Recent Developments on LSTC Barriers Models

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LSTC BARRIERS

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LSTC
Livermore Software
Technology Corp.

Outline

- Introduction
- Honeycomb Structure and Adhesive Modeling
- Validation
- Integration into Vehicle
- Conclusions

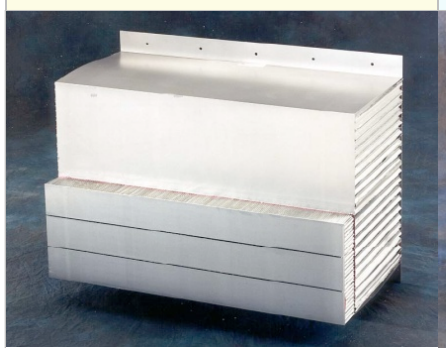
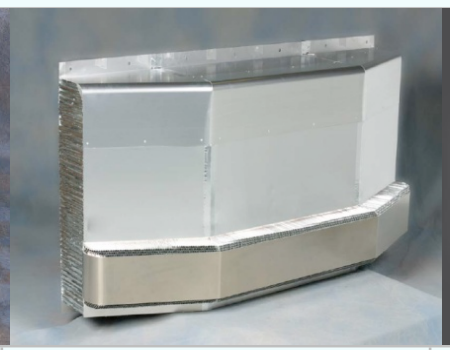
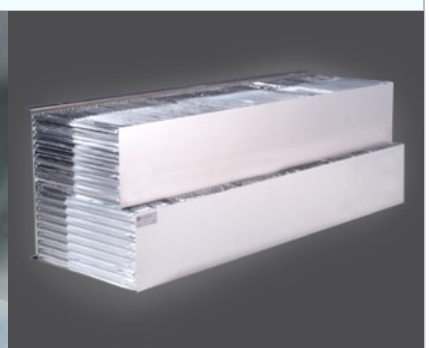
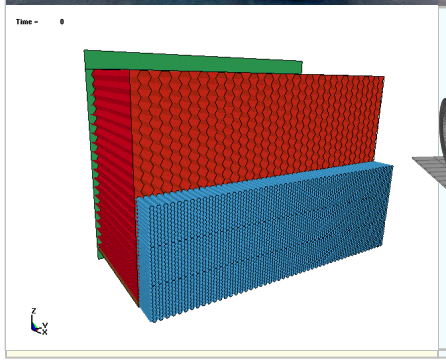
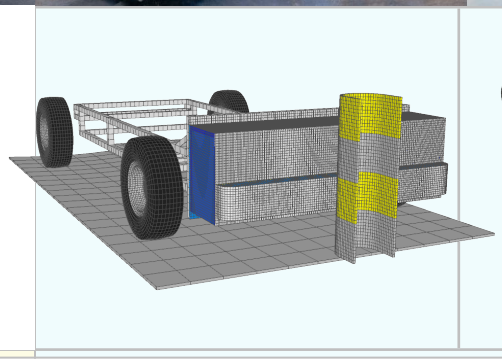
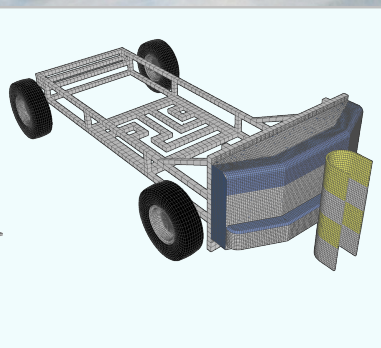
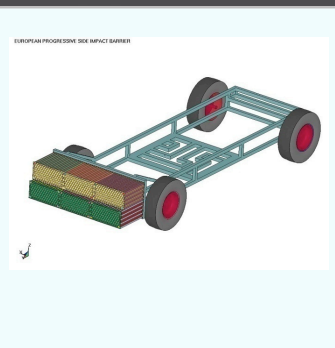
Introduction

- Accurate predictions of vehicle crashworthiness relies heavily on validated systems (Barriers, Dummies, etc) used to evaluate critical vehicle measurements
- Over the last few years, LSTC has been working with several OEM and suppliers with experimental data to help develop validated LS-DYNA Barrier Models for use in Crash Analysis
- This presentation will provide details regarding the development and the current status of LSTC FE Barriers.

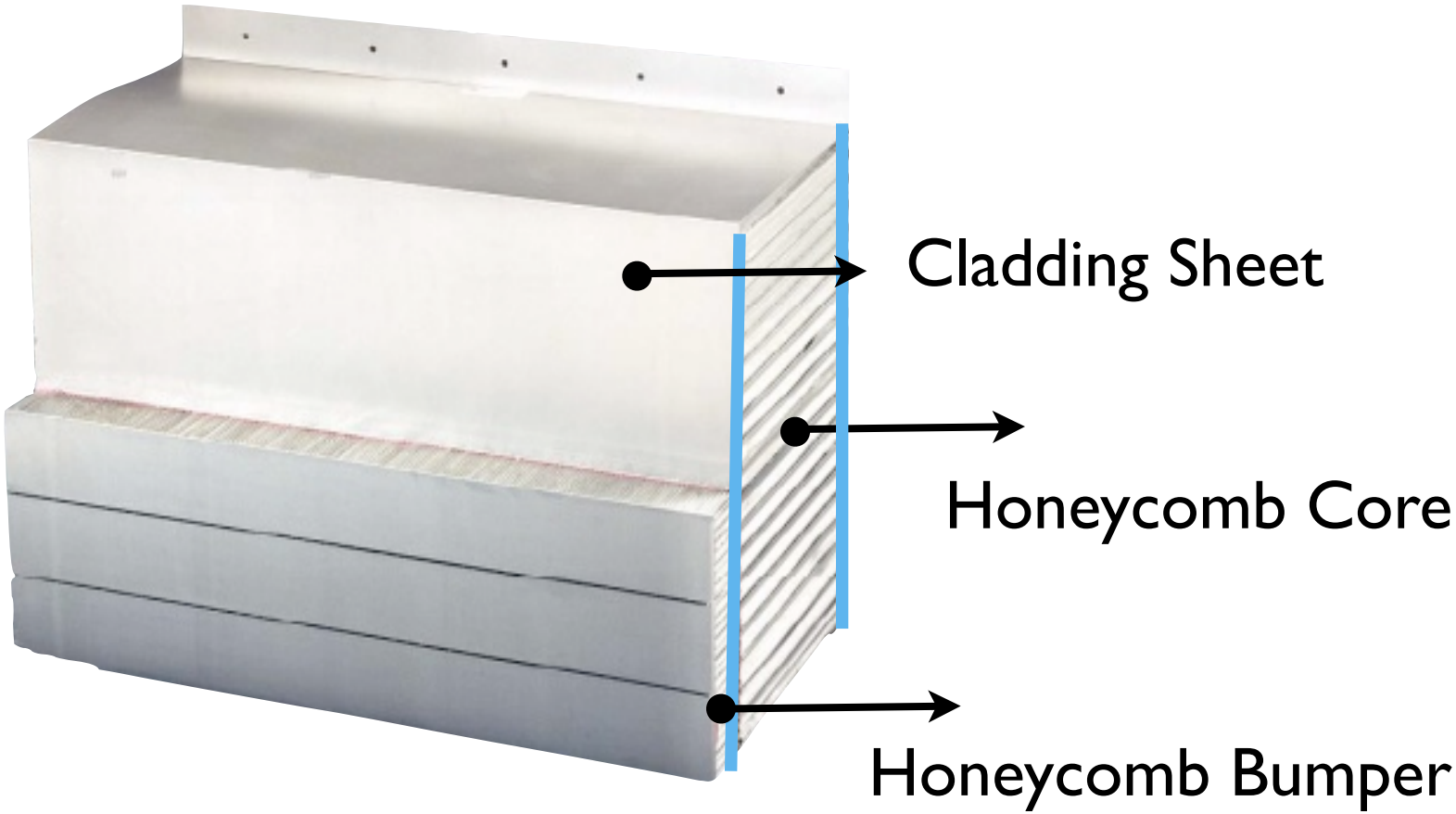
LSTC's FE Barrier Family

Frontal Barriers

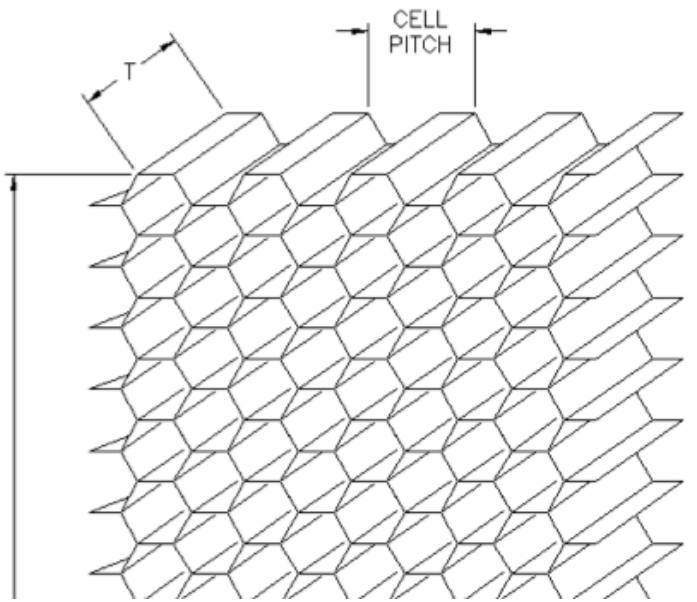
Side Impact Barriers

ODB	MDB (214)	SICE (IIHS)	PDB (Europe)
			
			

Main areas of Modeling

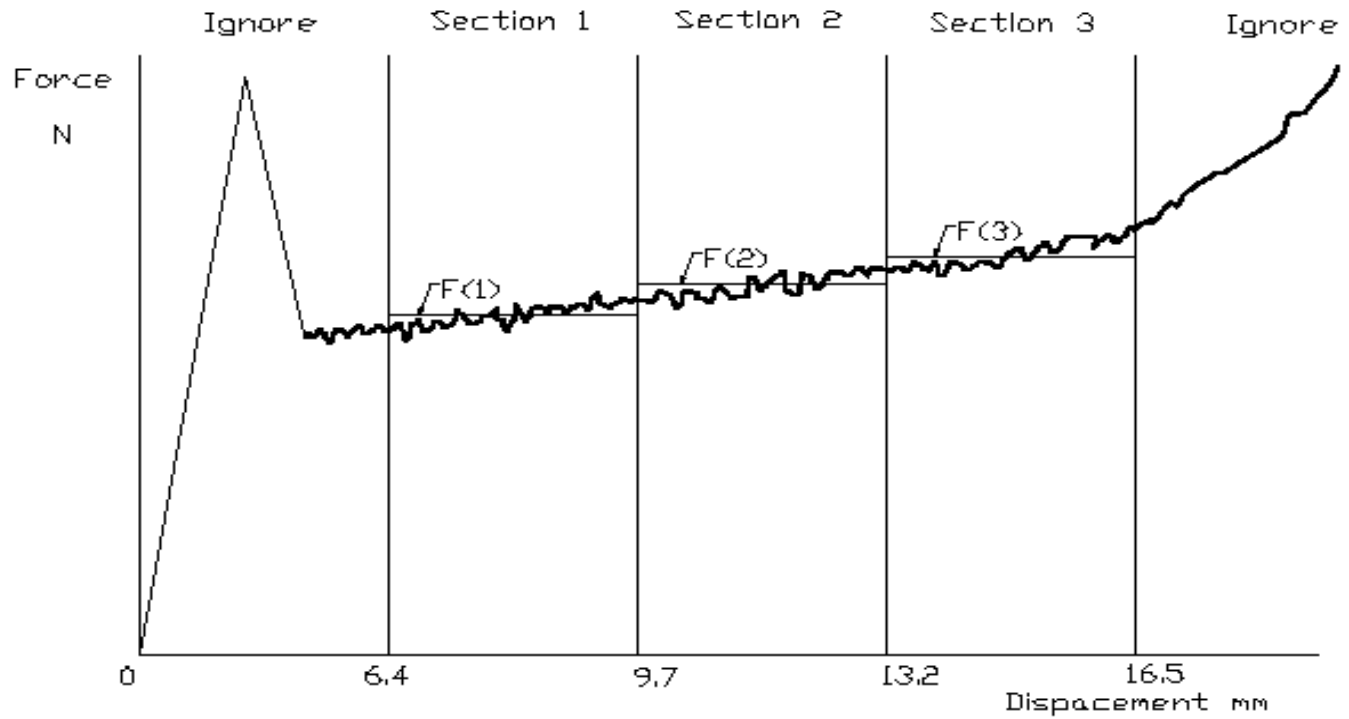


Honeycomb Structure Modeling



- Cellular structure
- Continuum using solid elements
- Shell Elements
- All LSTC barriers come in "SOLIDS" and "SHELLS" versions with the cost of the 'Shell' barriers roughly 4-20x that of the solids.

