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ANSYS LS-DYNA PC Modeling of Contact/Impact with High and Low Stiffness Materials in the Numerical Simulation of Nuclear Transportation Packages under 9 m Drop Tests

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PRESENTATION TOPICS

- IPEN Overview
- Introduction
- The Transportation Package
- Finite Element Model
- Improving the contacts
- Conclusions

IPEN Overview

IPEN – CNEN/SP is the Nuclear and Energy Research Institute
(Instituto de Pesquisas Energéticas e Nucleares)

IPEN is an autarchy of the estate of São Paulo, managed by the Brazilian Federal Government through CNEN, the Brazilian Nuclear Energy Commission, and associated to the University of São Paulo.

IPEN is organized in 12 centers and CEN, the Nuclear Engineering Center, is one of them.

The CEN Structural Mechanics Division has worked on the development of options to the storage of the spent fuel elements from the nuclear research reactor IEA-R1, located on IPEN, since 2000 which is supported by the IAEA, the International Atomic Energy Agency, through several research projects.

This work is included in the design of a dual purpose transportation and storage package for the spent fuel elements from the nuclear research reactor IEA-R1.

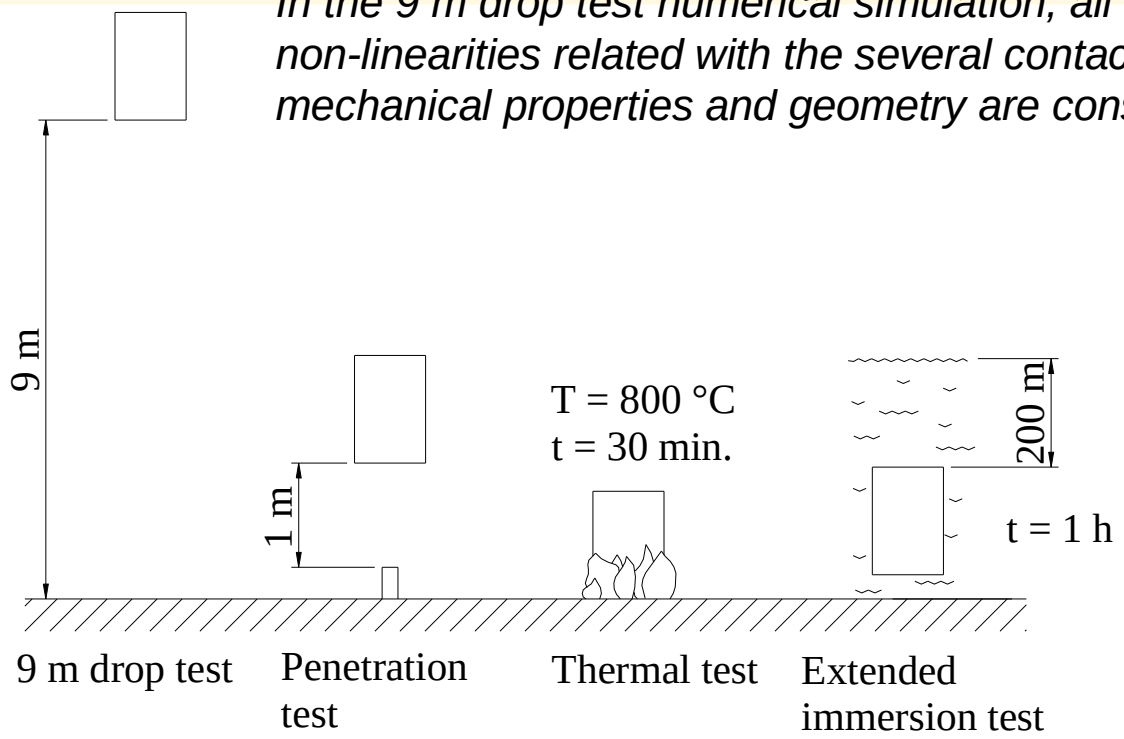
Introduction

The transportation packages must be structurally qualified for the hypothetical accident conditions:

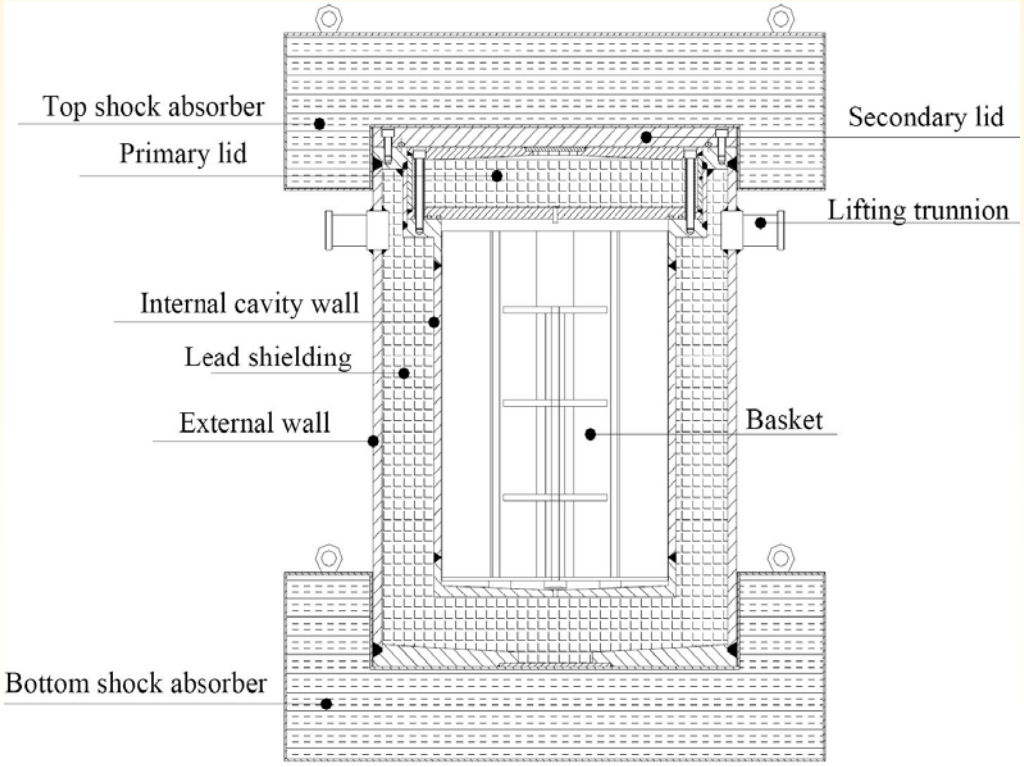
- A 9 m free drop onto a rigid target
- A puncture resultant from 1 m free drop onto a bar rigidly mounted perpendicularly on a rigid target
- A fire resulting in a temperature of 800 °C for 30 min
- A submersion to a 200 m depth of water

Prescribed Tests

In the 9 m drop test numerical simulation, all the existing non-linearities related with the several contacts, material mechanical properties and geometry are considered.



The Transportation Package



The Transportation Package

Design criteria: 21 MTR or 78 TRIGA,
max. weight 10 t, Type B fissile package

Design goal:

. 125 g in the internal basket

Main parts:

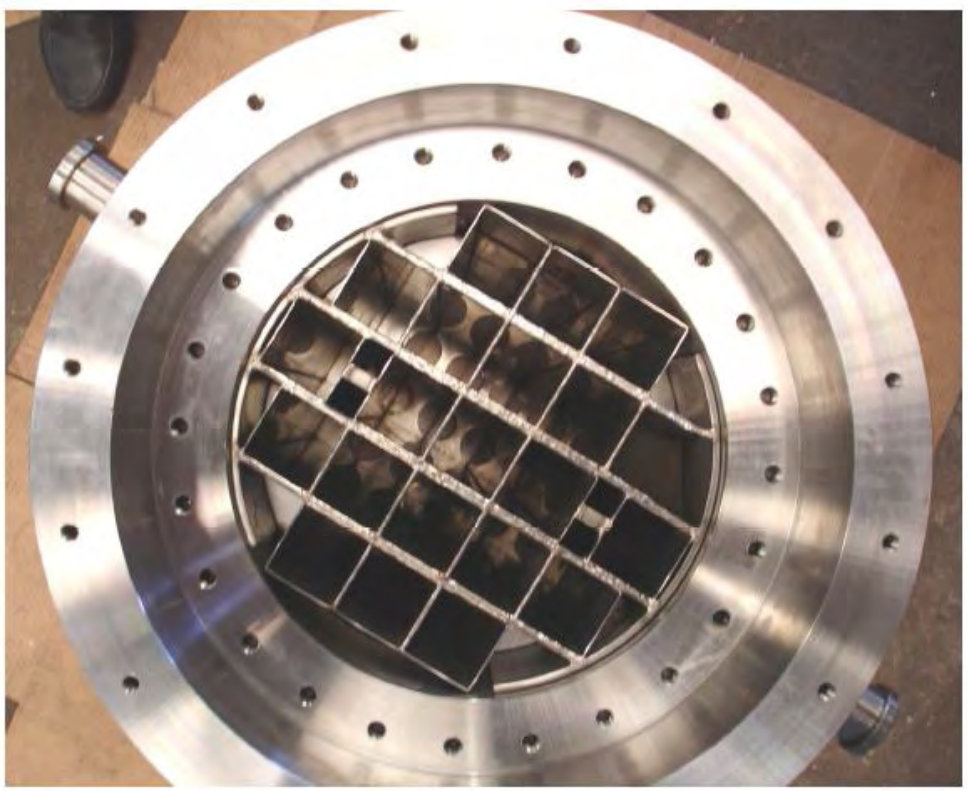
. Main body
. Heads
. Basket
. Dampers (impact limiters)
. Lids (In & External)
. Lead (biological shield)

