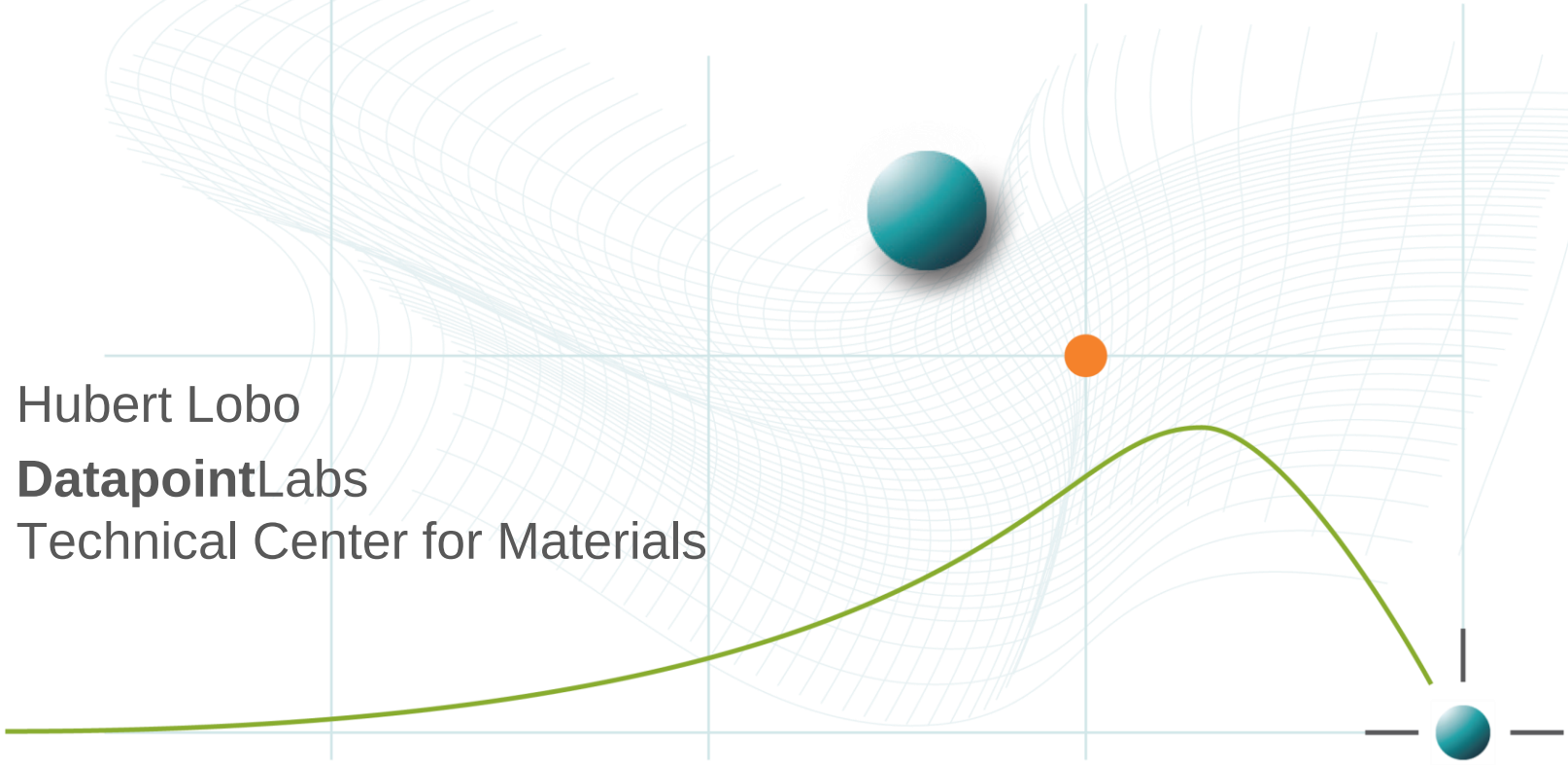
Progress on the Validation of Simulation for Ductile Polymers
and
An Introduction to Knowmats Knowledge Resource for Materials in Simulation



Hubert Lobo

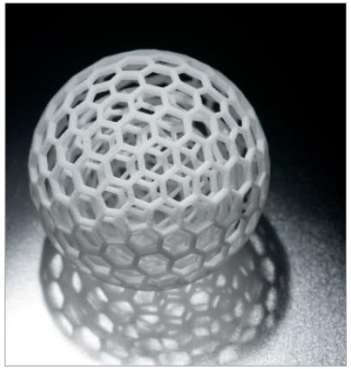
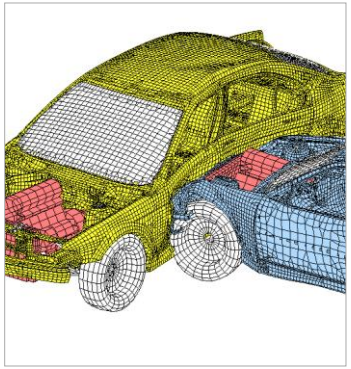
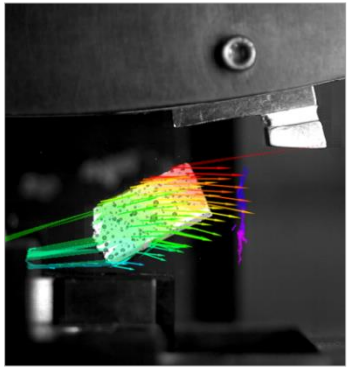
DatapointLabs
Technical Center for Materials

DatapointLabs TestPaks matereality knowmats picsci

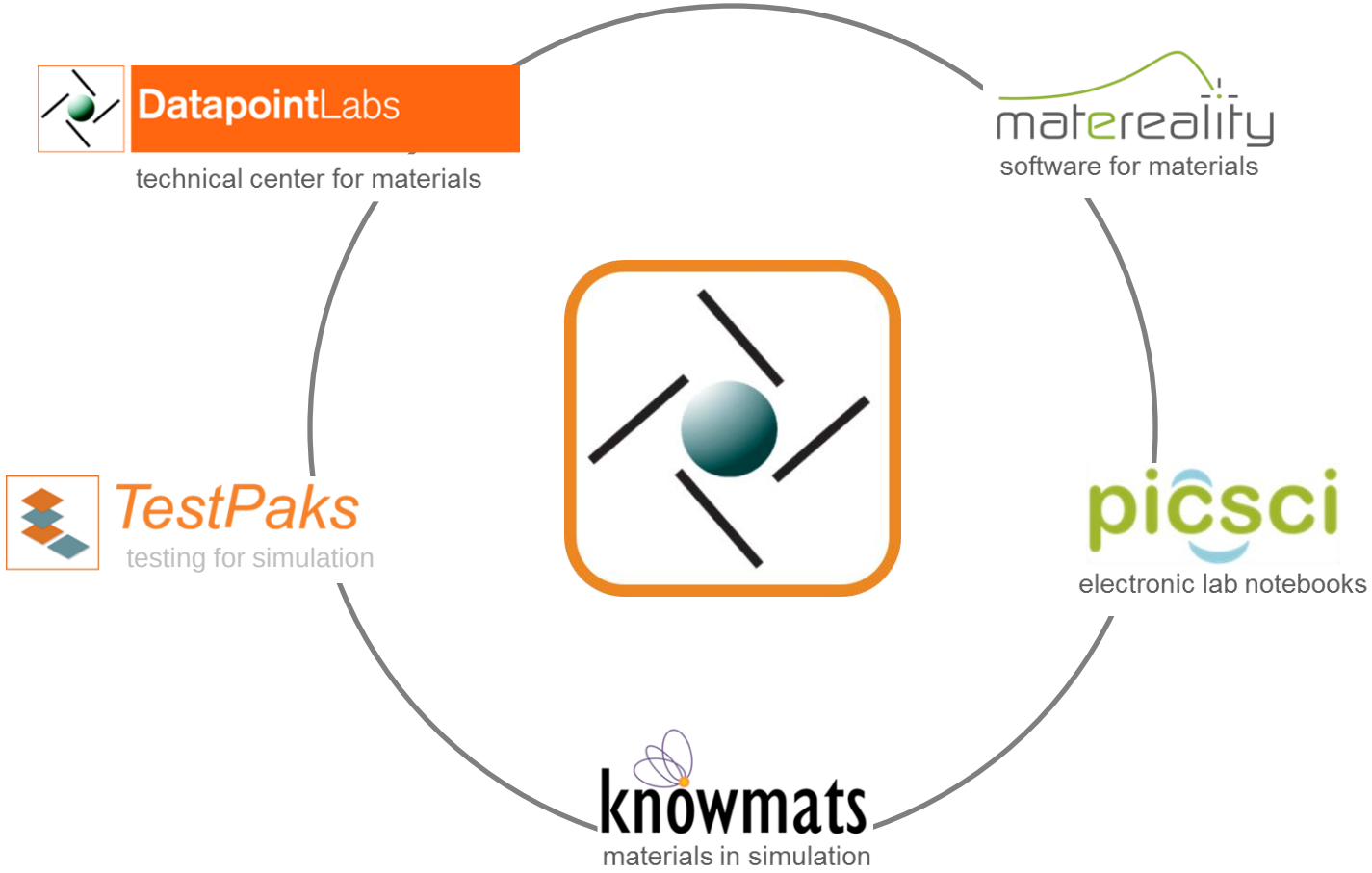
expert material testing | CAE material parameters | CAE Validation | software & infrastructure for materials | materials knowledge | electronic lab notebooks