Honeycomb Properties - Crush Strength

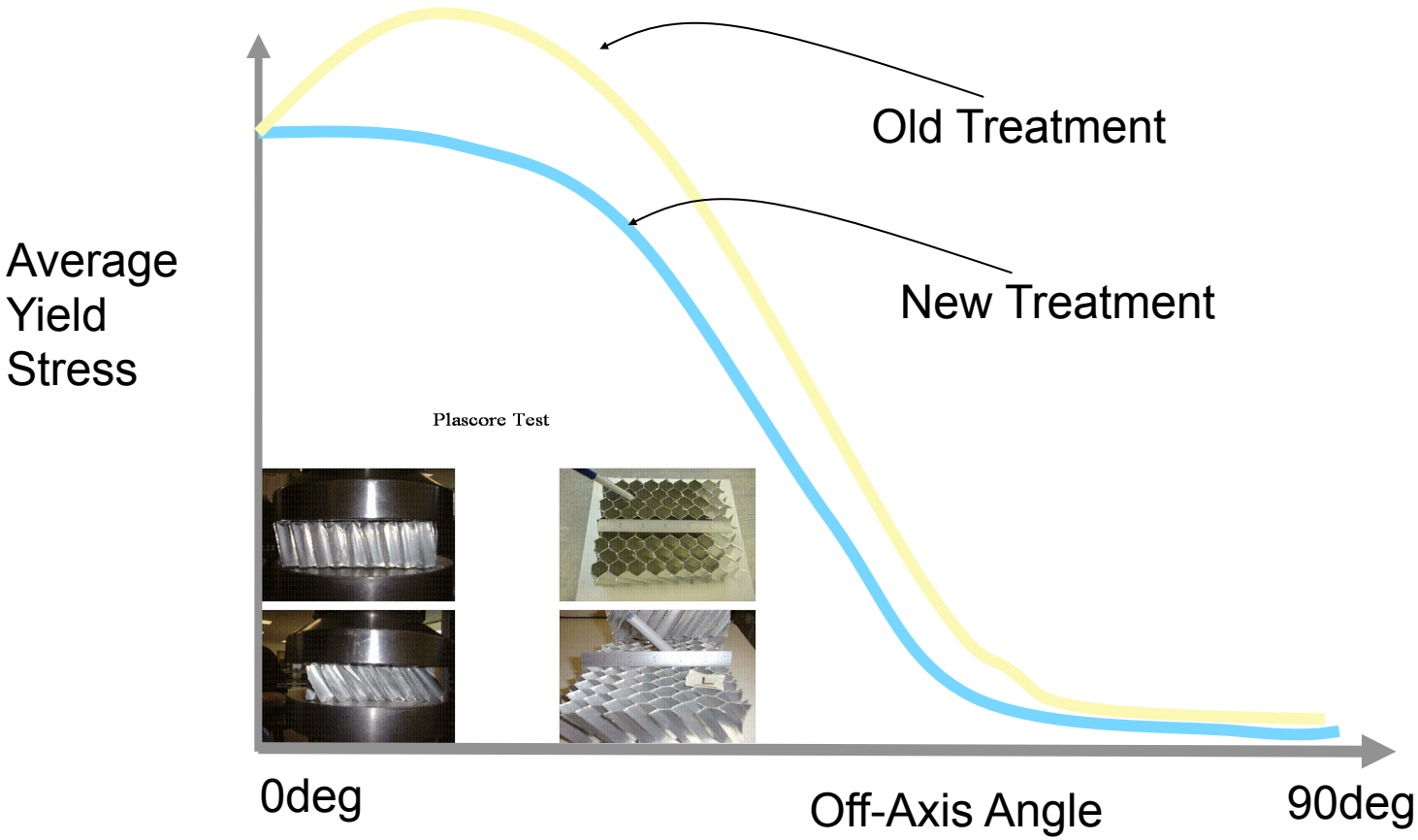


Crush Strength S(n) = F(n) / A ; n=1,2,3

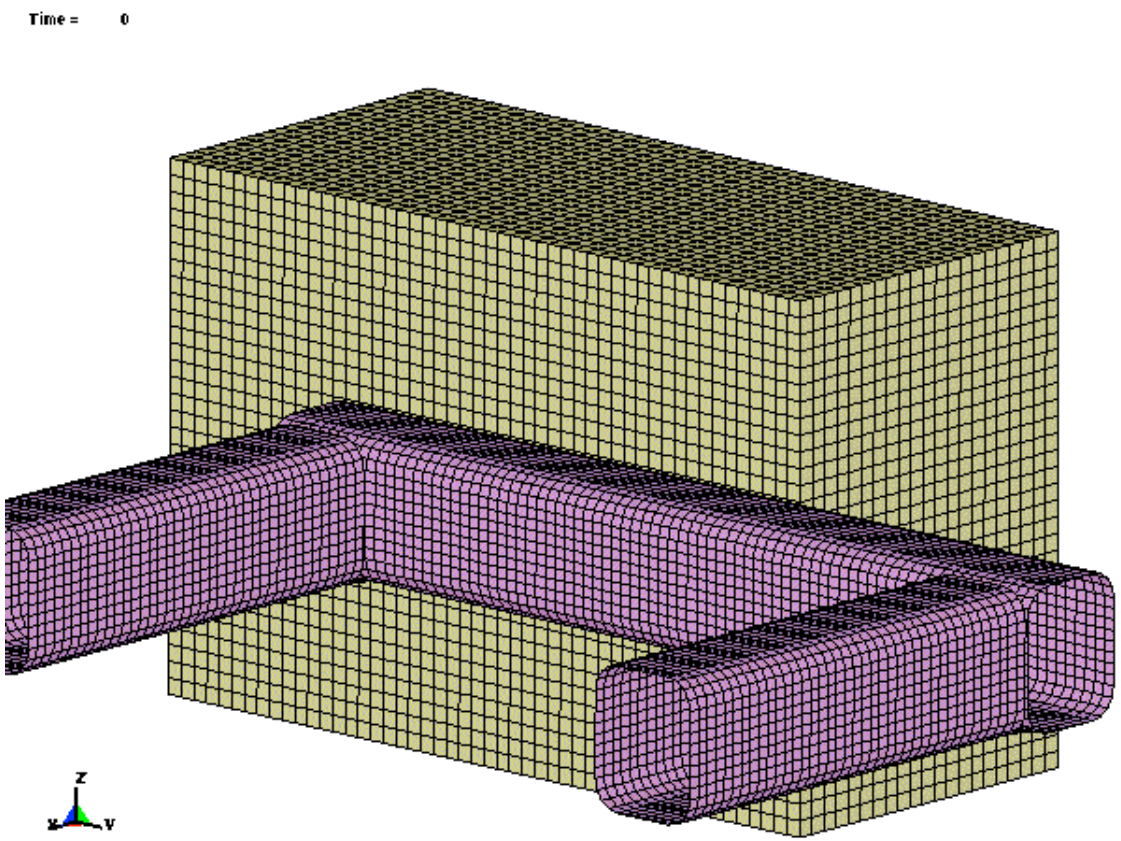
Scematic Load-Displacement Trace for Honeycomb Certification

Honeycomb Structure - Off-Axis

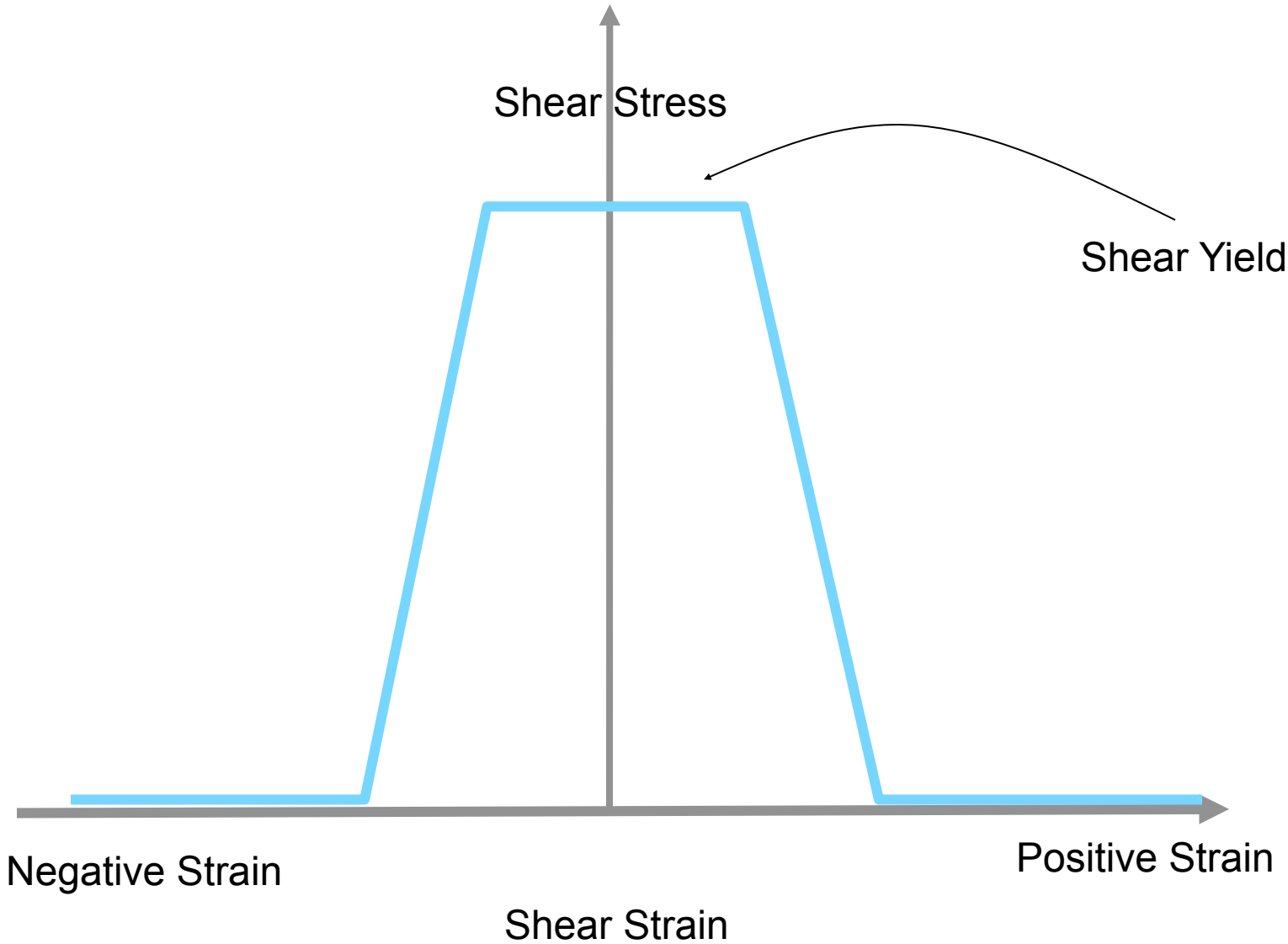
$$\sigma^{y}\left(\varphi,\varepsilon^{vol}\right)=\sigma^{b}\left(\varphi\right)+\left(\cos\varphi\right)^{2}\sigma^{s}\left(\varepsilon^{vol}\right)+\left(\sin\varphi\right)^{2}\sigma^{w}\left(\varepsilon^{vol}\right)$$