The Transportation Package

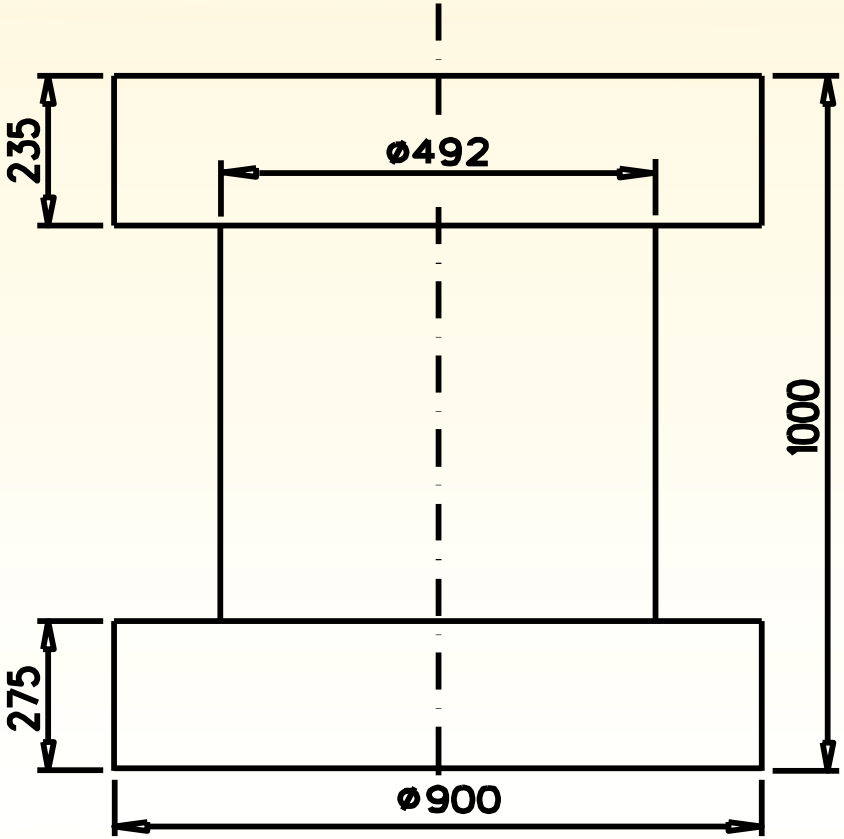
The package is a stainless steel cylinder with flat heads (the bottom one is welded and the upper one has flanges with threaded connections and internal basket (for the fuel elements)

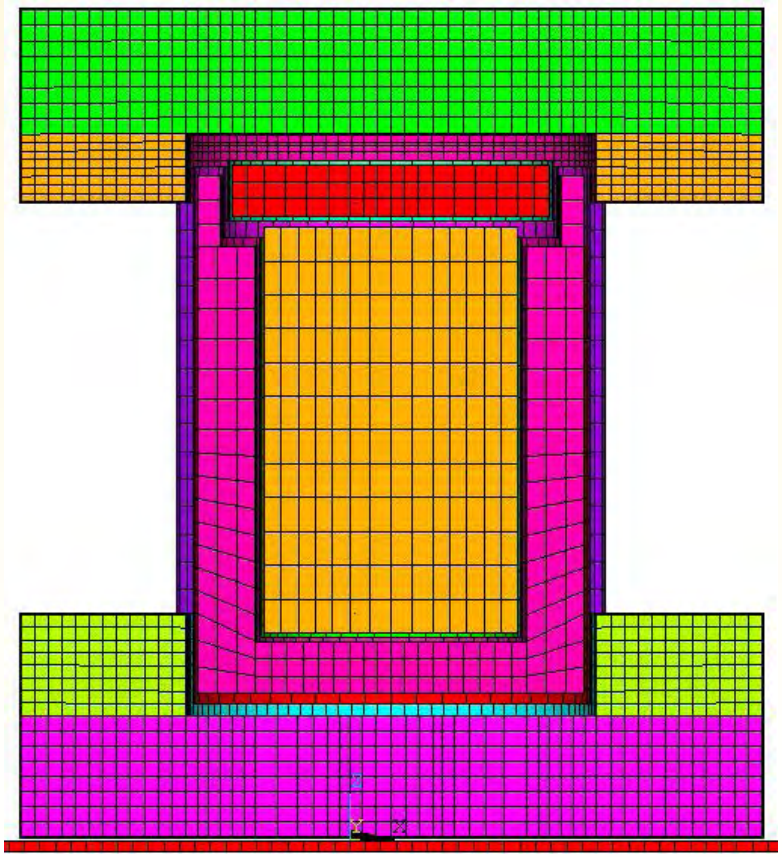
- It is surrounded by a biological shield of lead
- it has also upper and lower wood dampers contained in stainless steel shells