Mission

We strengthen the materials core of manufacturing enterprises to facilitate their use of new materials, novel manufacturing processes, and simulation-based product development.

Brands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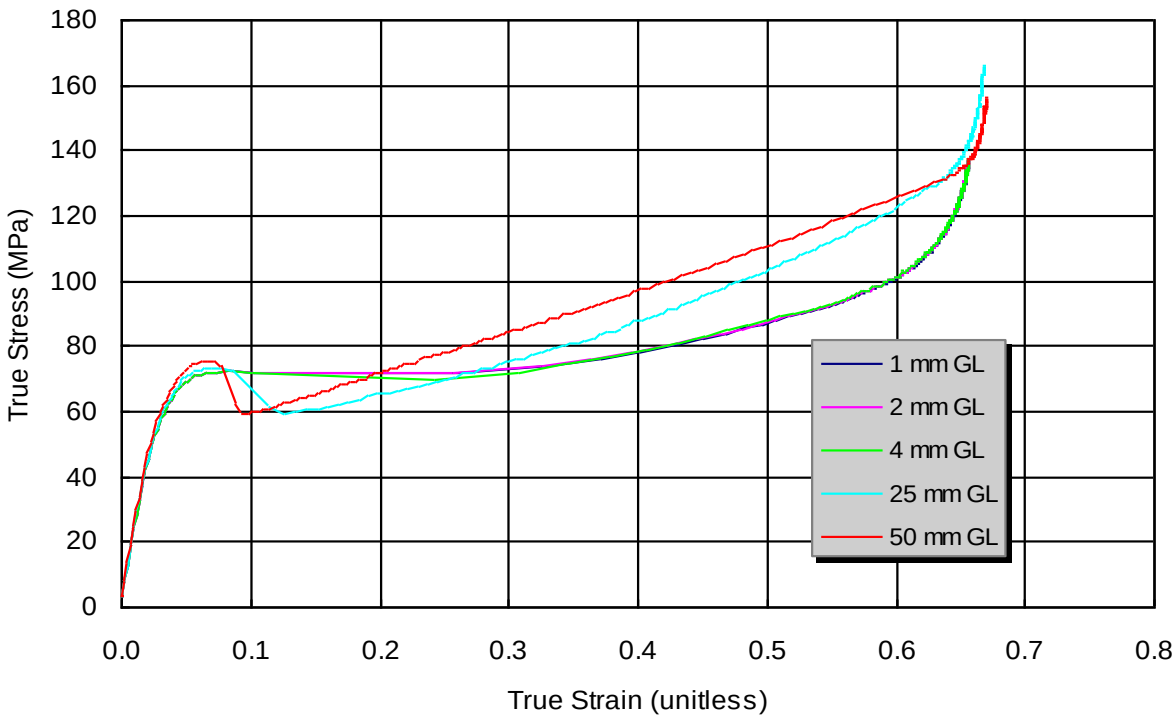
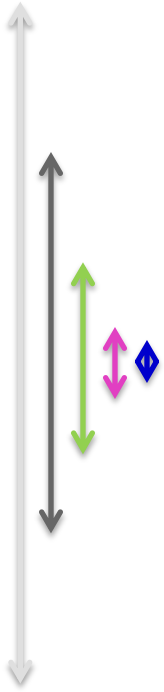
Tensile stress-strain behavior- some thoughts

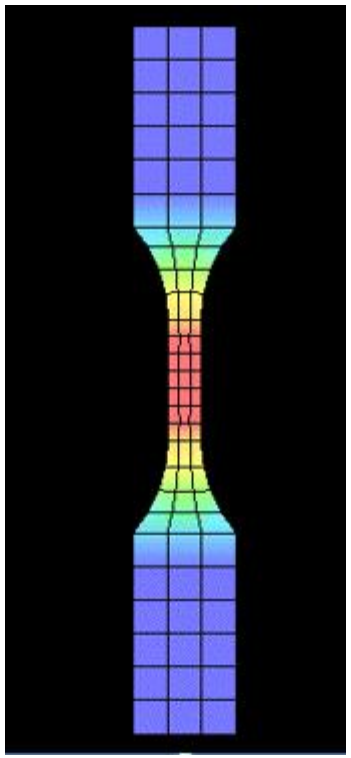
- Non-linear elasticity Lobo& Hurtado (2006)
- Plasticity occurs prior to yield Lobo& Hurtado (2006)
- No increase in volume strain prior to yield Lobo, Croop, &Roy (2013)
- Volumetric straining occurs at yield Lobo, Croop, &Roy (2013)
- Yield surface is not von Mises
- Volumetric and deviatoric behavior in flow region
- Failure is accompanied by rapid volumetric expansion

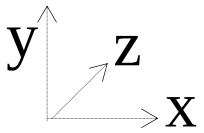
Obtaining true stress-strain

- Effect of gage length selection





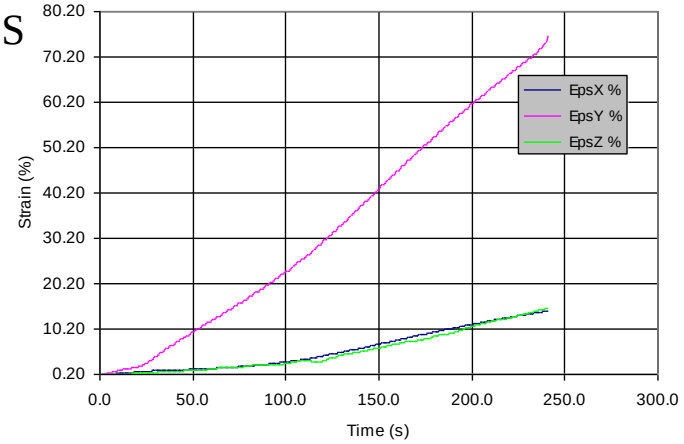


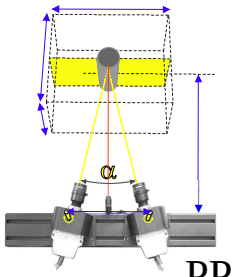


3D Stress-strain measurements for plastics

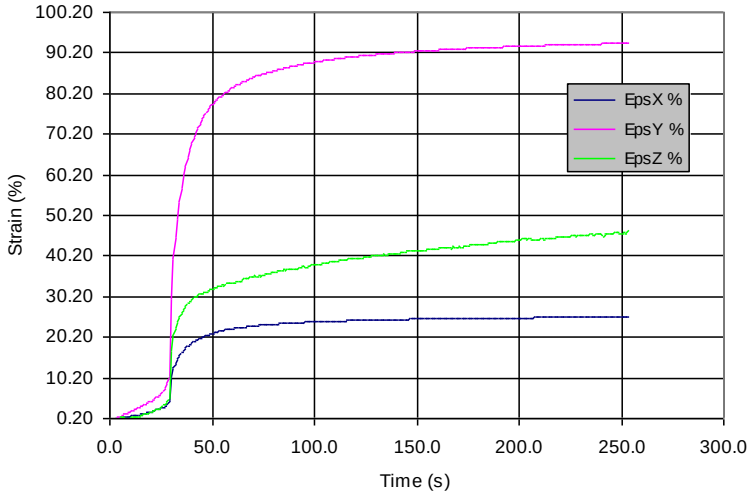
- Actual measurements in 3D
- Local y, x, z strains are measured
- Data used in
  - MAT-SAMP model
  - Druker-Prager model