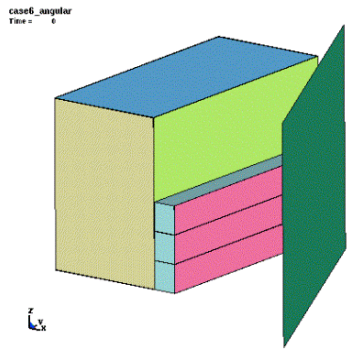
Localized Damage

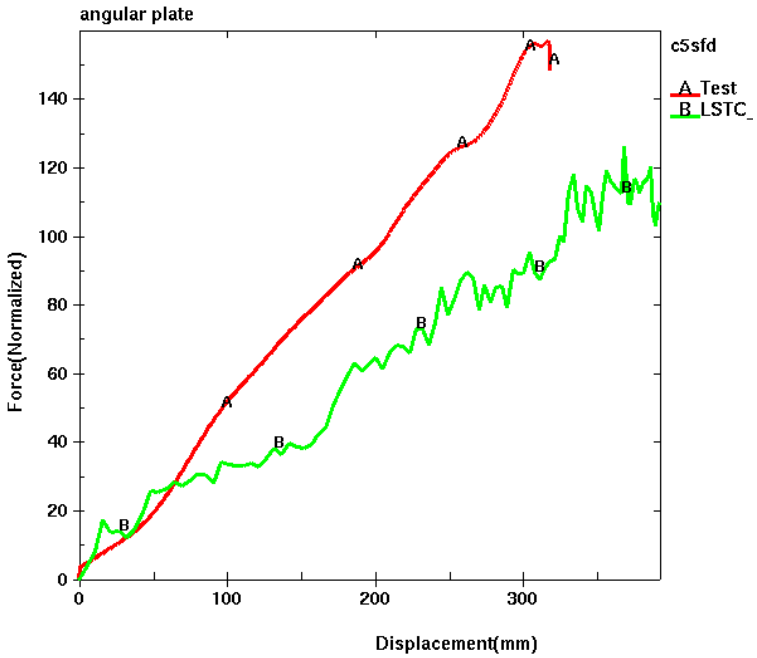


Shear Damage

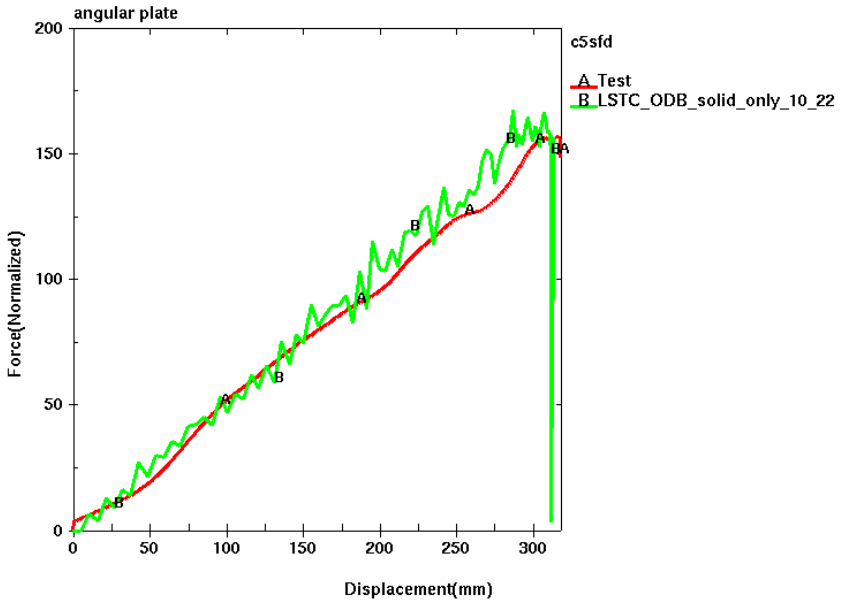


Shear Damage Evolution



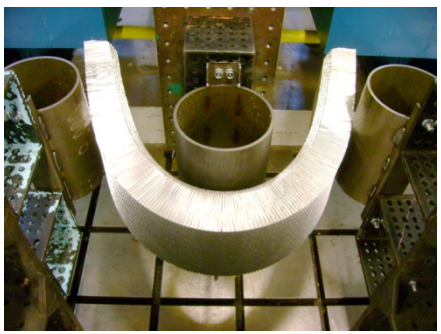


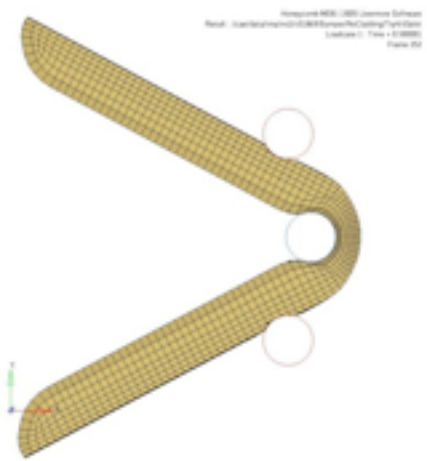
Old Damage

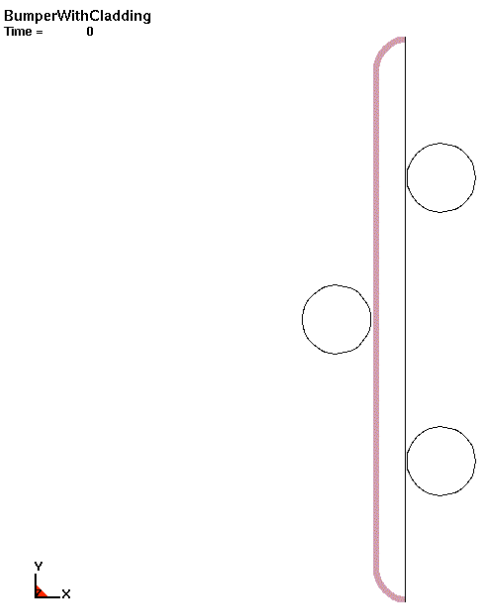


New Damage

Importance of Hardening



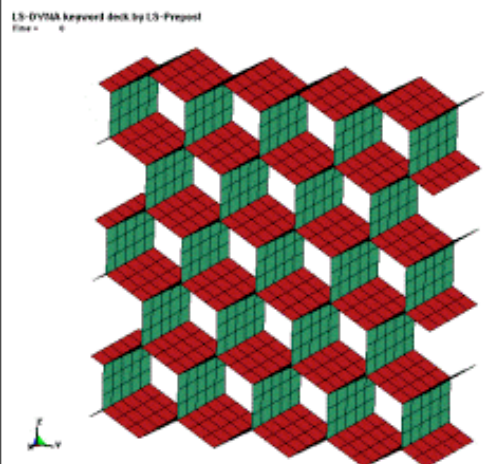


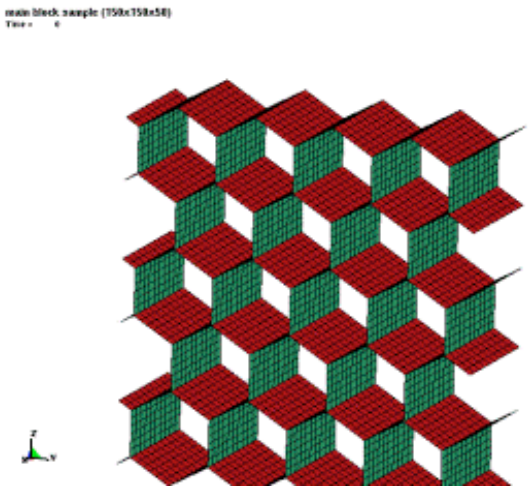


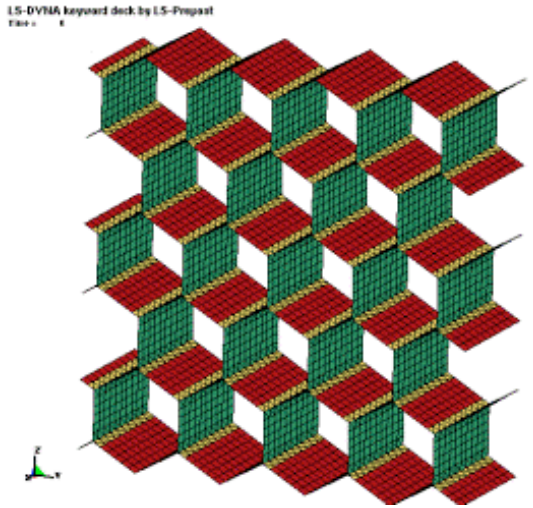
Shell Modeling of Core

- Physical realistic discretization of honeycomb cellular structure is probably the most realistic method of representation
- Actual cell size modeling may be still far-fetched but with shell thickness and material stiffness modifications, it is possible to capture a cell size that is close to reality and with workable element count
- Using LS-OPT one can easily determine the desired thickness and material yield with a cell size for a given average yield strength