The Transportation Package

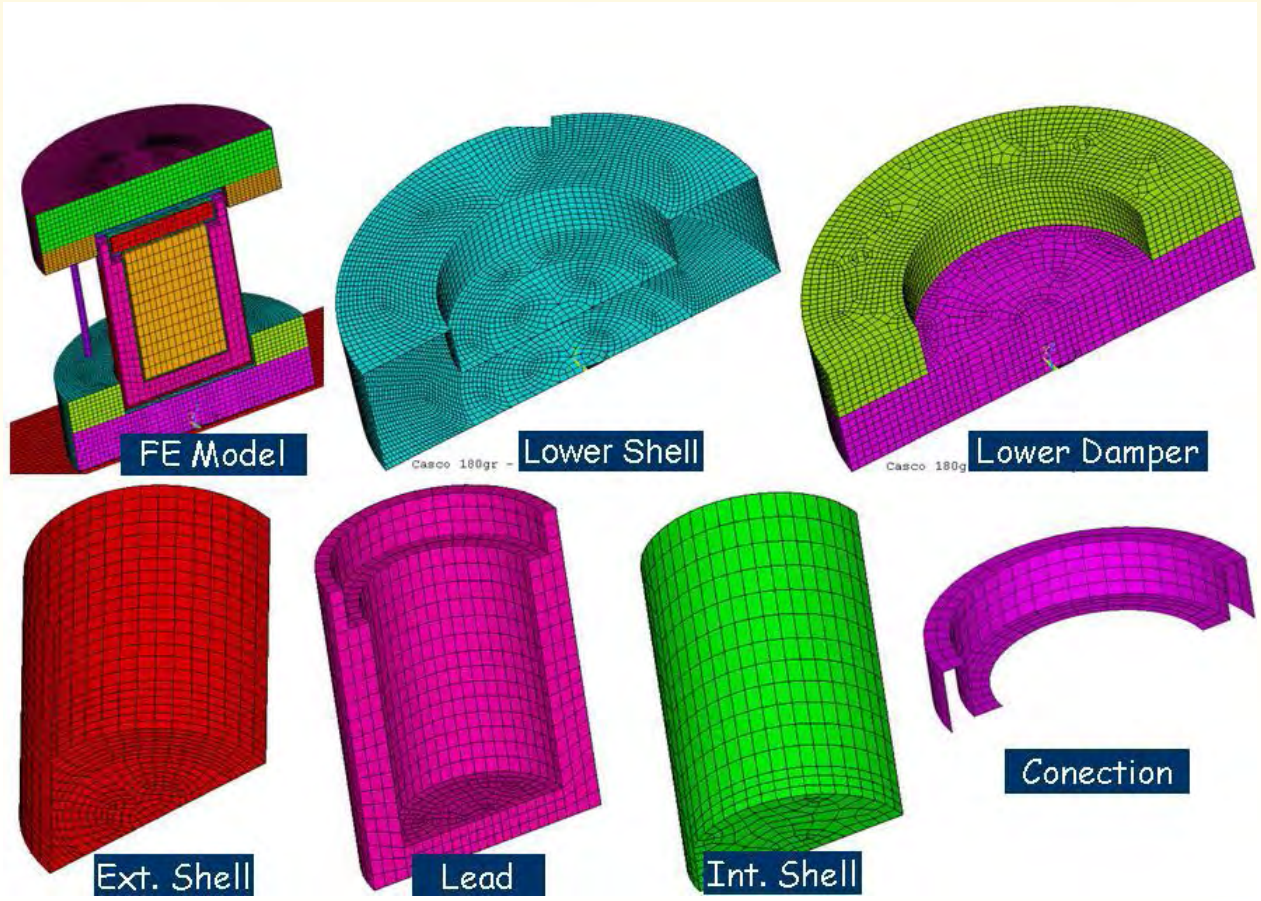


The Finite Element Model

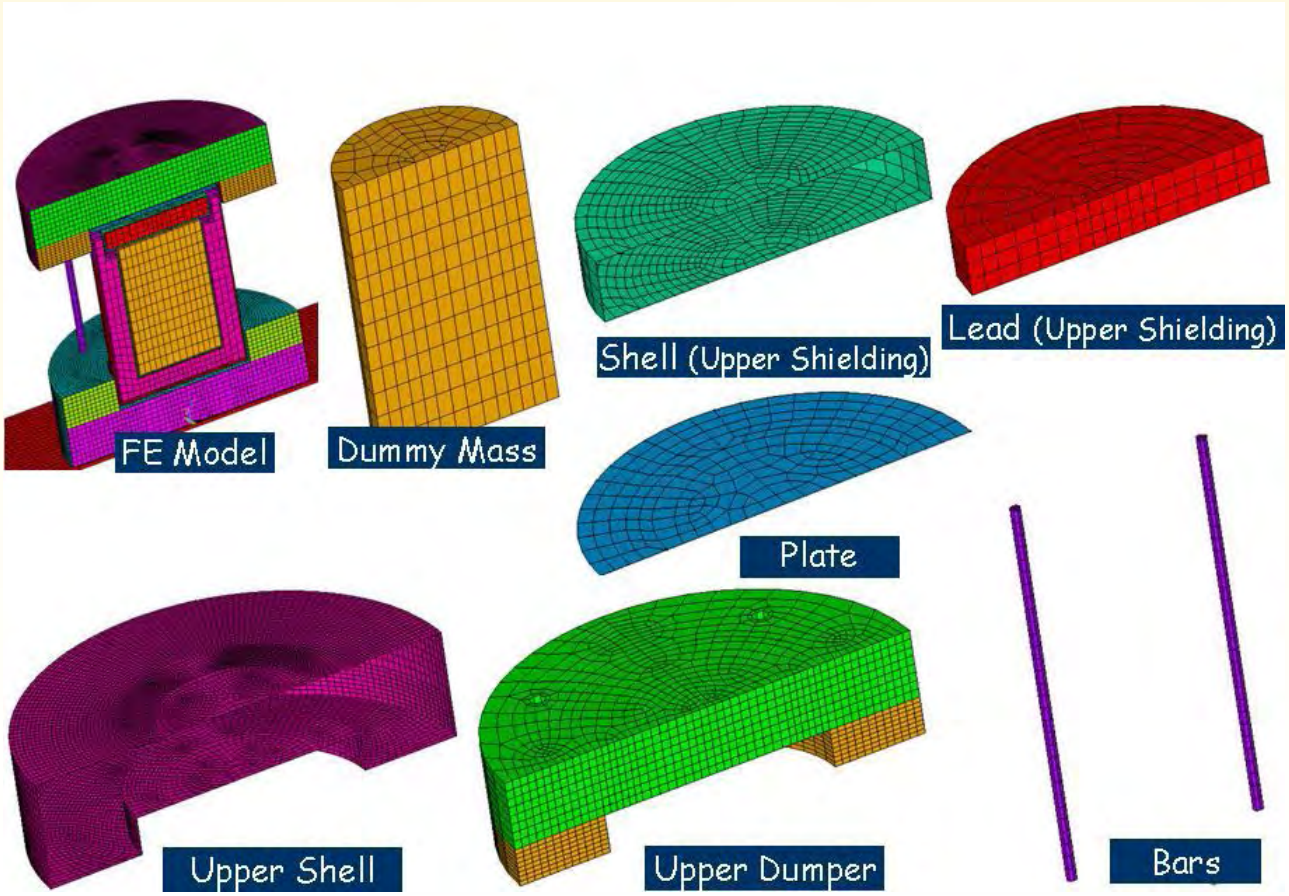




The Finite Element Model



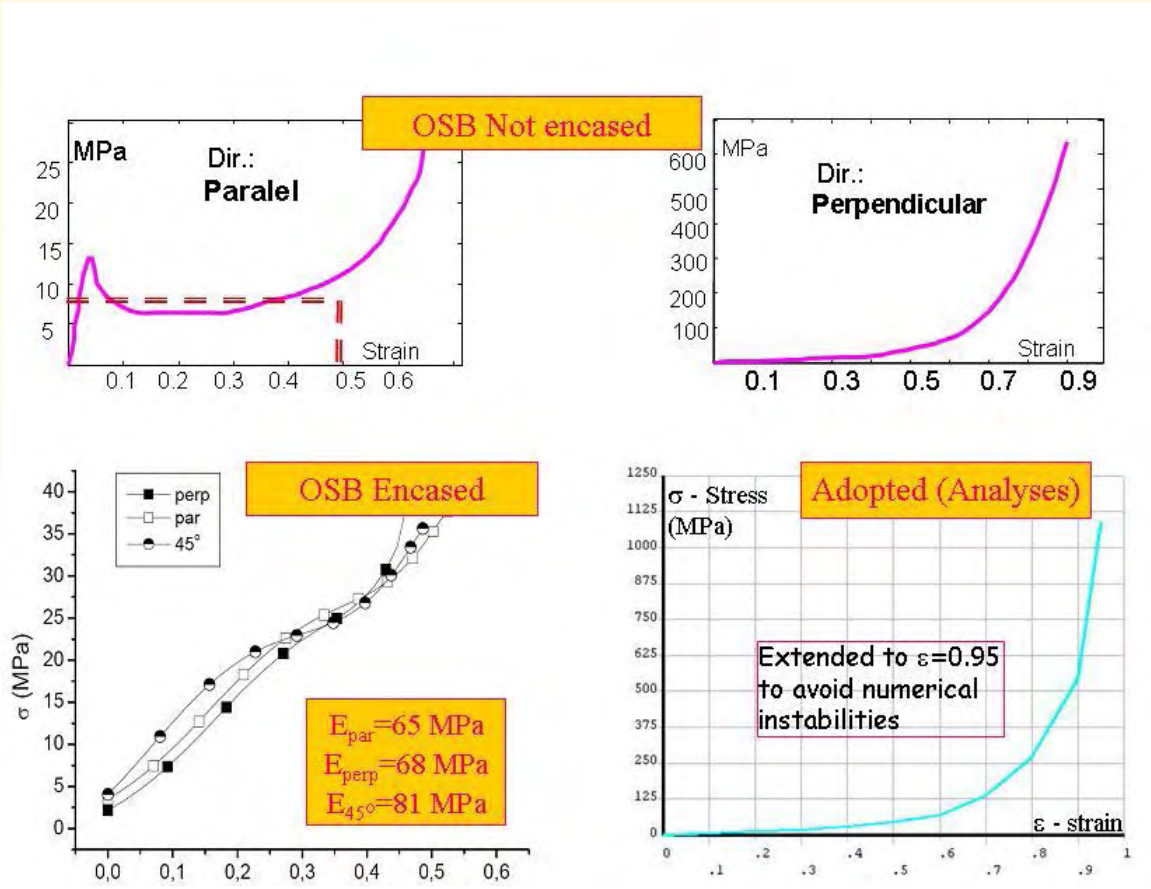
The Finite Element Model



The Finite Element Model – Material Data

Package Part	Material	Dimensions
Lower shell	stainless steel	dia = 900 mm
Lower Damper	wood (**OSB**)	dia = 894 mm
Inner Shell	stainless steel	dia = 328 mm
Lead	Lead	
Outer Shell	stainless steel	dia = 492 mm
Upper Damper	wood (**OSB**)	dia = 894 mm
Upper shell	stainless steel	dia = 900 mm
Tie bars	stainless steel	dia = 30 mm

The Finite Element Model – Impact limiters material properties



Contacts, Materials Models & Loading

1. Contacts: . defined as ASTS in the ANSYS LS-DYNA (Automatic Surface-To-Surface Contact)
   . defined as TDSS in the ANSYS LS-DYNA (Tied Surface-To-Surface Contact)

2. All materials, but the OSB and the rigid surface, were modeled as Bilinear Isotropic Material (BISO)

   The rigid surface was modeled with the RIGID option and same properties as the steel

3. Loading - **initial velocity** (corresponds to 9 m drop) plus the **gravity acceleration**

Improving the Contacts

Default Parameters
Timestep and Contact Stiffness
Large compressive strains x Extended Stress-Strain Curve
Increased Solid Element Thickness in Contact
Avoid duplicate contact definitions
Alternative procedure for considering all LS-DYNA contacts options

Improving the Contacts

ANSYS LS-DYNA _X_ LS-DYNA Solver

. Pre-processing

. Solve (indirectly calls the LS-DYNA Solver)