ABS

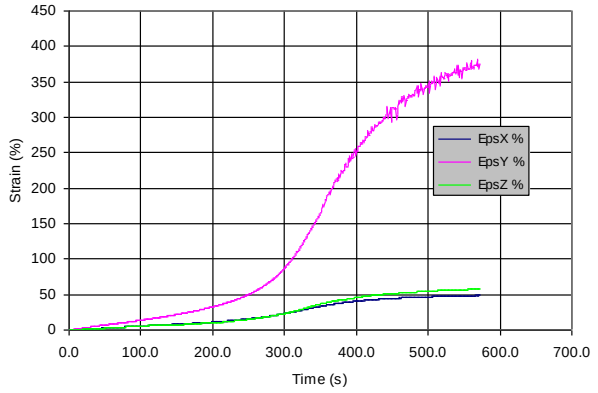




PC



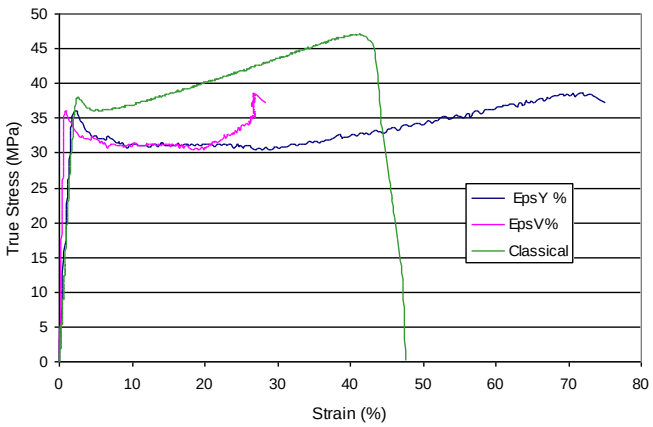
PP



True stress v. volumetric strain and true strain

- True stress calculated from x-z strain
- Y-strain is localized, true
- Volumetric strain obtained from YXZ strains
- Fail strain is measured

ABS



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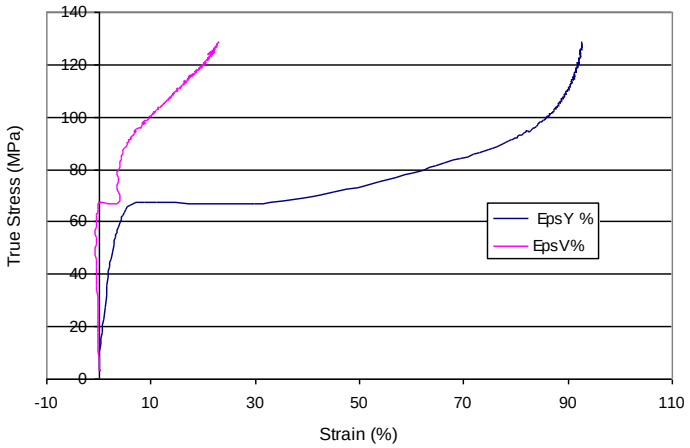

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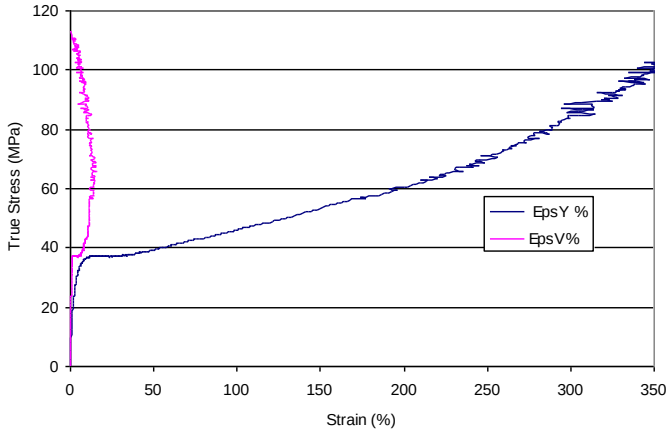
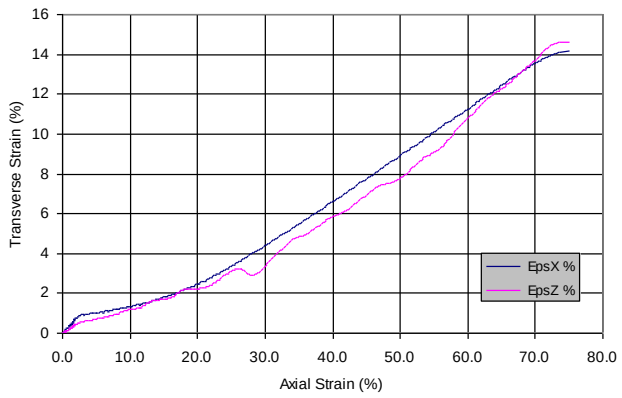


extruded sheets

Transverse v. axial strain

- X and z strains may not coincide
- May depend on material and processing

ABS



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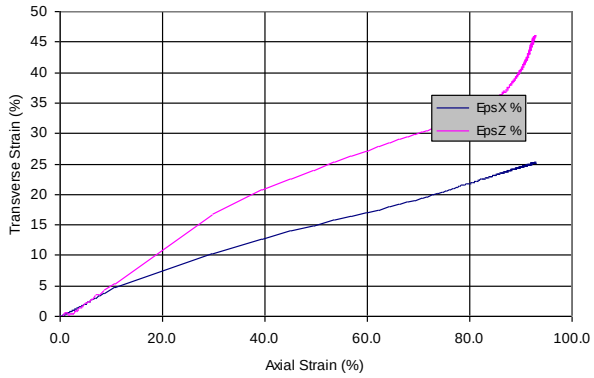