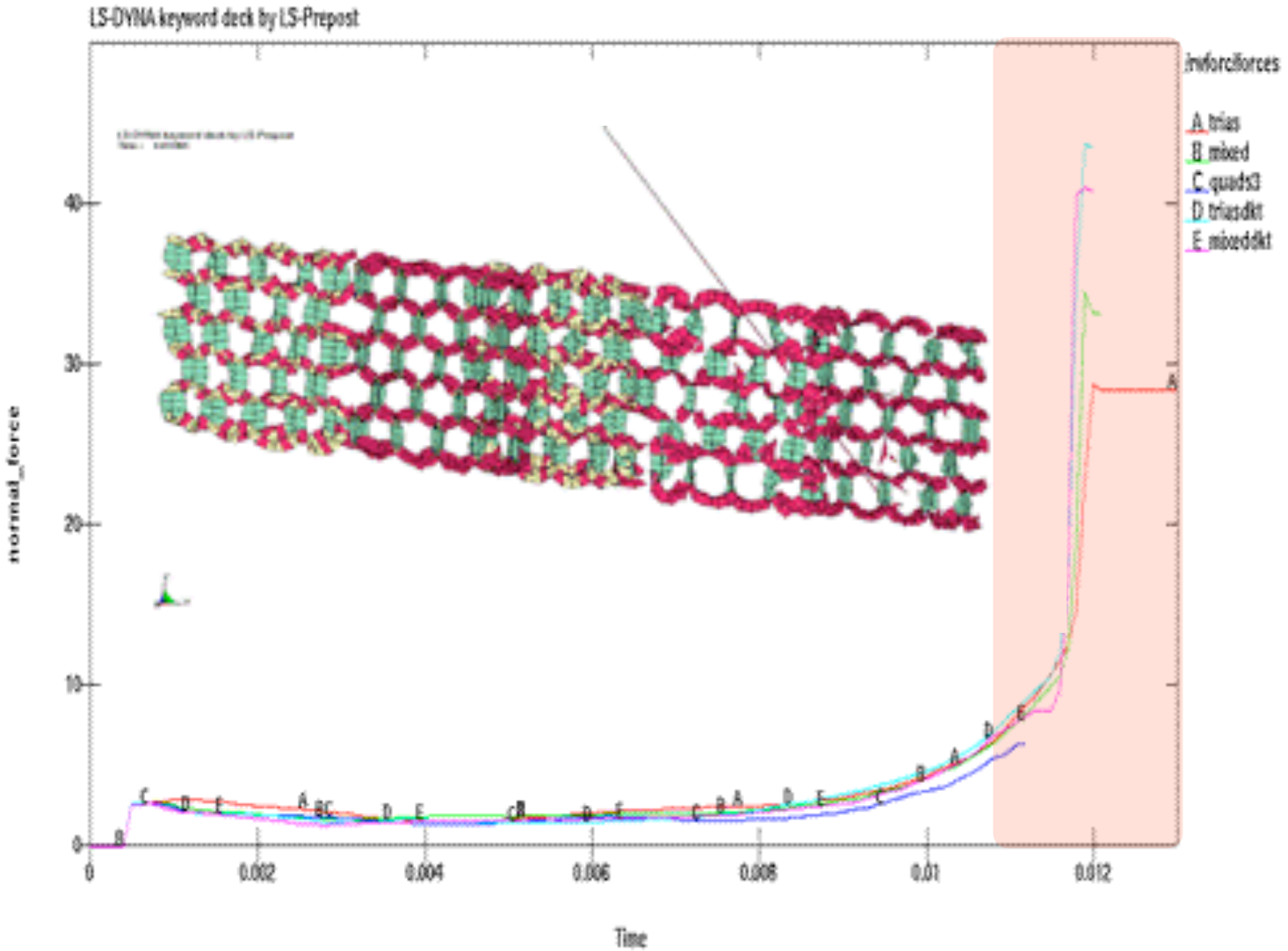
Cell Discretization





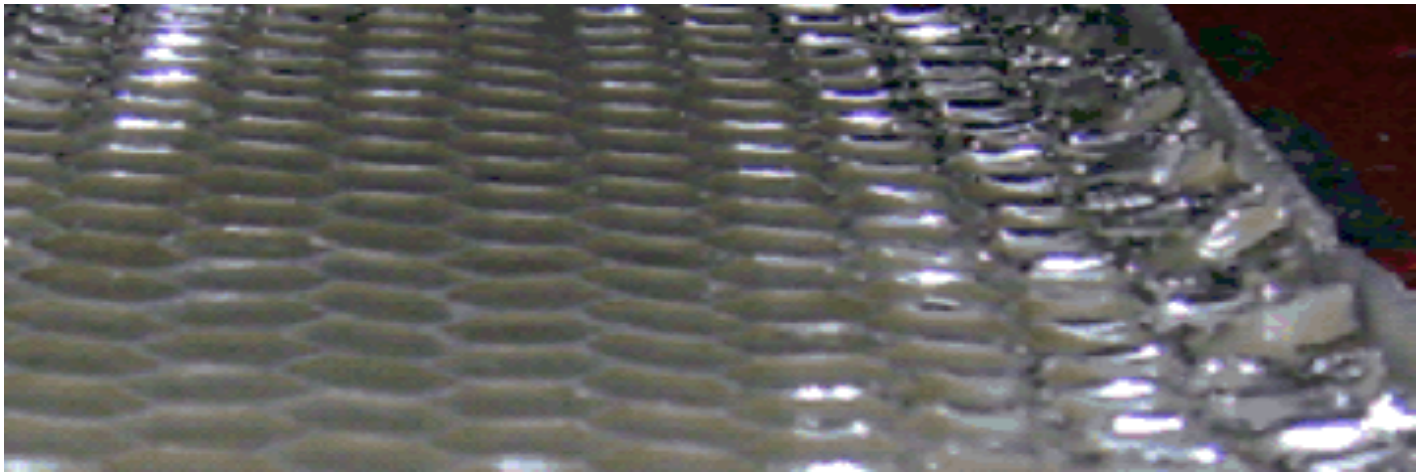


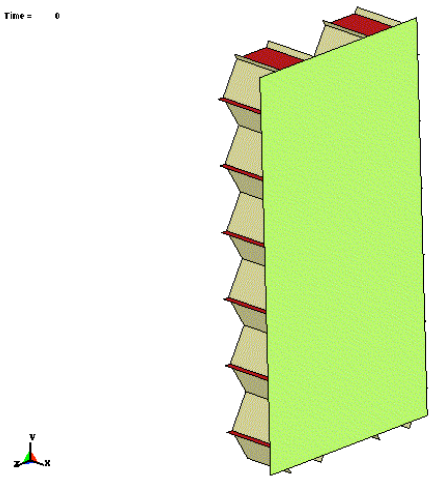
Shell Element Modeling

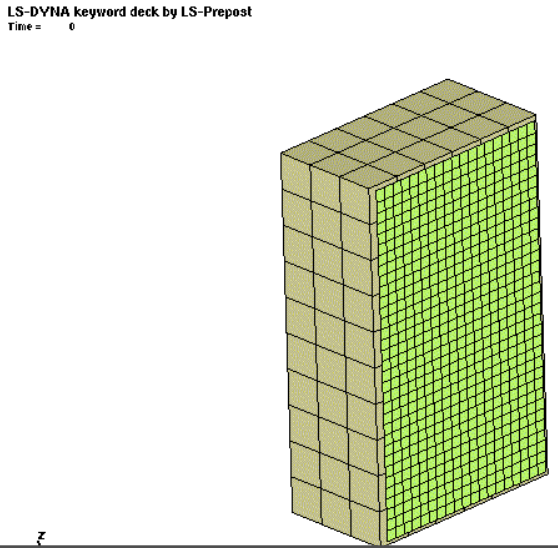


Adhesive Modeling

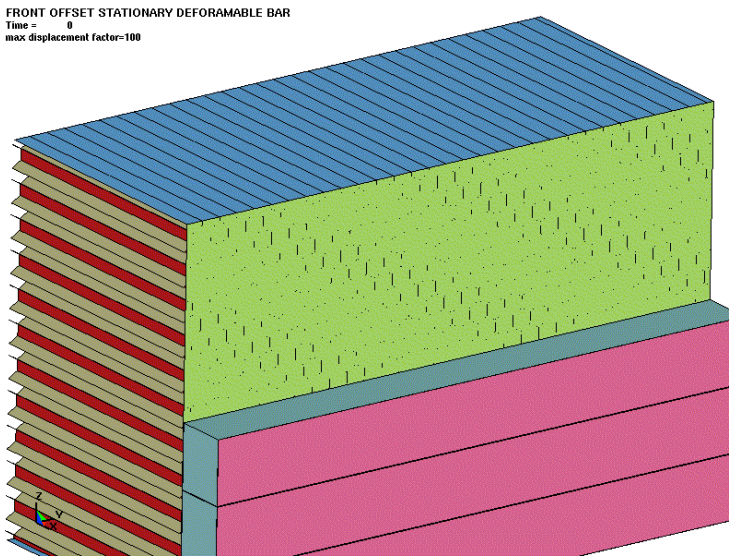
*CONTACT_AUTOMATIC_NODES_TO_SURFACE_TIEBREAK

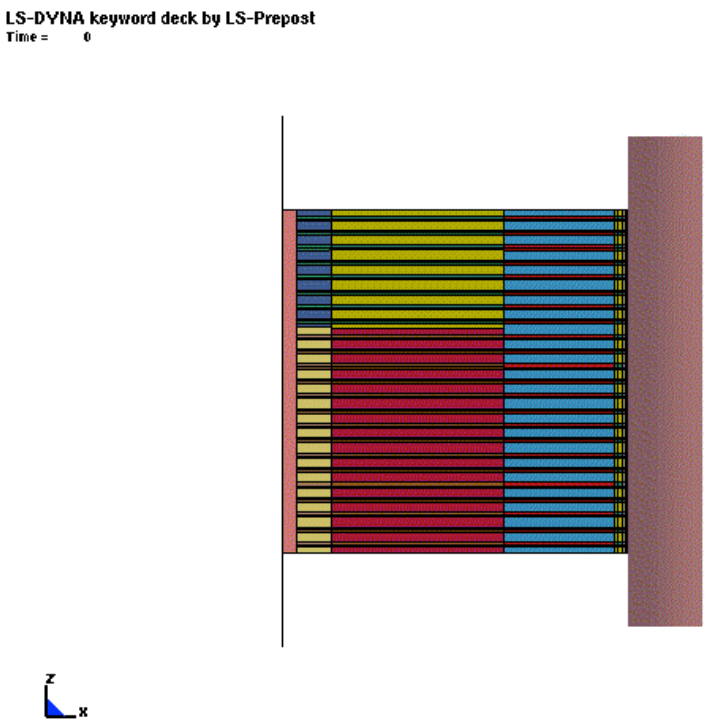






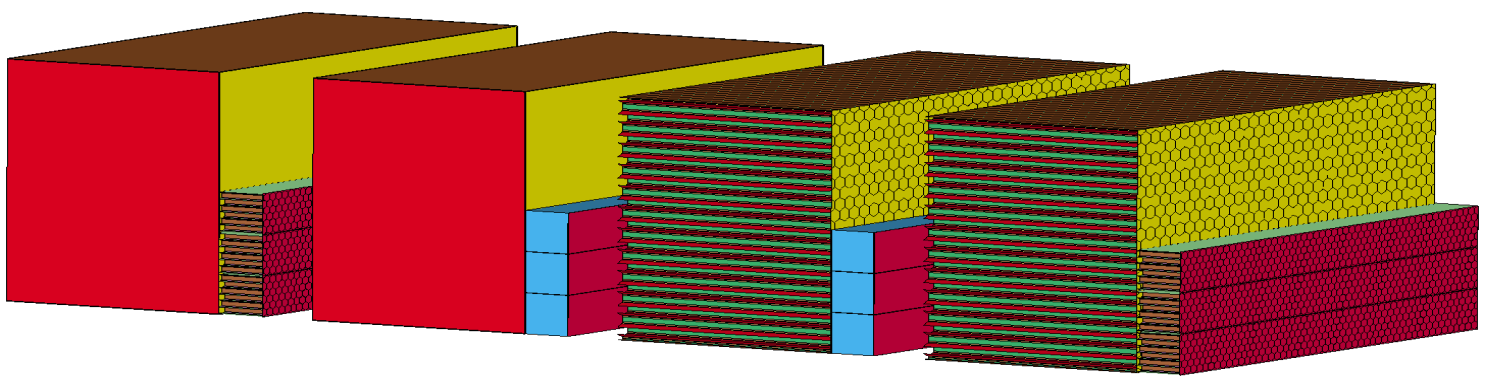
TINC - Incremental Displacement in Tiebreaks



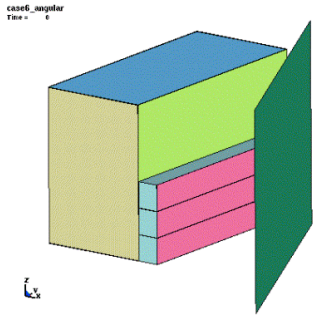


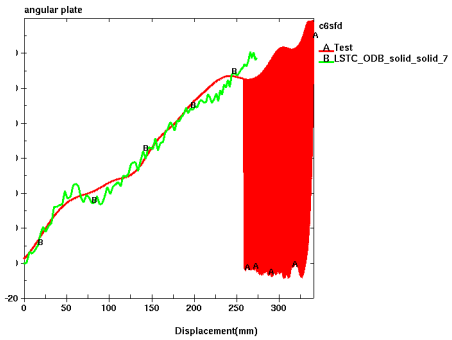
LSTC ODB Status Update

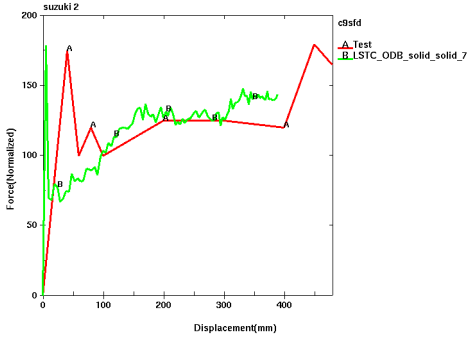
- Development based on 16 available OEM Tests
- Both Shell and Solid Version show promising results
- Solid version used to perform **LS-OPT/**DOE (200+ runs) to study sensitivity of some important variables such as honeycomb shear damage, adhesive failure strength, cladding failure , etc.
- Verification runs made to reduce overall MSError compared to test

