSTD.csv*

3. Validation protocol incl. a description of the load case

1.1 Classification of validation load case

Body region	Thorax
Level	Component
Load case	Dynamic Axial Compression of an Intervertebral Disk
References	Christou, A., Grigoriadis, G., Carpanen, D., Newell, N., & Masouros, S. D. (2017). Biomechanics of a lumbar functional unit using the finite element method. IRCOBI Conference 2017, 668–669.
Unit system	kg - mm – ms – kN – GPa
Code	LS Dyna 9.3.0

1.2 Disclaimer

The validation kit was developed in close cooperation within the THUMS USER COMMUNITY 2 (TUC2) research project. Any use of this validation environment shall be entirely at the user's own risk and responsibility. University of Munich (LMU), AUDI AG, Autoliv, BMW AG, Daimler AG, Porsche AG, Toyota Motor Corporation, Volkswagen AG and ZF TRW do not assume any responsibility for the validity, accuracy, or applicability of any results obtained from this research model and do not assume any liability or responsibility whatsoever for any damage, claims, injury or loss of any kind that may arise from or in connection with any use of, reference to and/or reliance upon this manual.

University of Munich (LMU), AUDI AG, Autoliv, BMW AG, Daimler AG, Porsche AG, Toyota Motor Corporation, Volkswagen AG and ZF TRW ask that the TUC 2 project will be acknowledged under references for any use of this FE model resulting in papers and publications.

2. Description of the Validation Environment

In this section the validation environment is described, including the numerical model of the experimental setup without the HBM to be validated. For each of the above mentioned input decks a short description of the file contents is given. The protocol of section 4 describes how a human body model needs to be processed to be integrated in and validated with this environment FE model.

2.1 *main.k* - main file

The main file contains only the termination time and the other include files. The termination time for the solver is defined to 60 ms. This entire simulation setup has been prepared in the S2 units system: mm-ton-s.

Further, all include files of the validation environment are specified in this main file:

- *geom.k*
- *bc.k,*
- *out.k*
- *control.k*
- *IVD.k*

Where IVD.k is the prepared HBM component file.

2.2 *geom.k – Model Geometry Including Pots and Potting Material*

In this file the geometry (part-, element-, node- and material definitions) of the following setup components are specified (see **Table 2**):

Table 1 - Content of file 'geom.k'

Part	Part-ID	Material-ID
Lower Potting	1	1
Upper Potting	2	1
Upper Pot	3	2
Lower Pot	4	2

The pots were modelled with a diameter of 60 mm and the material properties of aluminum. The potting was modelled with a diameter of 60 mm and the material properties of PMMA. The potting blocks were modelled as a rigid material. Therefore only the density of the PMMA Material is needed, and is specified at 1.18 g/cm^3. The specimen is attached to the potting material using *CONTRAINED_RIGID_BODIES cards as described in section 3.3.

2.3 *bc.k* – Boundary Conditions

The following boundary conditions and constraints are defined in the validation environment:

2.3.1 Rigid Body Definitions

It is assumed that the structural stiffness of the potting is sufficient high such that it can be modelled as a Rigid Body. This is because in addition to the potting material the specimens were also held in place with bone screws. Also as the loading does not reach the destructive domain, many dynamic effects can be assumed to be negligible. The interface elements belonging to the cortical bone (for models with deformable vertebrae) are redefined as rigid elements and then joined to the potting using a *CONTRAINED_RIGID_BODIES card.

2.3.2 Setup Constraints

A prescribed motion was given to all of the nodes on the upper surface of the upper pot in the Z direction. This motion was extracted from the LVDT data and constructed of average depending on the spinal segment level. The lower edge of the bottom pot is held fixed using a Single Point Constraint boundary condition for all degrees of freedom.

2.3.3 Contacts

No contacts are defined for this validation setup as to not interfere with the rigid body constraints.

2.4 *out.k* – Output Definitions

The following output parameters are defined in the validation environment.

A nodal time history output was defined for the center of the upper surface of the upper pot. This output was defined to check that the impactor movement was correct.

Further, a section force output was defined to measure the contact force flowing through the upper pot. This section force output is a force-time history output and is used to make comparisons to the experimental results.

2.5 *control.k – control cards*

The control cards associated with the HBM being simulated are located in control.k.