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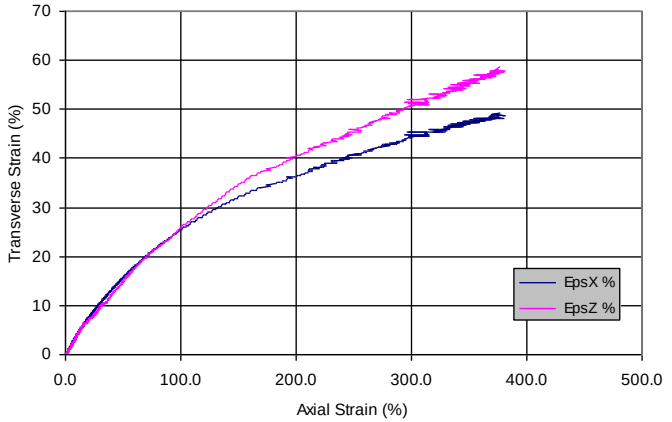
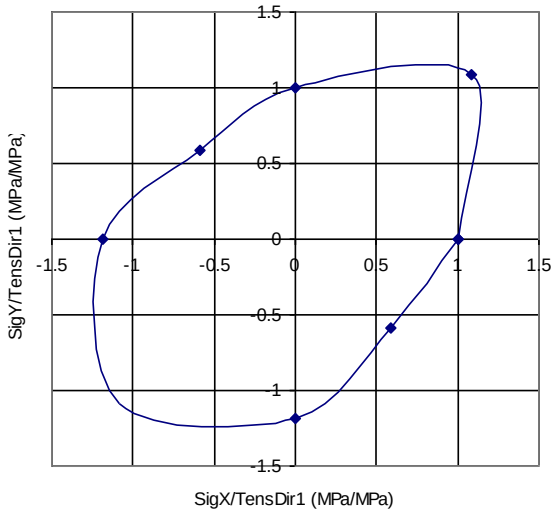
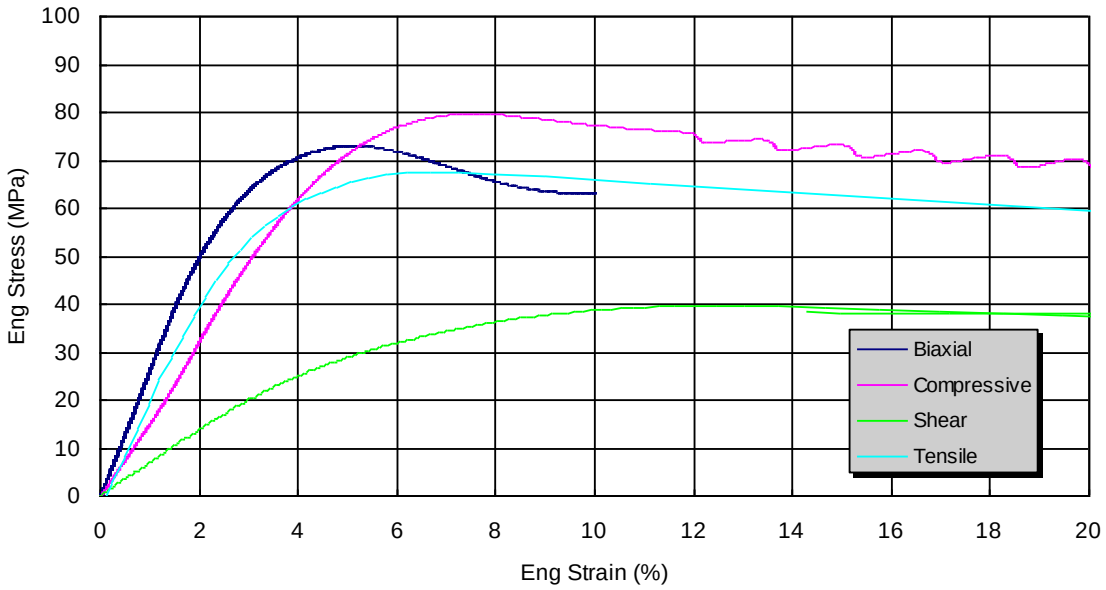


Yield and failure in plastics - PC

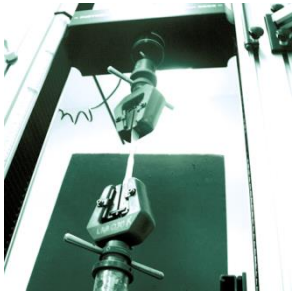
- Yield surface – Available test modes
  - Tensile
  - Compressive (CLC)
  - Shear (classical or Iosipescu)
  - Biaxial



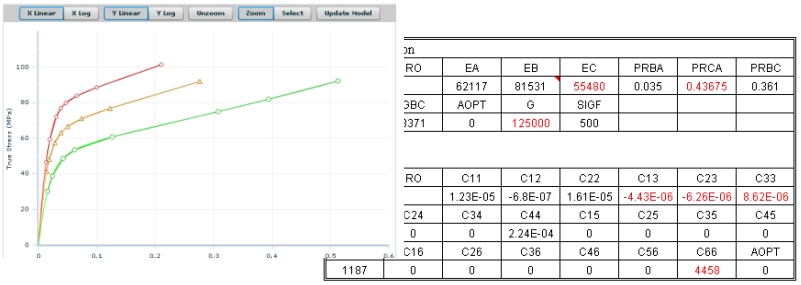


Material parameter conversion

- Need accurate consistent data on your material
- All required properties must be measured
- Material parameter generation must be correct
- Validation can be beneficial



testing



RO	EA	EB	EC	PRBA	PRCA	PRBC
	62117	81531	55480	0.035	0.43675	0.361
GBC	AOPT	G	SIGF			
3371	0	125000	500			

RO	C11	C12	C22	C13	C23	C33
	1.23E-05	-6.8E-07	1.61E-05	-4.43E-06	-6.26E-06	8.62E-06
C24	C34	C44	C15	C25	C35	C45
0	0	2.24E-04	0	0	0	0
C16	C26	C36	C46	C56	C66	AOPT
1187	0	0	0	0	4458	0