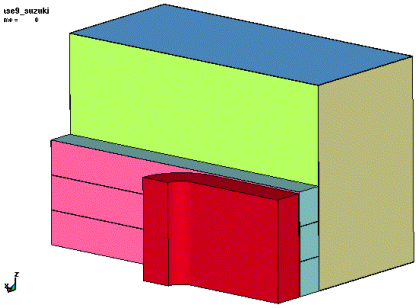


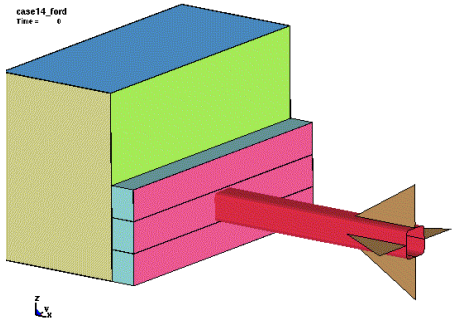
Solid Results

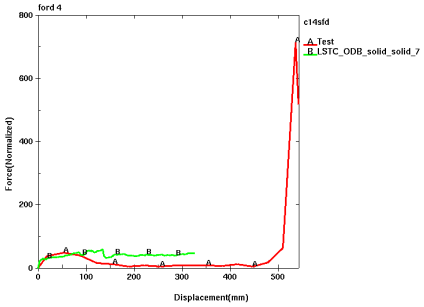


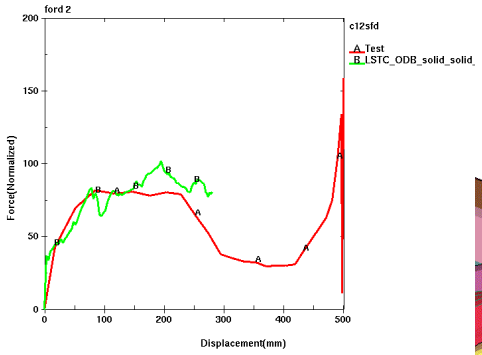


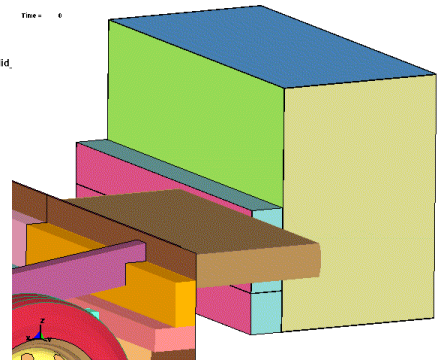


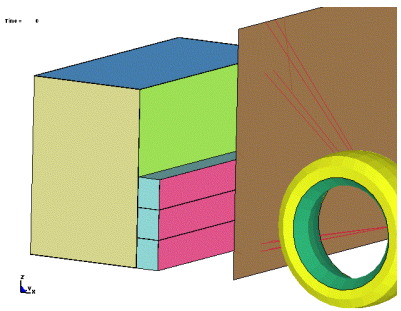


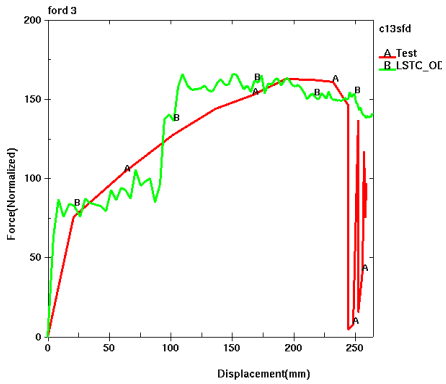


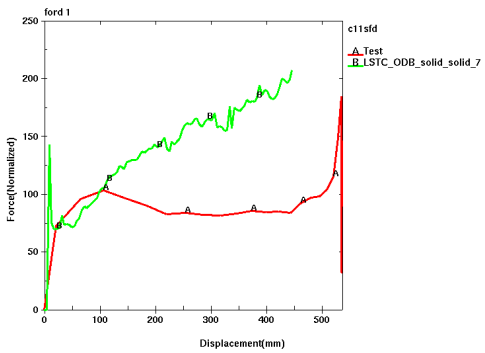


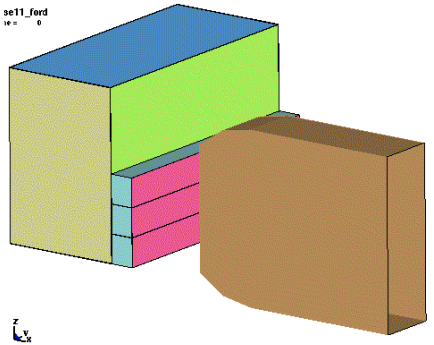




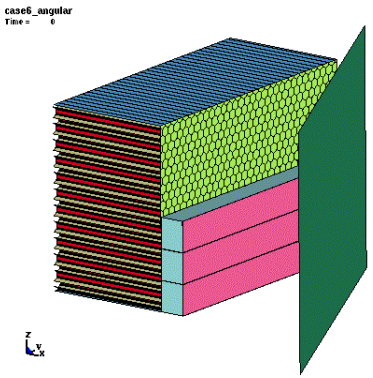


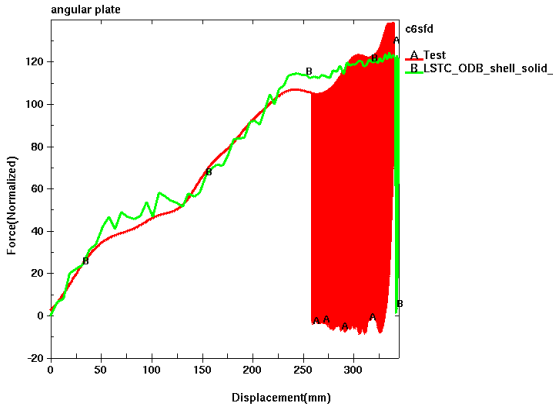


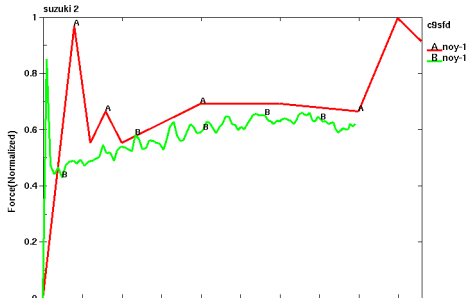


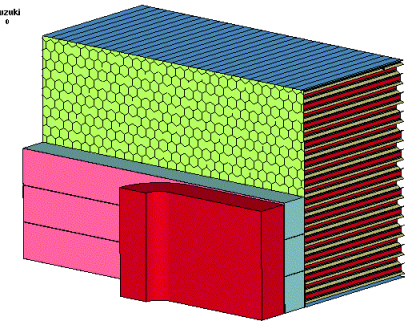


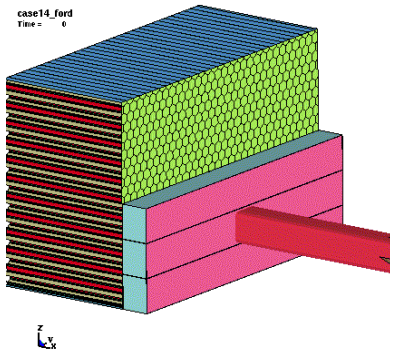
Shell Results

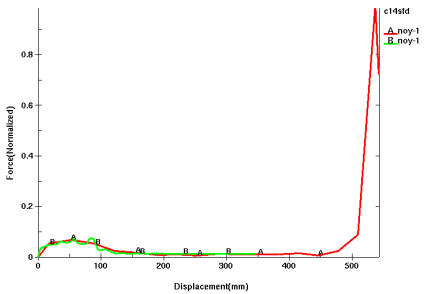


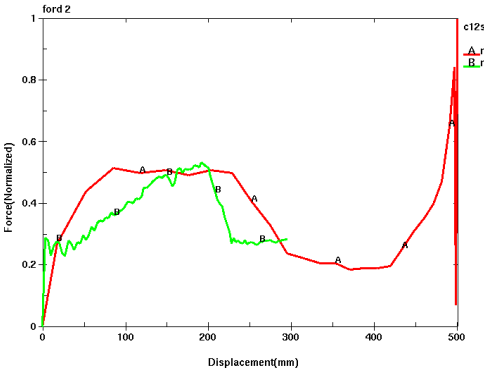


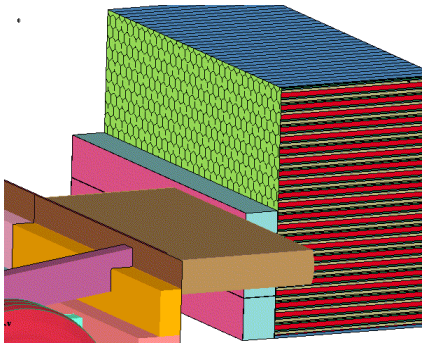


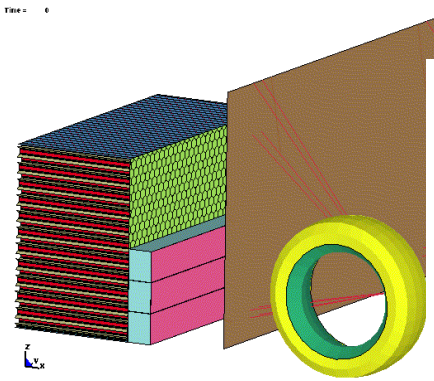


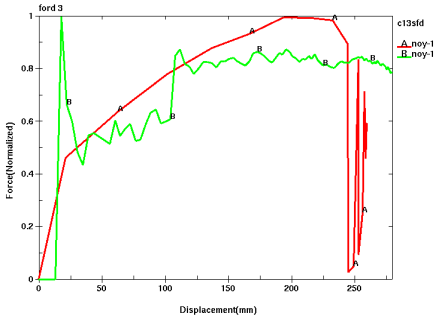


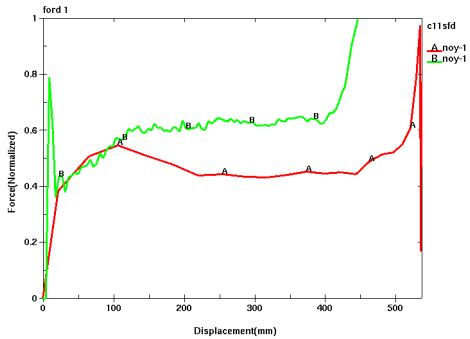


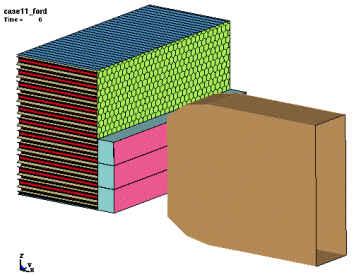












Side Impact Barrier 214 Pole Test

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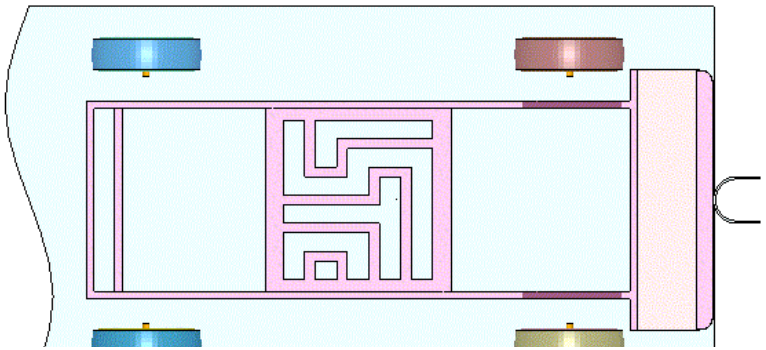

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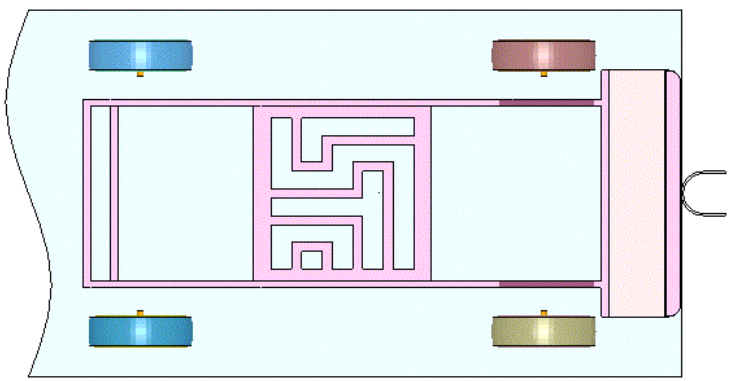

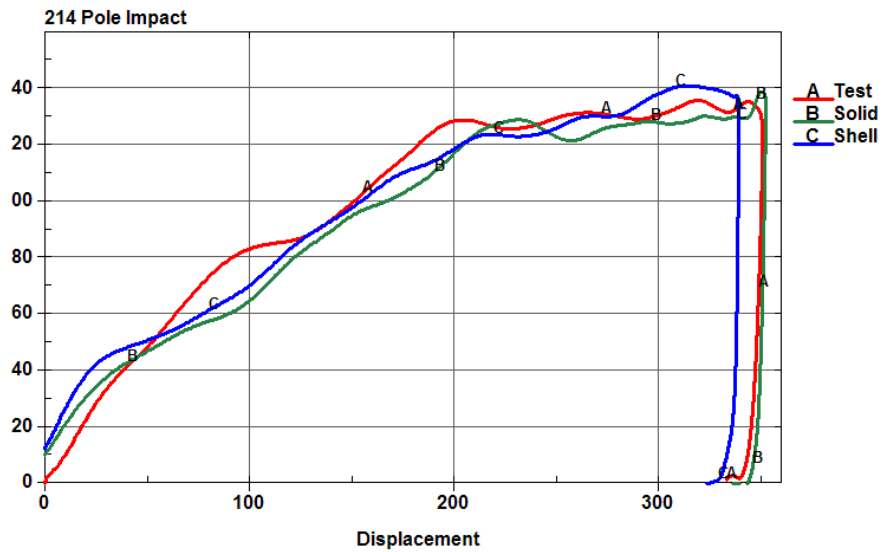

Side Impact Barrier 214 Wall Test

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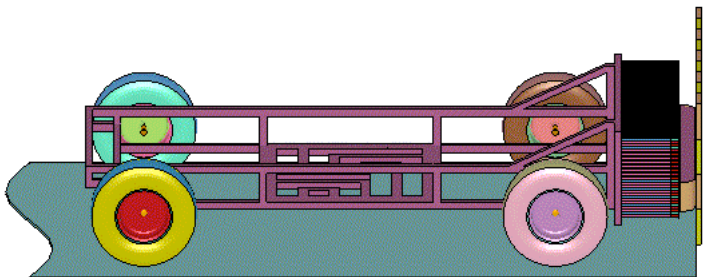
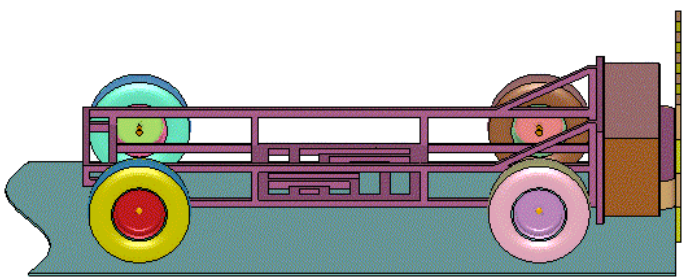
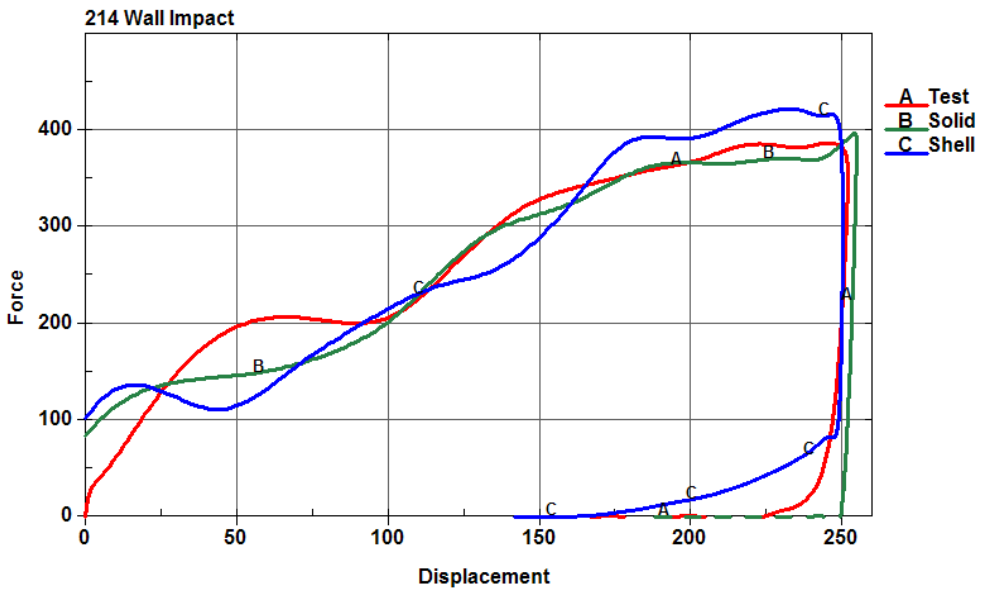