. Pos-processing

. ANSYS Pre-processing

. ANSYS Solve → file '.k' (kill solver)

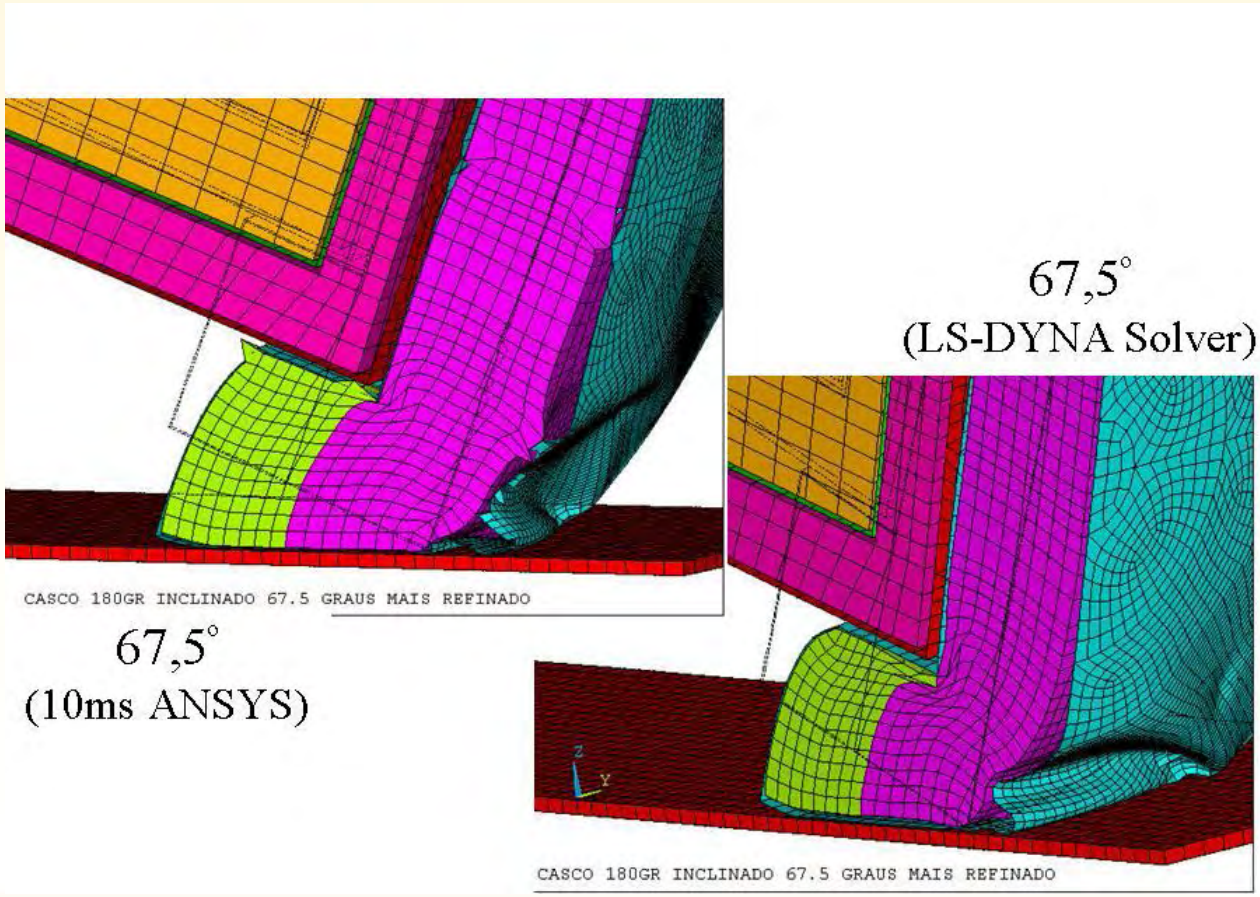
. File '.k' Editing

(LS-Dyna Contact parameters)