data + conversion

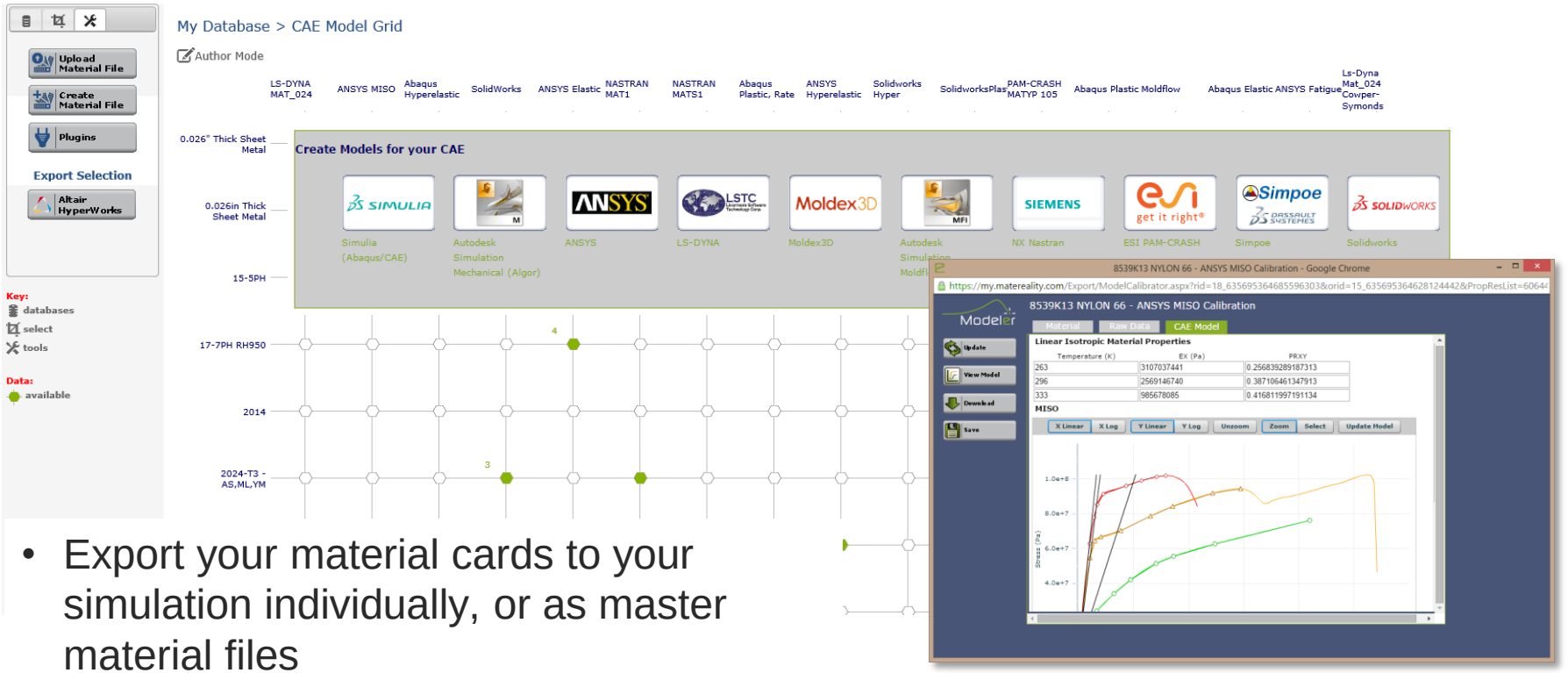
your design

Obtaining material parameters for CAE

testing | material parameters | CAE material file | validation

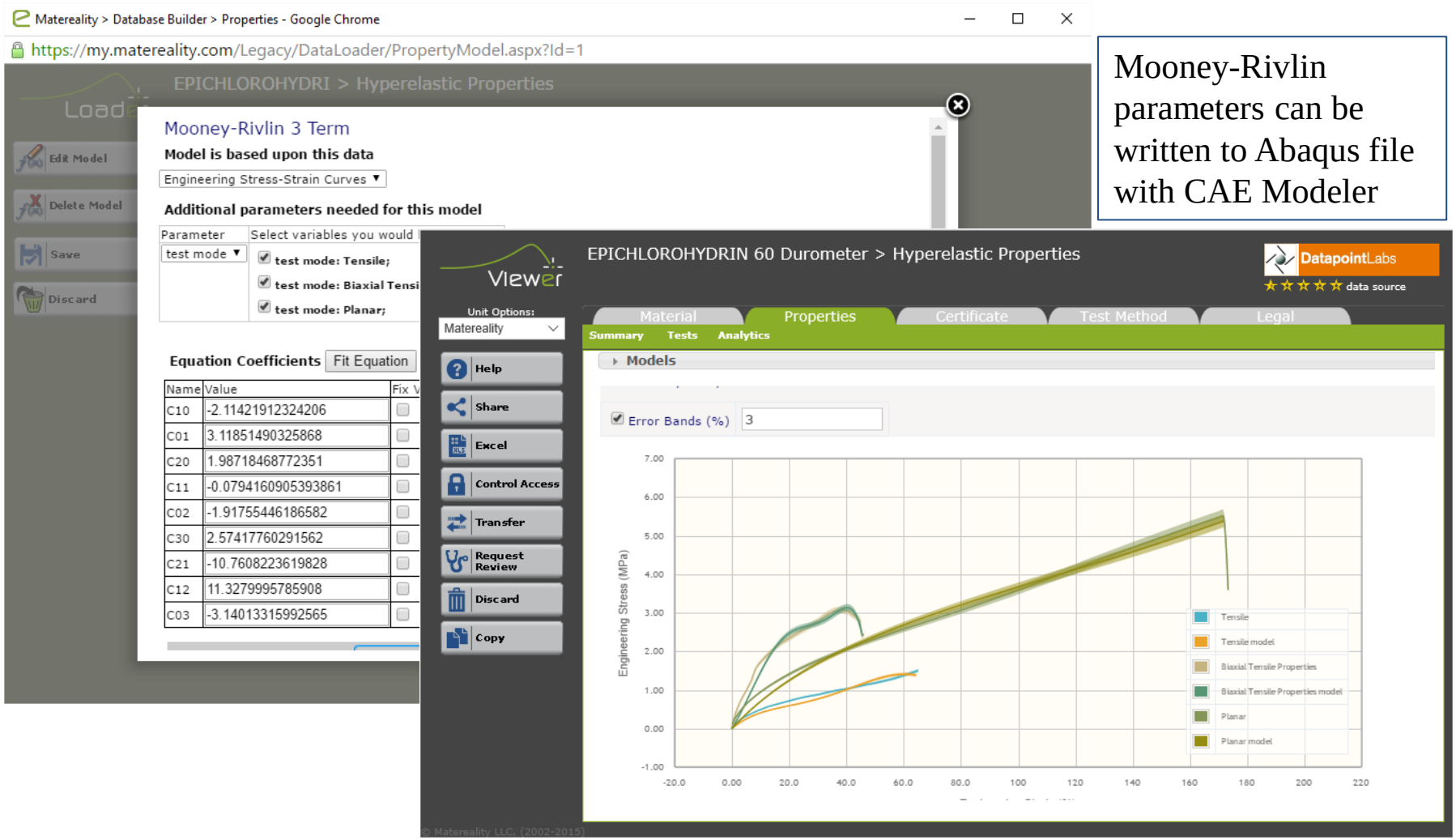
Your data, material cards and test reports are deposited directly into your Matereality database

Software for material parameter conversion



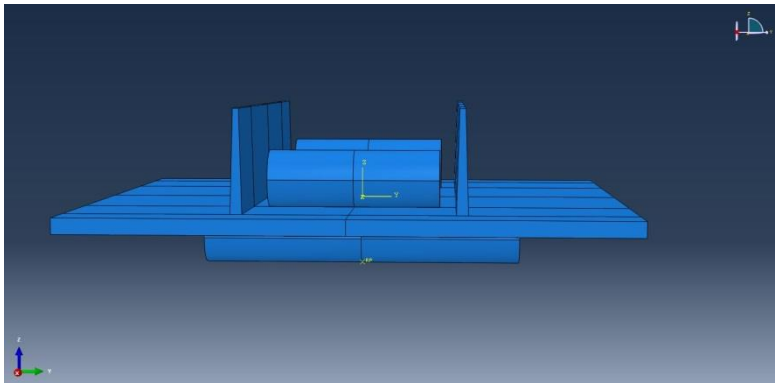
- Export your material cards to your simulation individually, or as master material files

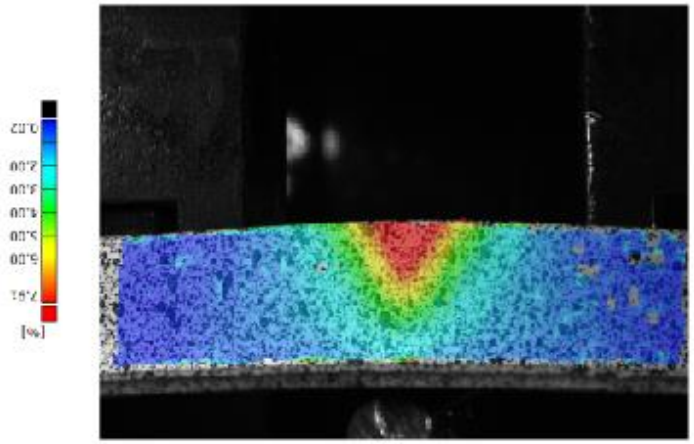
Fitting equations and evaluating quality of fit