Time = 0





214 SIDE IMPACT BARRIER

- Shell version has been validated with 7 additional test cases

  Case2 - 0 degree Flat wall

  Case3 - Pole impact

  Case4 - 15 degree angle

  Case5 - 30 degree angle

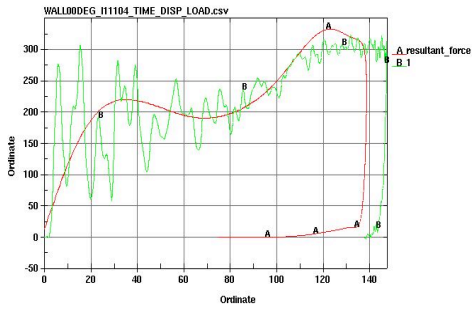
  Case6 - 100 % rocker

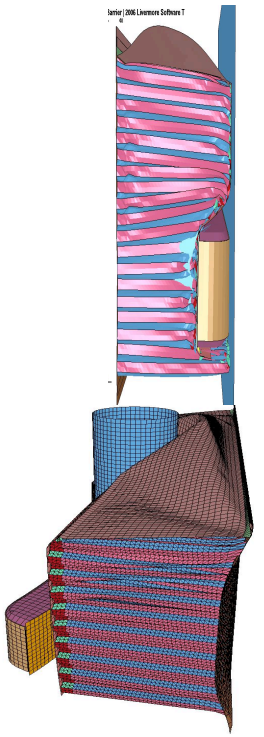
  Case7 - 50 % rocker

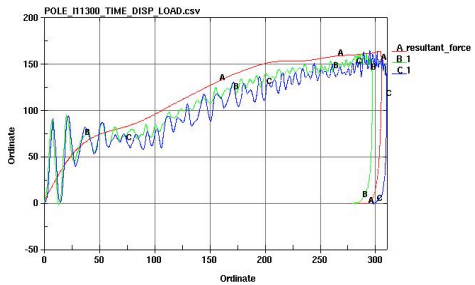
  Case8 - 100 % no bumper

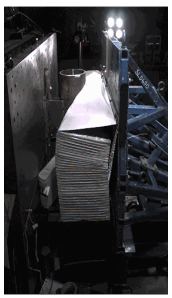
- Version2 was released Feb 4th 2010

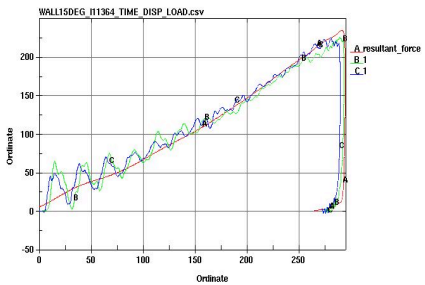
214 Test Cases 0, Pole, 15,

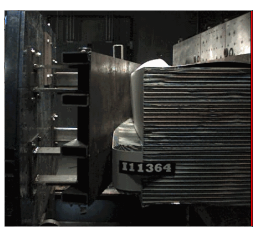


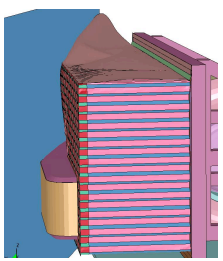






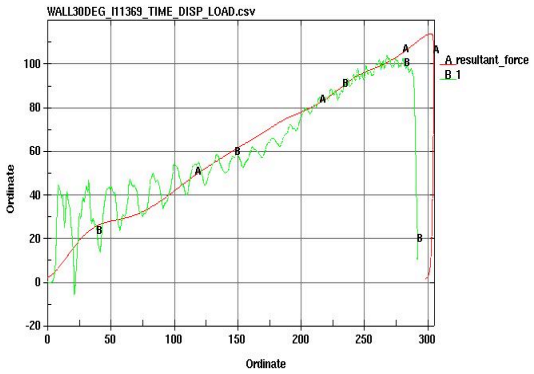


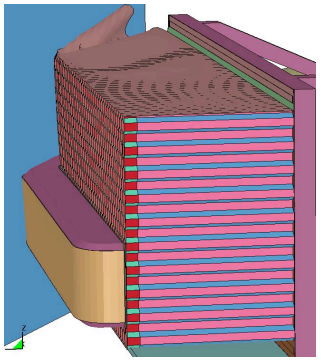


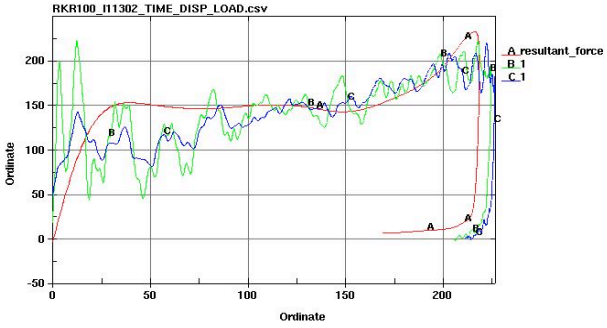


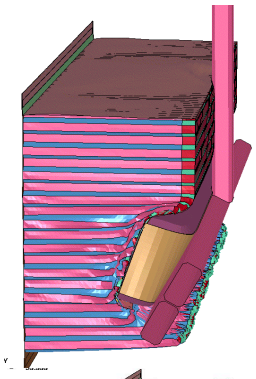
24

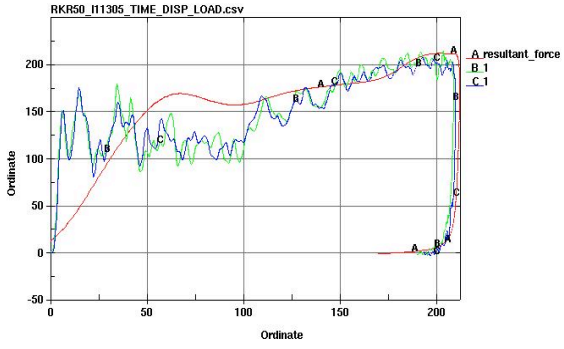
214 30, Impactor-1, Impactor-1a

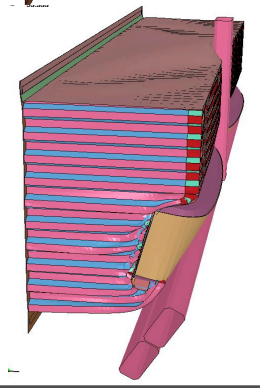






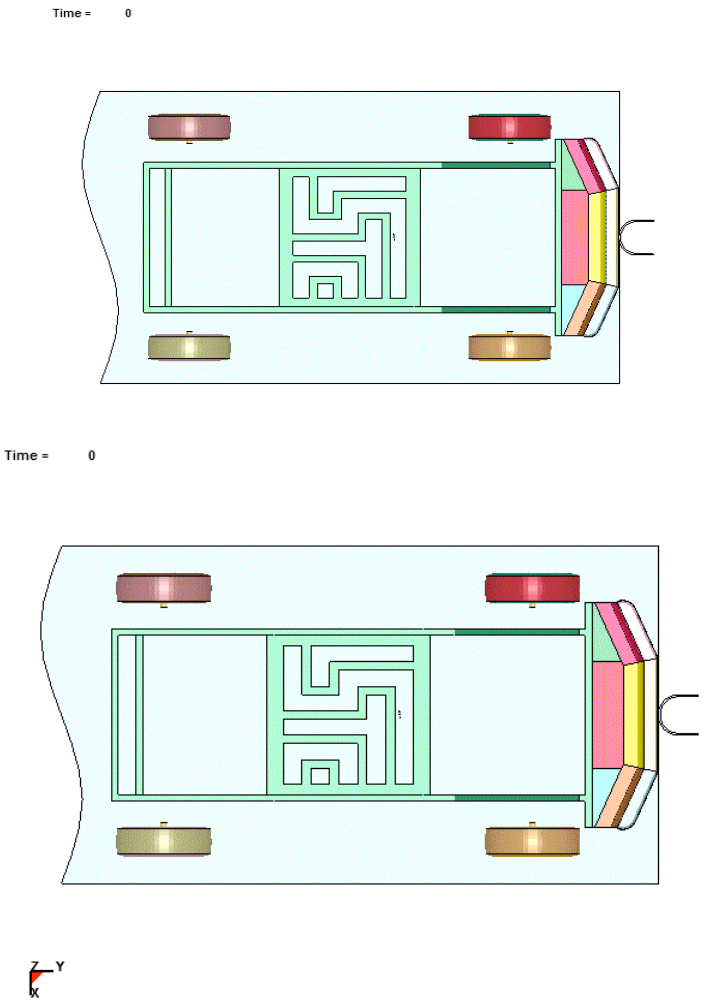






25

IIHS Pole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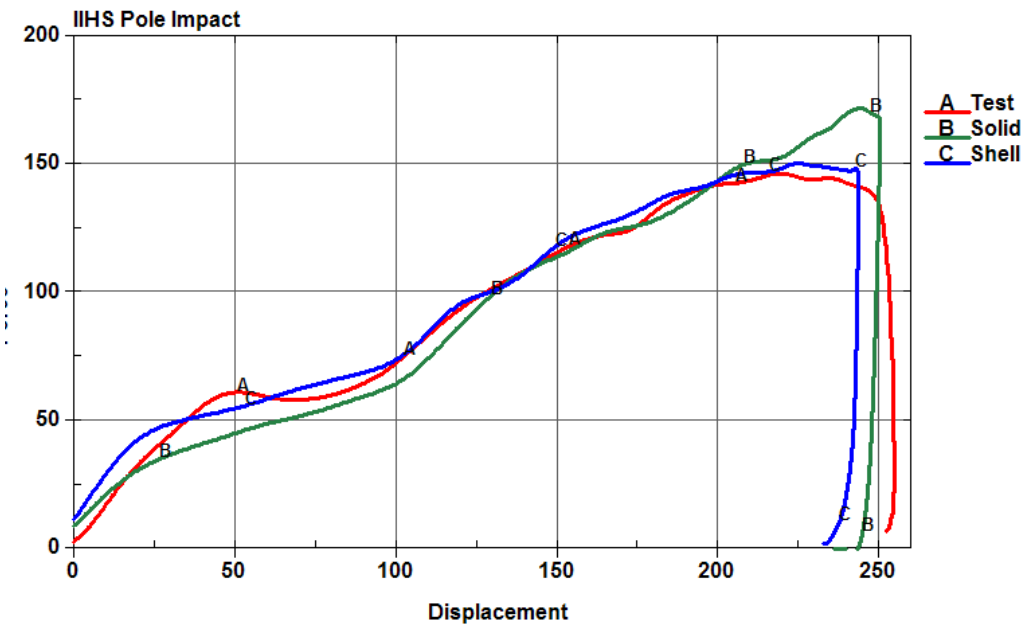
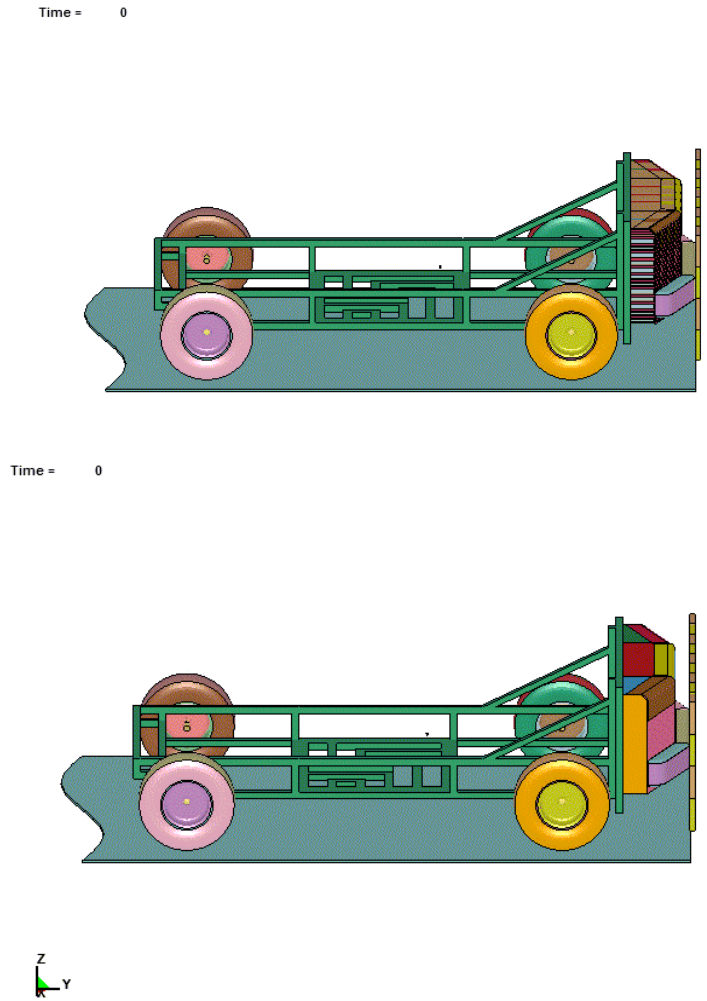

IIHS Pole Impact
200
150
100
50
0
0
50
100
150
200
250
Displacement
A Test
B Solid
C Shell