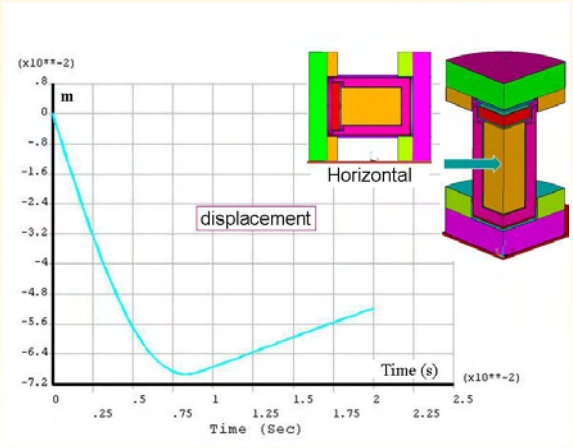
. LS-DYNA Solver

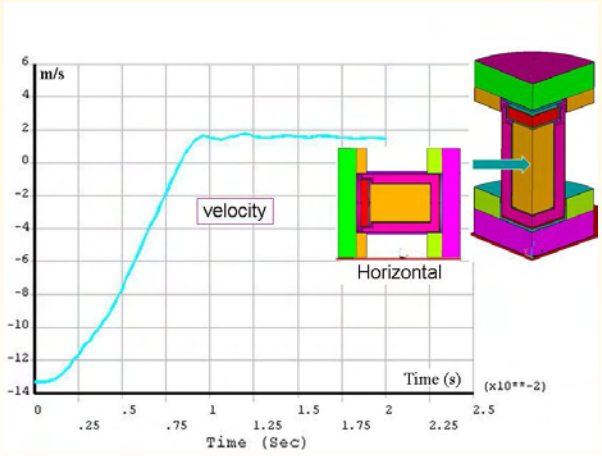
. ANSYS Pos-processin

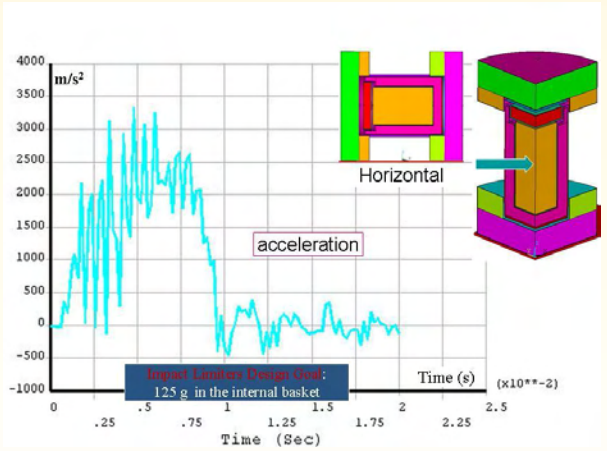
Improving the Contacts



Conclusions





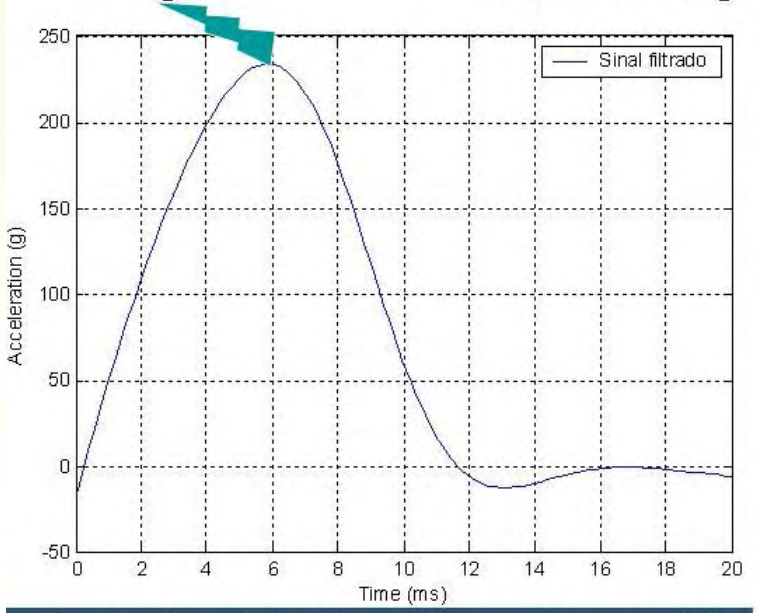


Conclusions

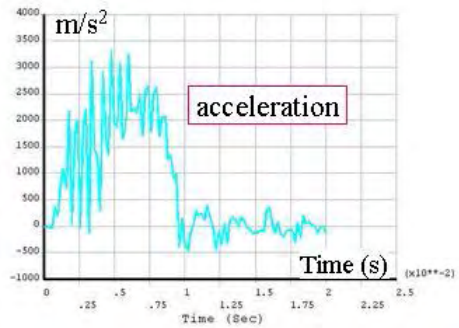
1:2 Model
Max. Acceler.
≈ 240 g

Scal tion

Prototype
Expected Max.
Acceler. ≈ 120 g



Acceleration - After Signal Filtering (Butterworth)



Impact limiters Design Goal:
125 g in the internal basket