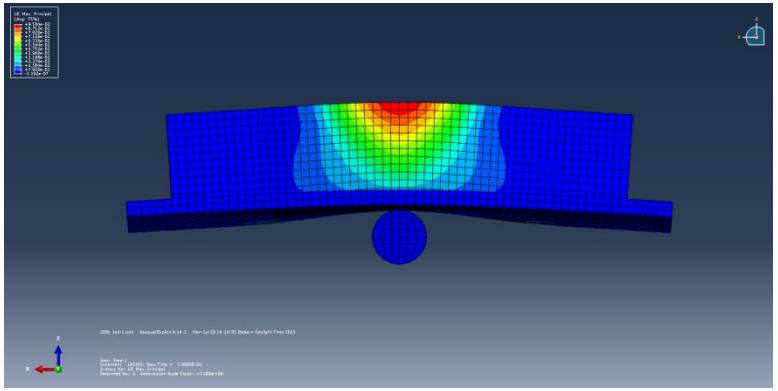


Mooney-Rivlin parameters can be written to Abaqus file with CAE Modeler

Plastics Validation by *CAETestBench*

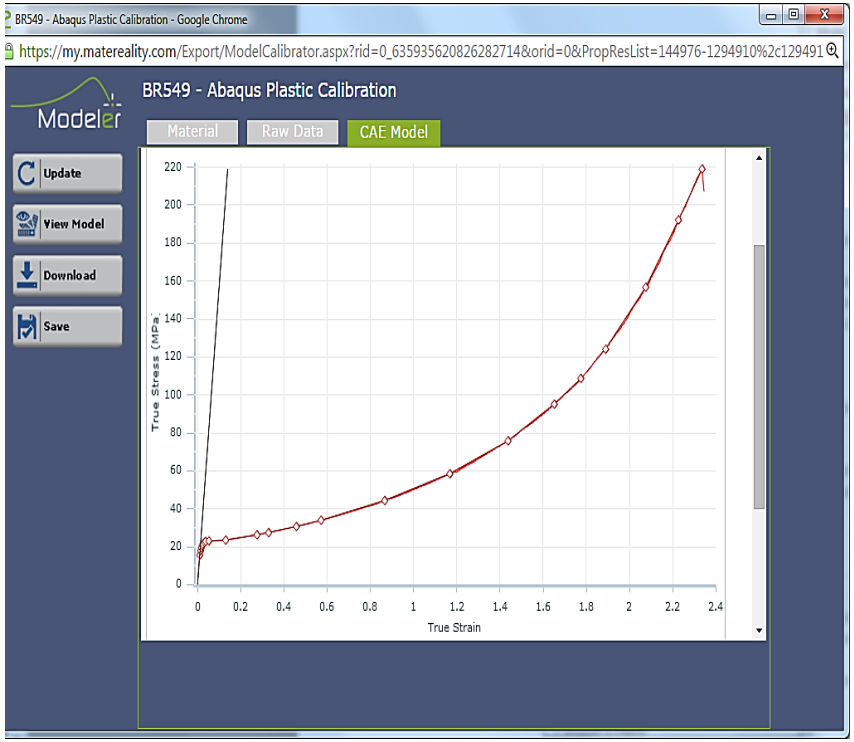


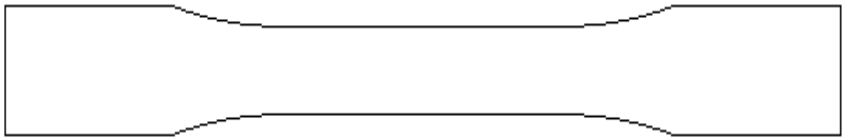




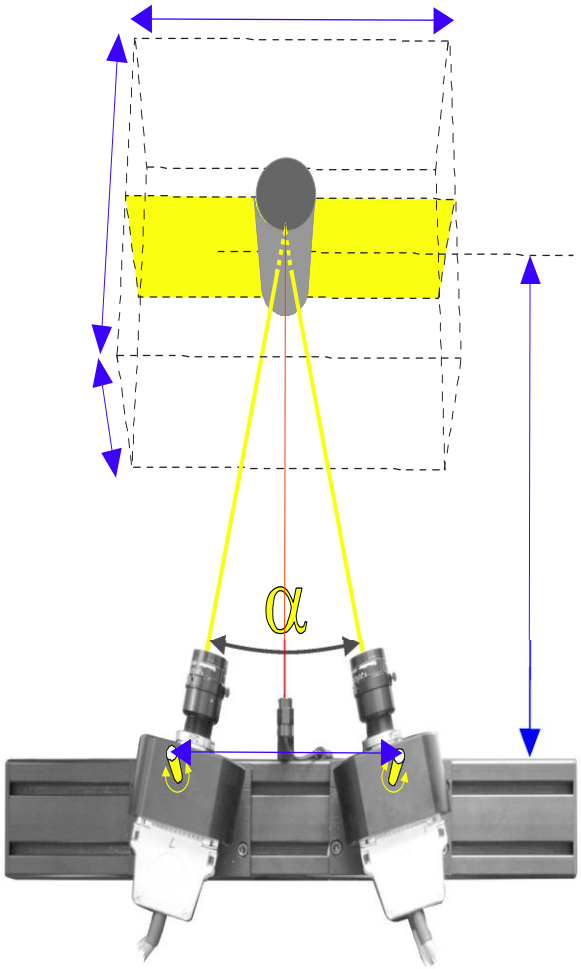
Material Model: Polypropylene

- Tensile and Density Test
- Elastic
  - E = 1572 [MPa]
  - υ = 0.29
- Plastic curve (Right)
- Density
  - ρ = 7.9 E-06 [tonne/mm^3]
- Measured at QS speeds





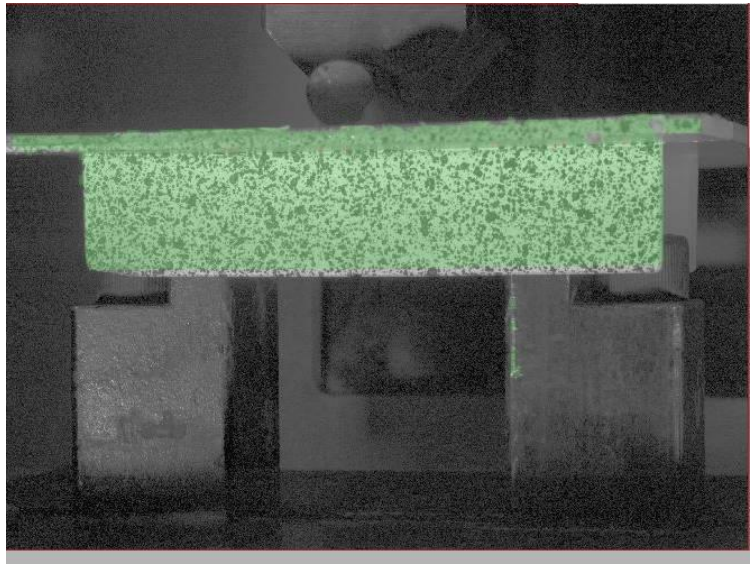
DIC Operation



- Speckle pattern is broken into facets (elements)
- Speckle pattern is tracked frame to frame
- Calibration of a volume is performed through measuring calibration panel in various orientations in the test space.
- Strains can be captured on the micro-strain level
- Strain filed can be mapped over the actual part image

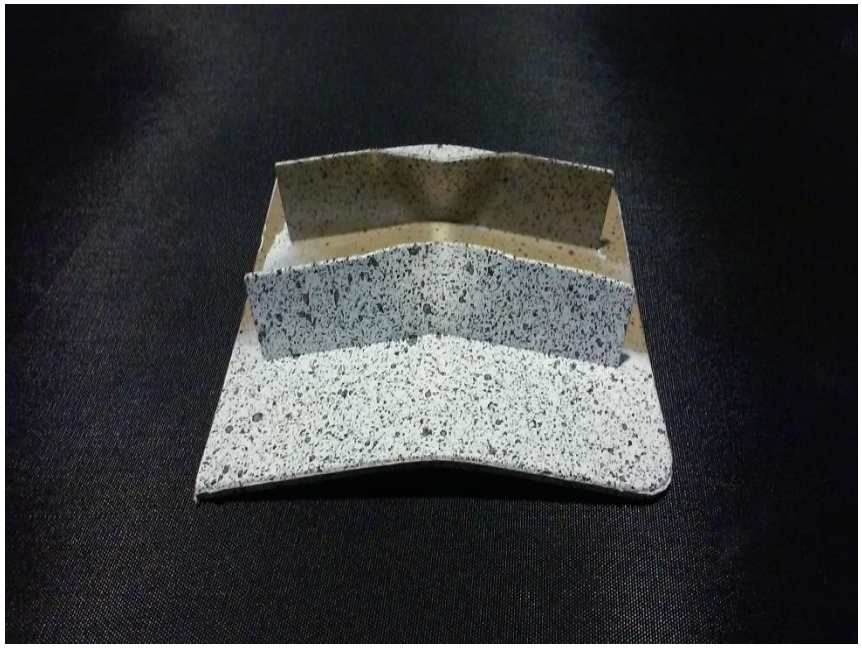
Experimental Setup

- Instron 8872 universal testing machine (UTM)
- 1 mm/min displacement of nose
- Apply speckle patter to part to allow use of DIC strain capture
- Two camera DIC to capture
  3D strain