IIHS Wall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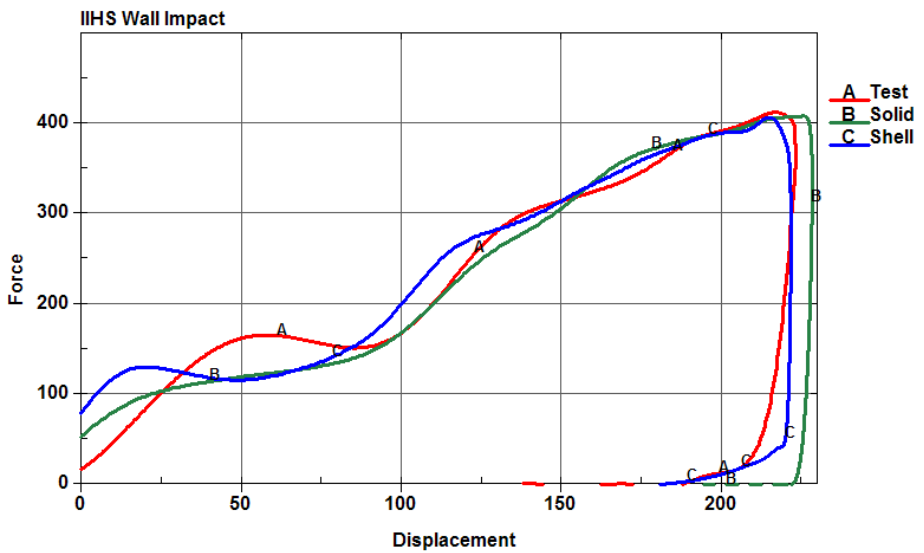
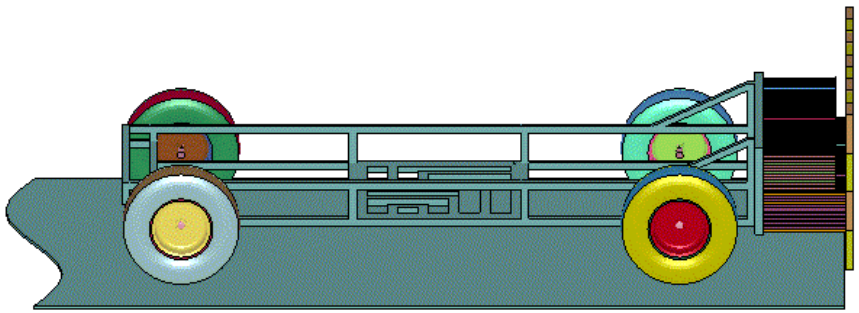
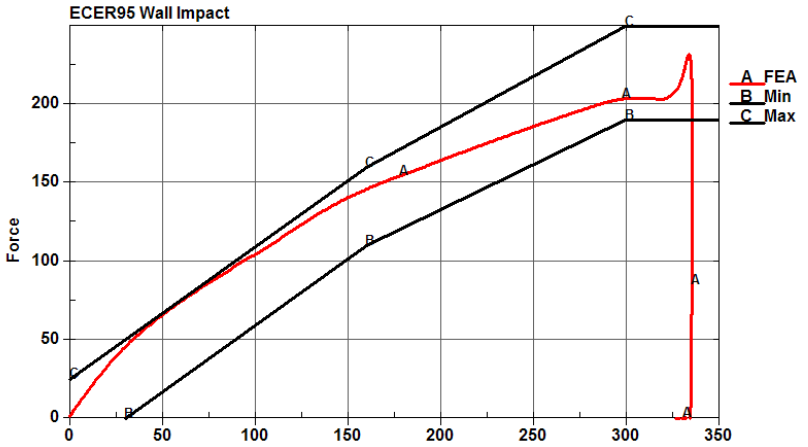
Time = 0


IIHS Wall Impact
Force
Displacement
0
100
200
300
400
0
50
100
150
200
A Test
B Solid
C Shell

PDB ECE95 Wall Impact





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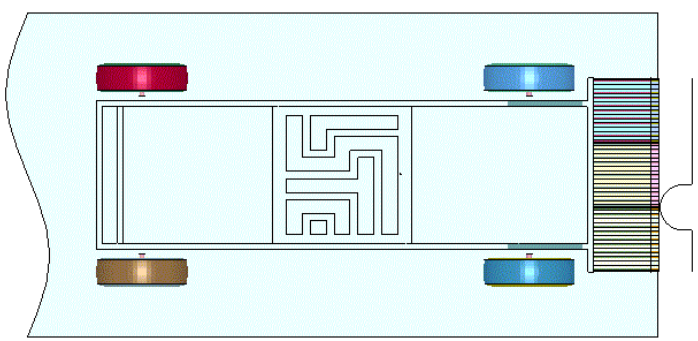
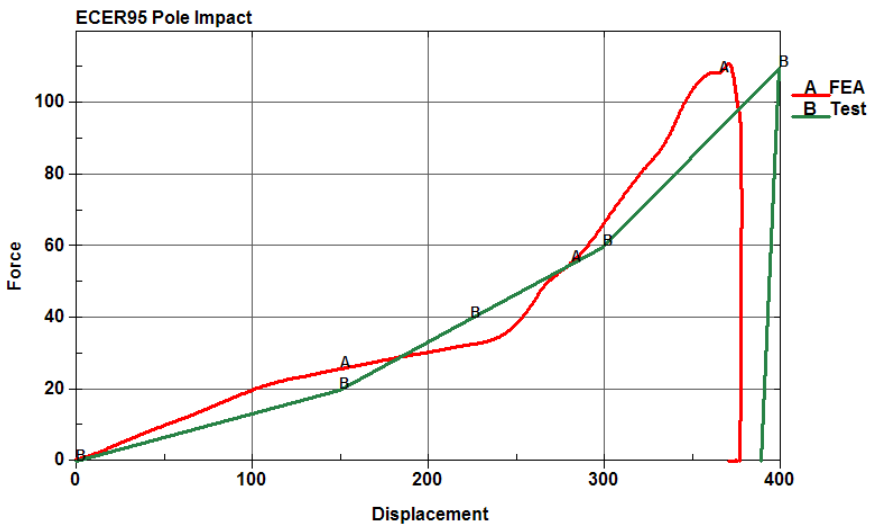
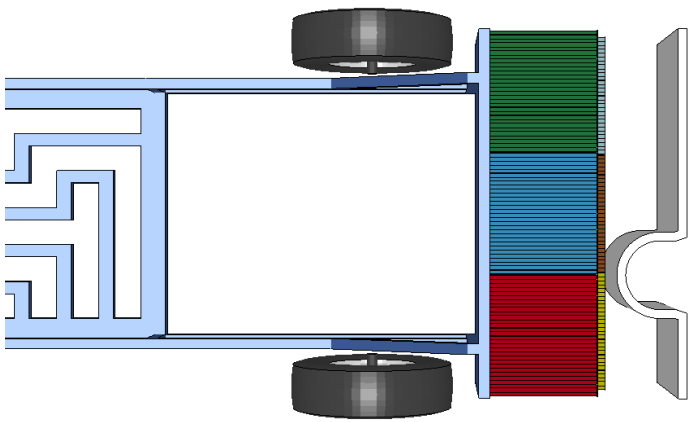
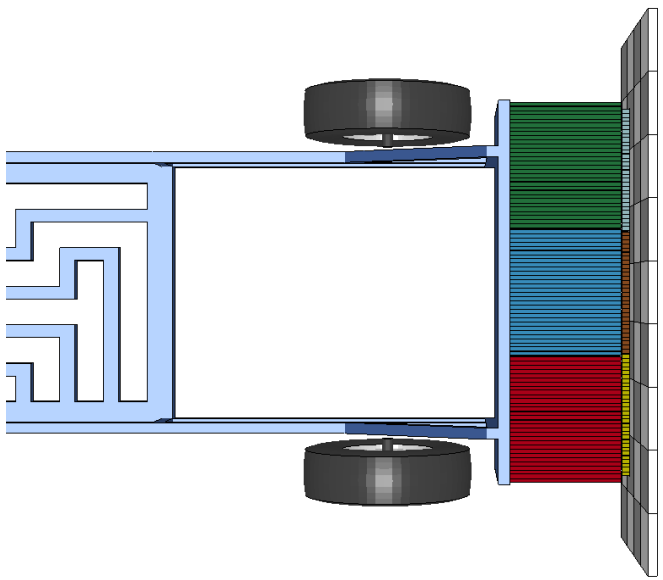