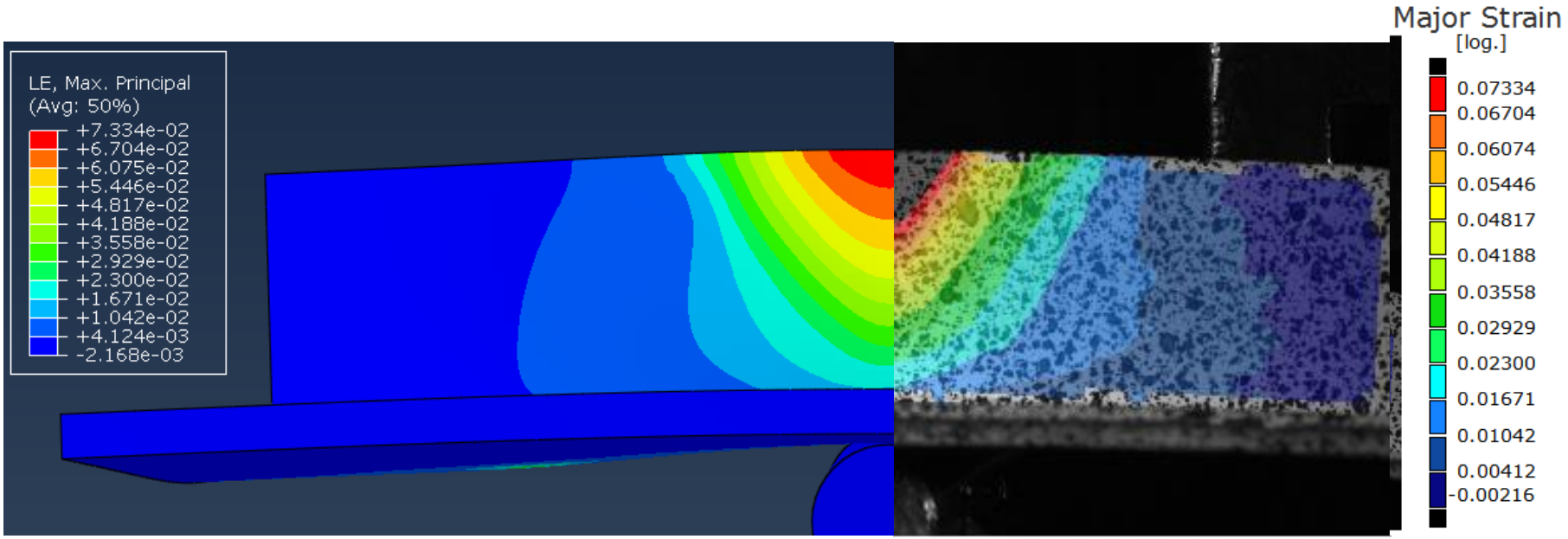


Deformed Part

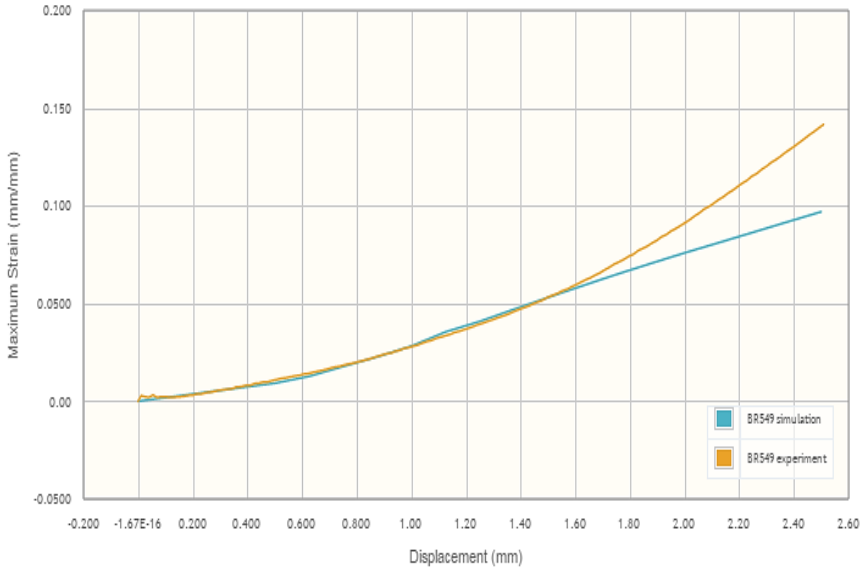
- Loaded past yield
- Observed symmetric buckling inwards
- Slight indentation of support pins causing stress whitening on the reverse side of the part

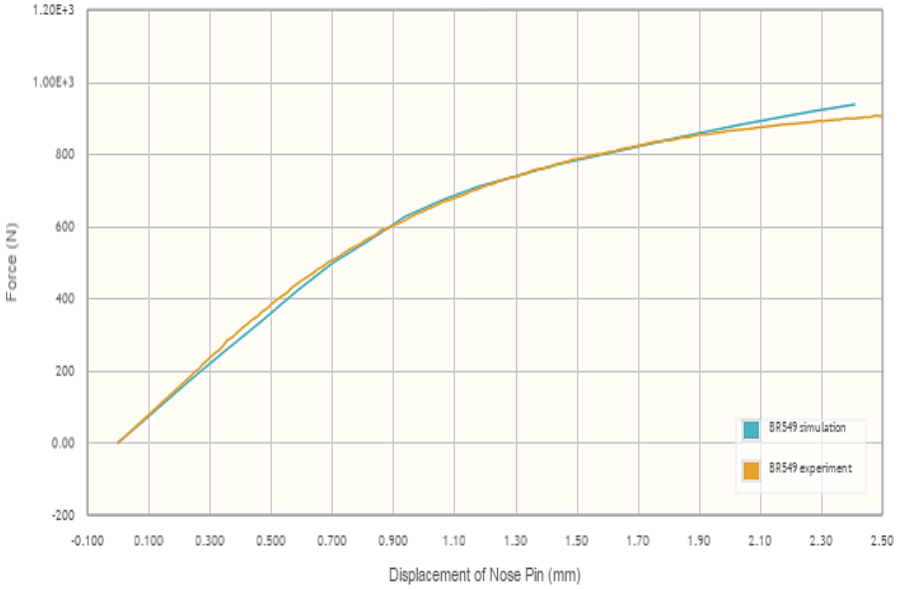


Matching Simulation to Reality



Comparison of Simulation to Experiment



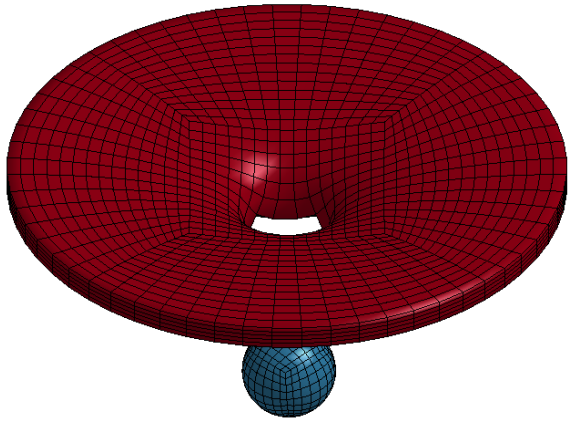


- Strain vs. Displacement
  - Diverges after 2 mm

- Force vs. Displacement
  - Similar response throughout

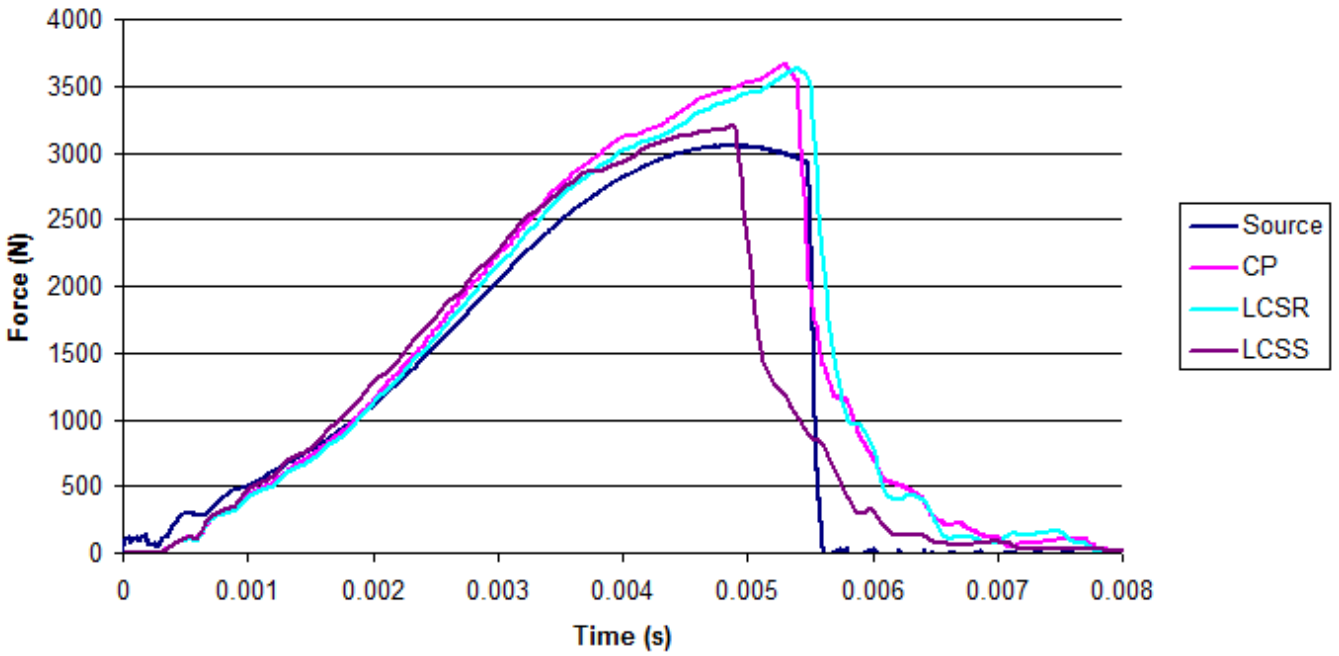
LS-DYNA Validation of Dart Impact - PP

- MAT_024 material model fitted with Matereality



Falling dart validation for PP

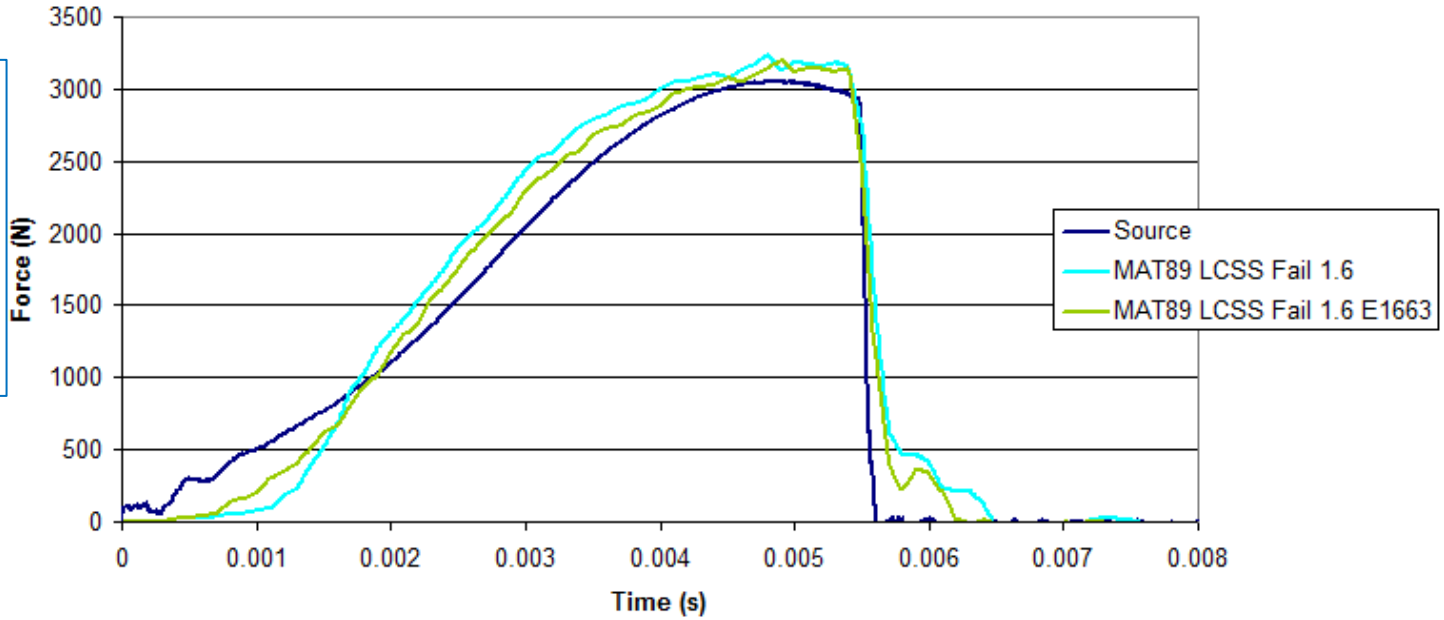
- MAT_024 Material Model
  - Various rate dependency options
- VP=1
- Fail Strain extrapolated to 1.2



LS-DYNA validation using MAT_089 (LCSS)

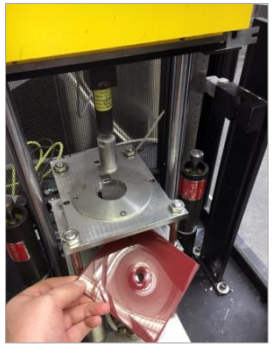
- Where modulus is rate-dependent
  - Effect of highest and lowest elastic modulus values.

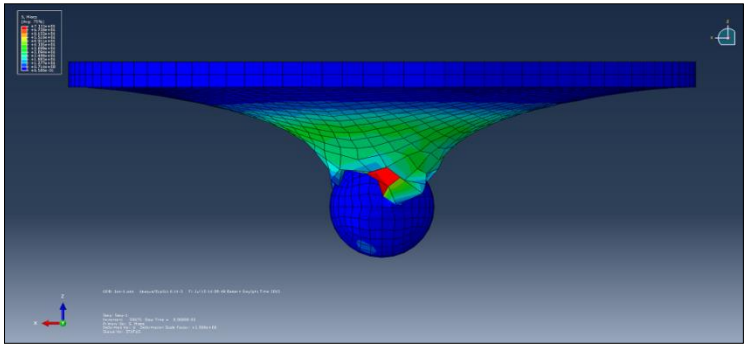
When the elastic modulus was changed to the modulus corresponding to the slowest strain rate, a stiffer initial response was observed



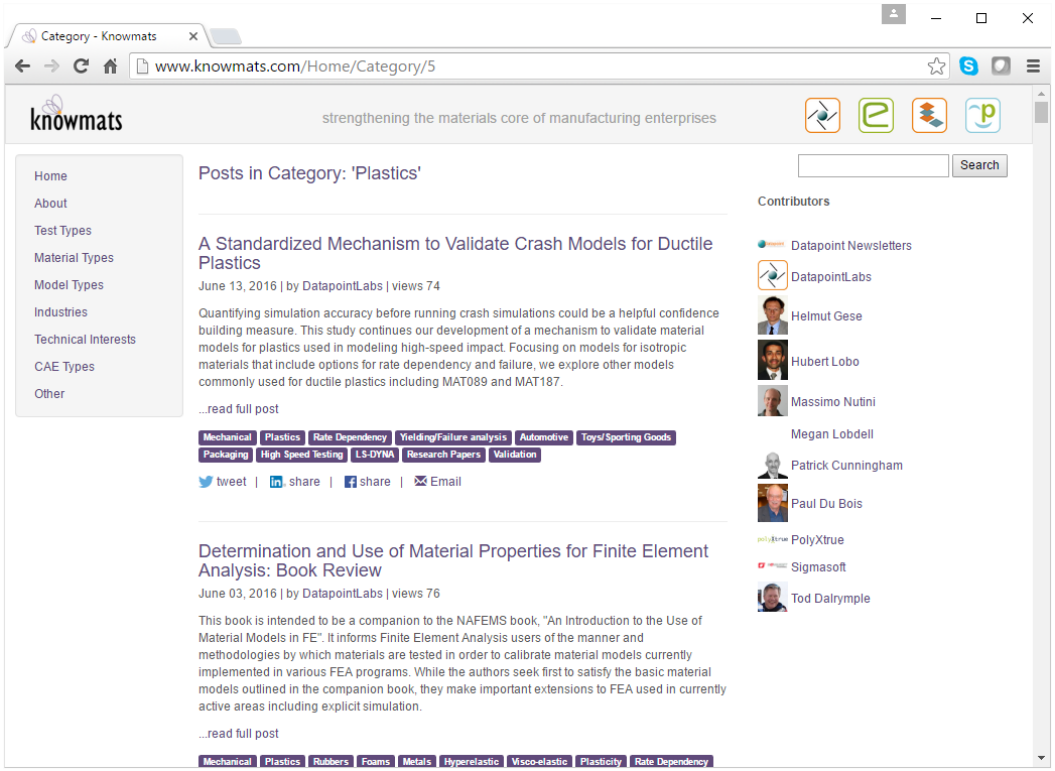
Dynamic Validation of Dart Impact - ABS

- ABAQUS-Explicit





Use Knowmats™ to learn more about materials in simulation



Knowledge accumulated by DatapointLabs, partners, industry experts

Contributors invited!

20 years of **Datapoint**Labs

- Focused on “materials in simulation” since 1995
- Deep domain expertise
  - physics of materials, CAE parameter conversion, software for materials
- Market dominant and world renowned