ECE Rev 95

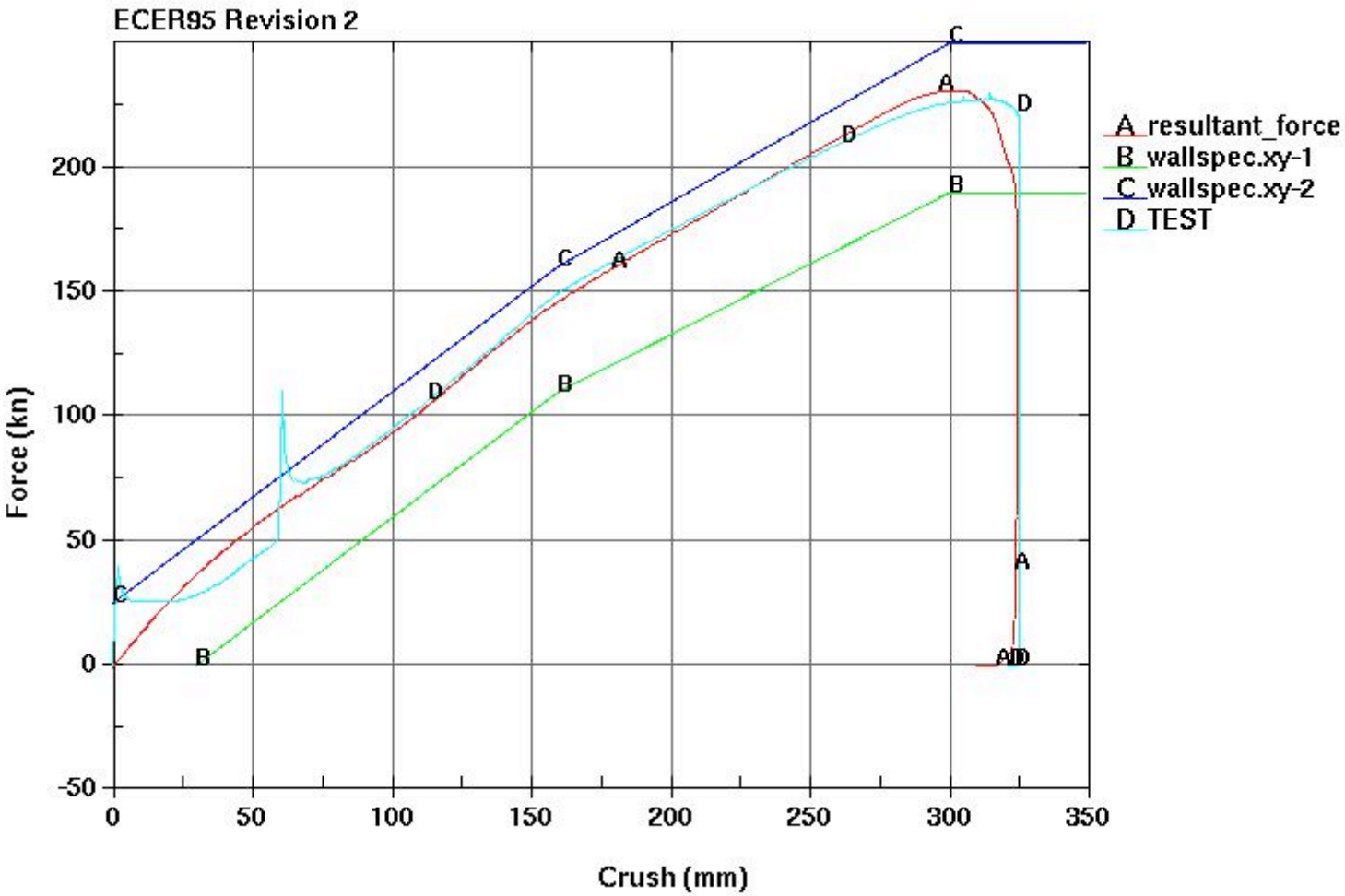


Pole Impact Setup



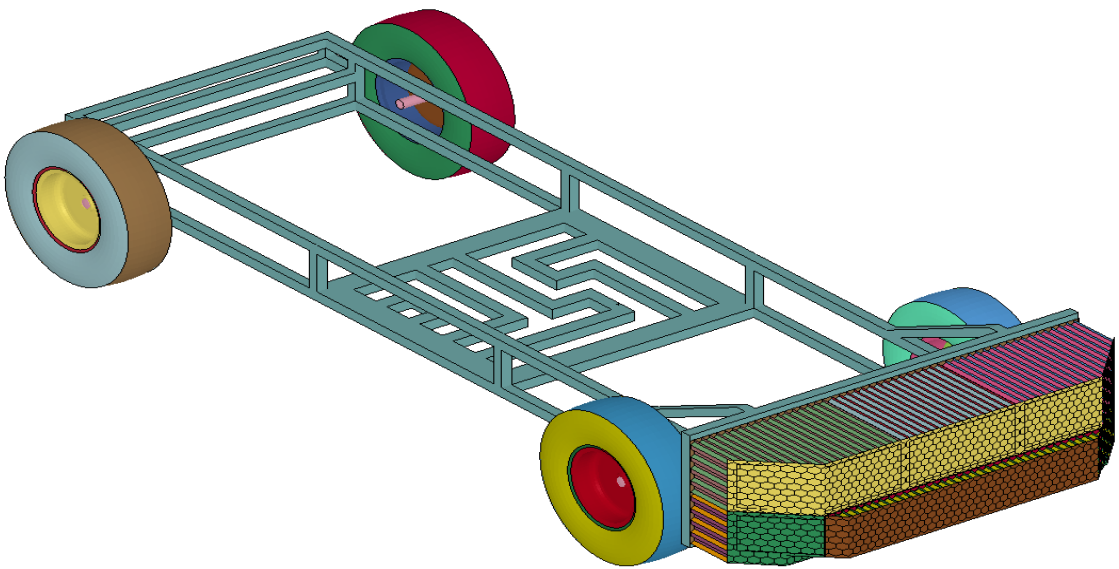
Flat wall Impact Setup

ECE Rev 95 version 2

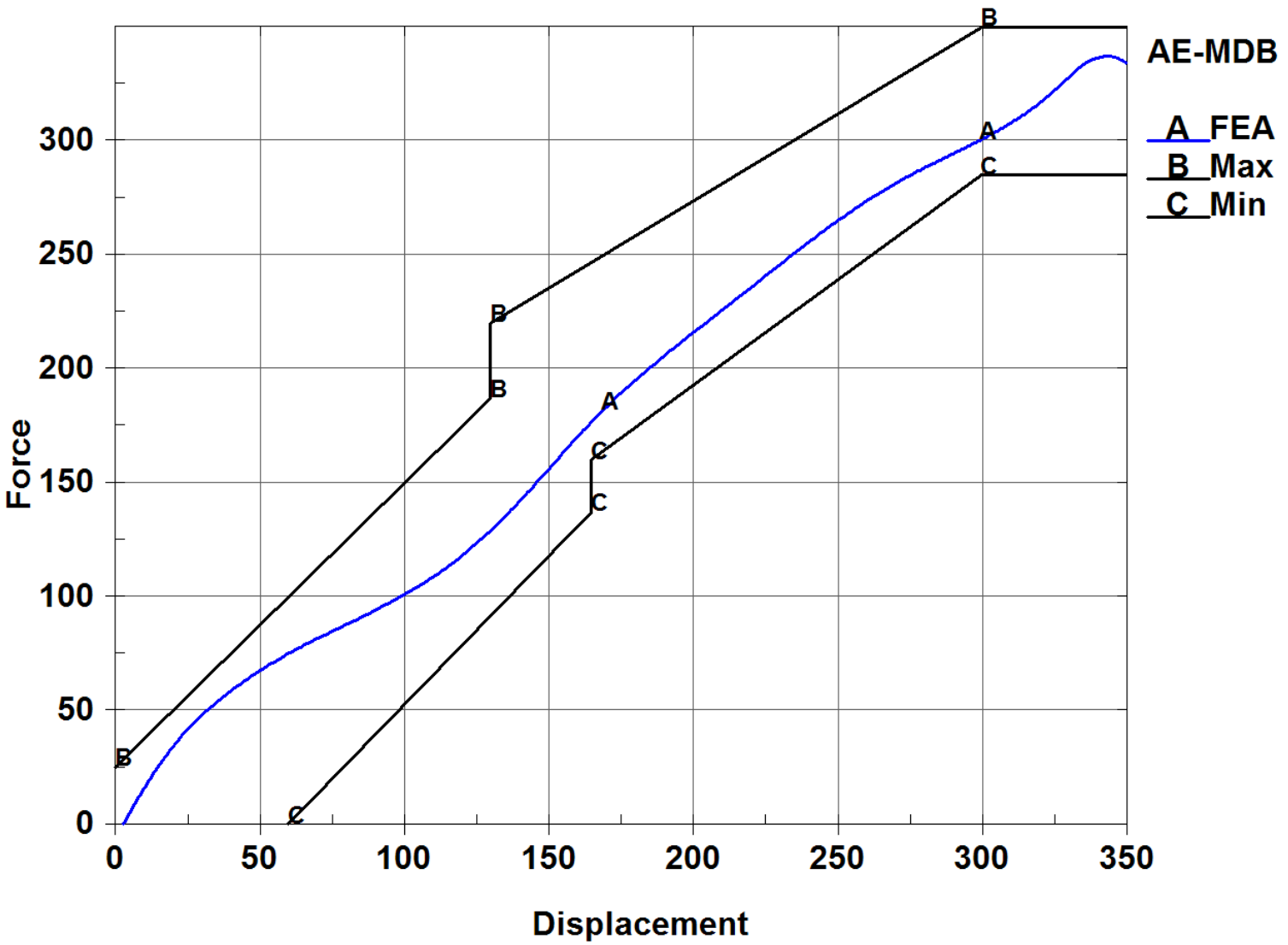


AEMDB V3.10

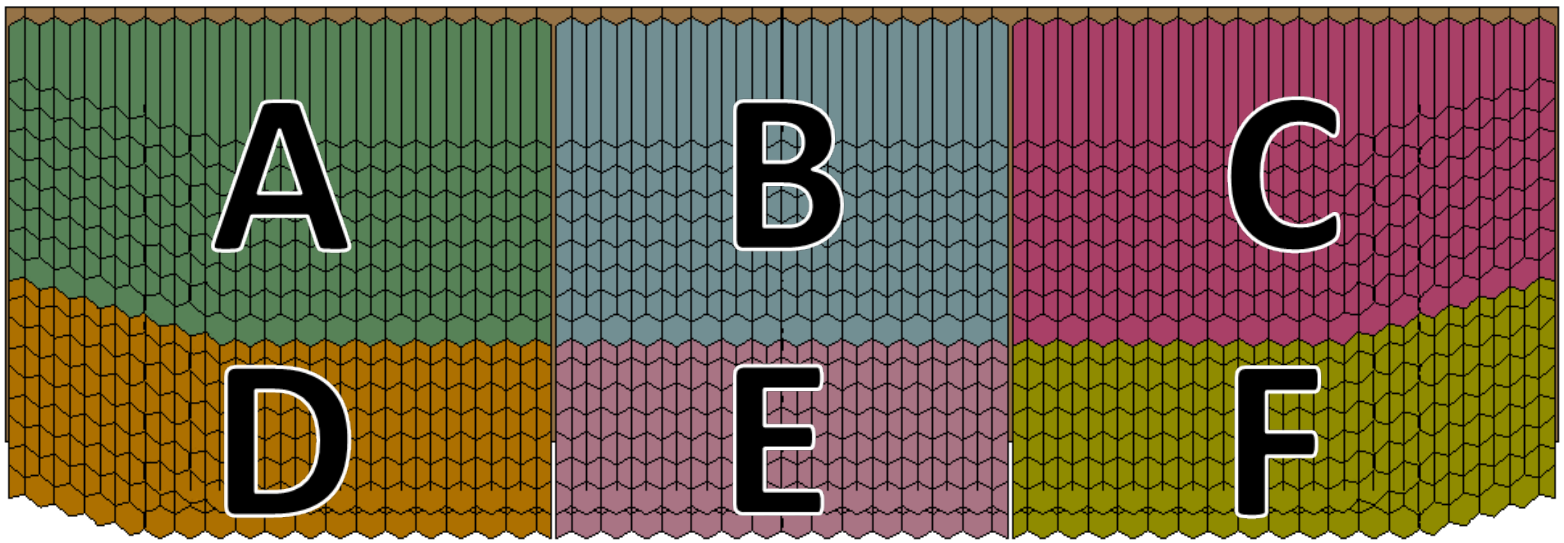
- Advanced European Moving Deformable Barrier
- Validated according to Version 3.10



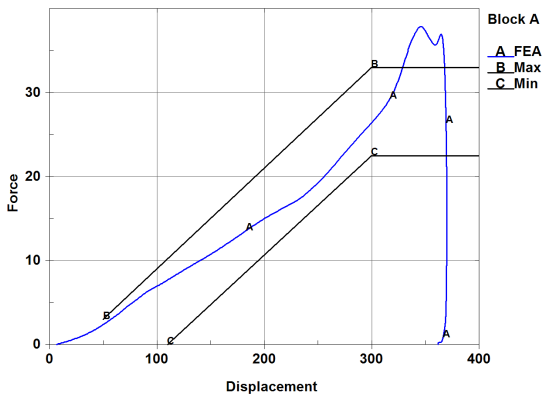
Full Barrier Results

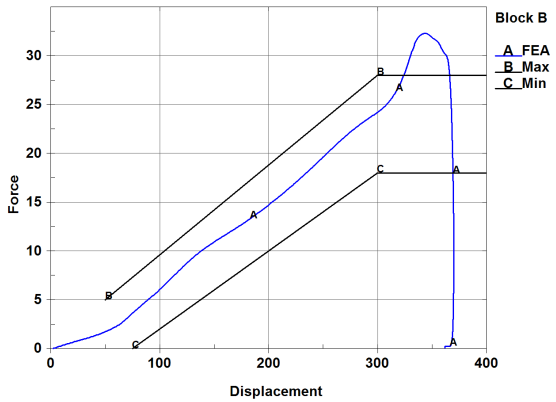


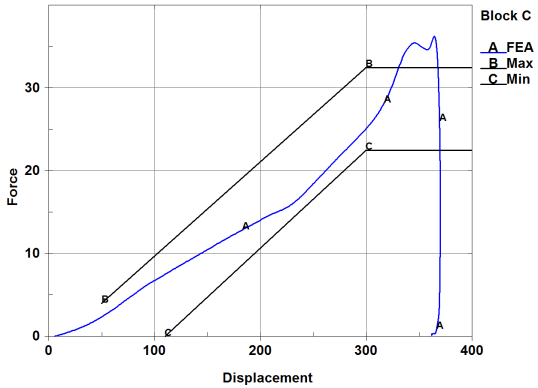
Block Layout

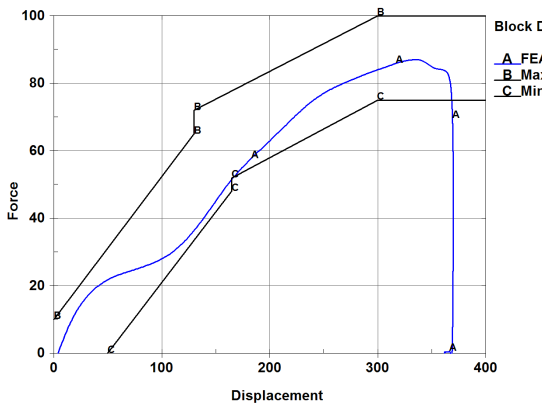


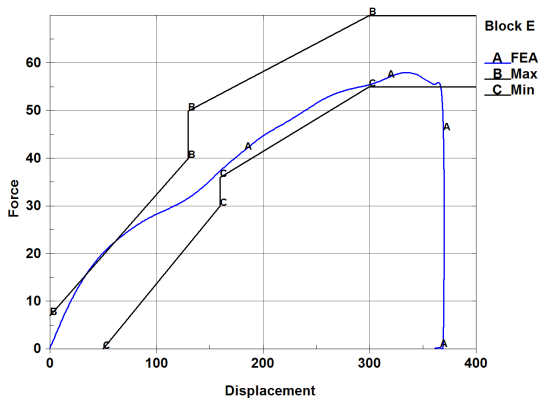
Block Results

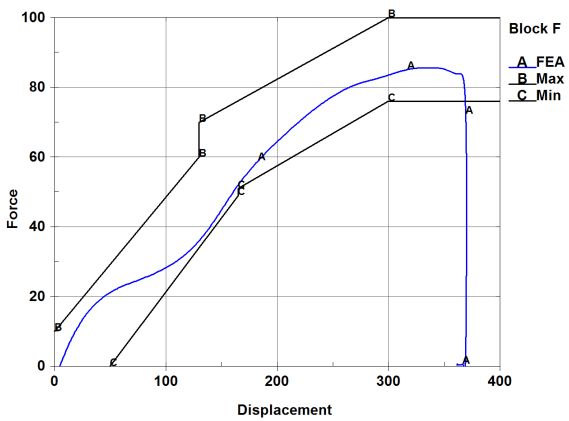












Positioning of Barriers

- Recommended method is to use

  *INCLUDE_TRANSFORM

- Honeycomb material coordinate system and cart inertia tensor update was most common problems from users.
- Cart inertia properties now are defined in local coordinate system and the coordinate system is defined using nodes.
- AOPT on mat_modified_honeycomb is also defined using local coordinate system.
- This will now enable user to position the barrier in any pre-processor and replace the nodal coordinates in the barrier.

Contact between vehicle and barrier

- Recommended to isolate barrier and vehicle self contacts
- Define a separate contact between the vehicle and barrier

  *contact_automatic_surface_to_surface.

- Caution: If the vehicle contact is type 13 with 0 for slave side (treat entire system) then the vehicle contact should be define with a part set to include only the vehicle parts

Conclusions

- LSTC is committed to providing the best in quality barrier models for use in crash simulations
- We thank all the OEMs who generously provided their experimental data and worked with us continuously to achieve acceptable correlation
- You can download the latest barriers from

  ftp://user:computer@ftp.lstc.com/lstc-barriers