

A Strategy for Material Testing and Data Management for the Automotive Industry

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DatapointLabs

+

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a DatapointLabs Affiliate



America's fastest growing private companies

Material

Testing × Data Management × Software

the science of materials...



About us



Expertise

- **Pioneers in materials support of product development / R&D for 18 yrs**
- **Broad experience with diverse materials**
- **Testing over 1500+ materials/yr**
- **Support of 34 CAE design codes**
- **1000+ customers, 34 countries**



Technology

- **Extensible material databases**
- **Enabling software apps**



- Plastic
- Rubber
 - Film
- Metal
- Foam
- Adhesive
- Composite
 - Cement
 - Ceramic
 - Paper
 - Fiber

The Material Data Challenge

Obtaining enterprise-relevant data

- **Not commonly in public domain**
- **Free data may be too generic**
- **Unmanageable risk for PLM**

Today's best practice

- **Test your own materials**
- **Understand your data**
- **Use with confidence**
- **Don't lose it**

Adding materials to the PLM core

Relevant (purpose-specific) data
Trusted and Validated
Disseminated
Controlled
Expandable

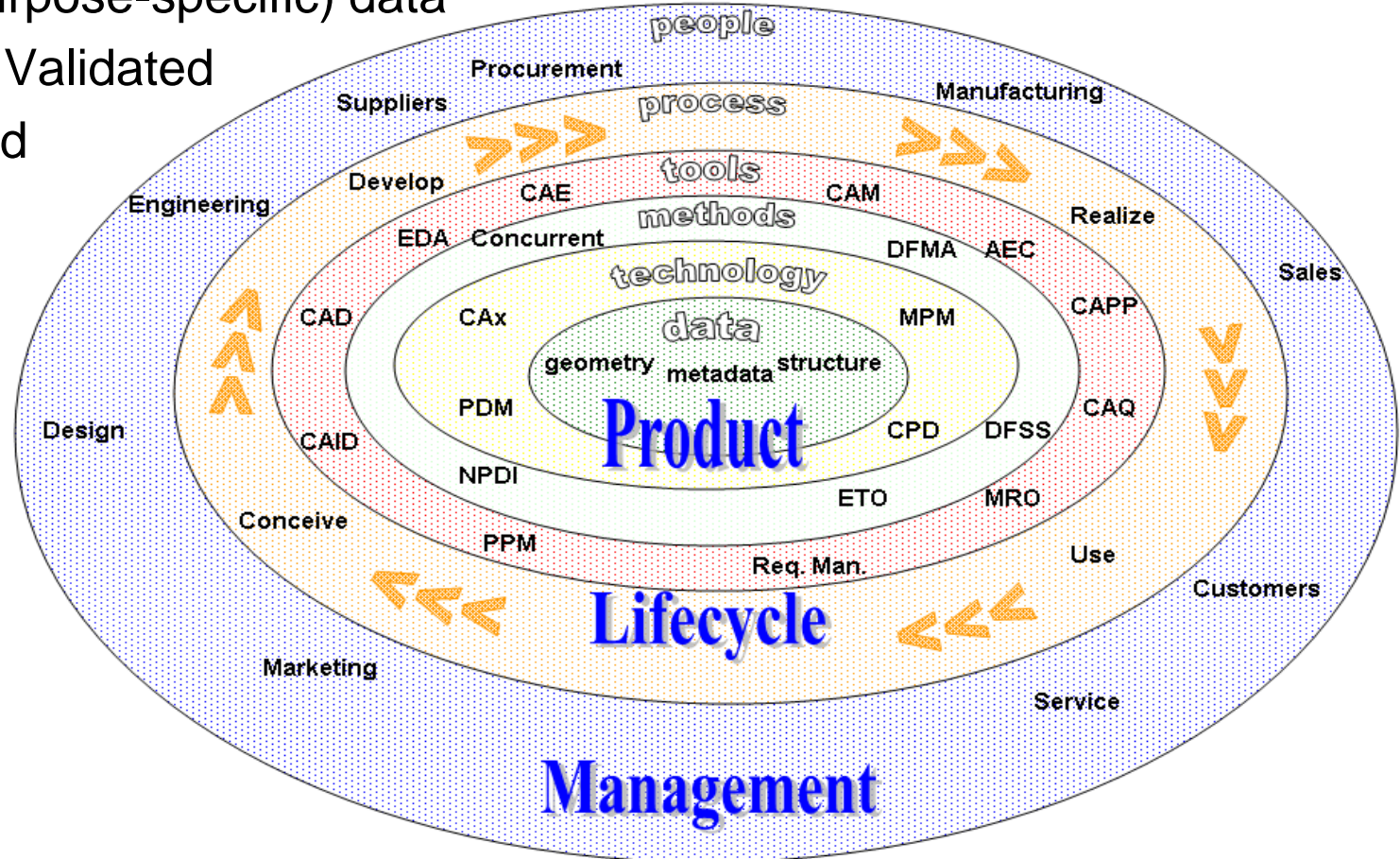


Image copied from wikimedia.org/wikipedia/en/1/1c/Plm1.png

Relevant Material Data

The actual material used for the product
 Must represent the actual end application

- **Processing**
 - *Formed, tempered...*
- **Environment**
 - *Fuel, coolant, salt spray saturated*
- **Situation**
 - *Rate dependent*
 - *Temperature*
- ...



Mechanical stress-strain testing
 in a liquid, non-ambient environment

Trust and Validity

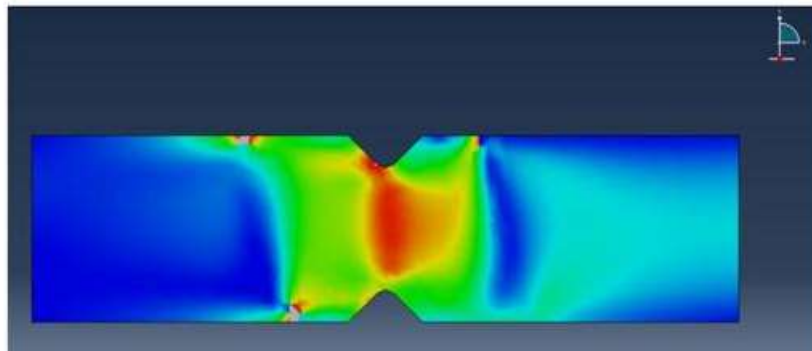
Data must be from a trusted source

- **Internal lab**
- **Qualified ISO lab**
- **A great technical authority**

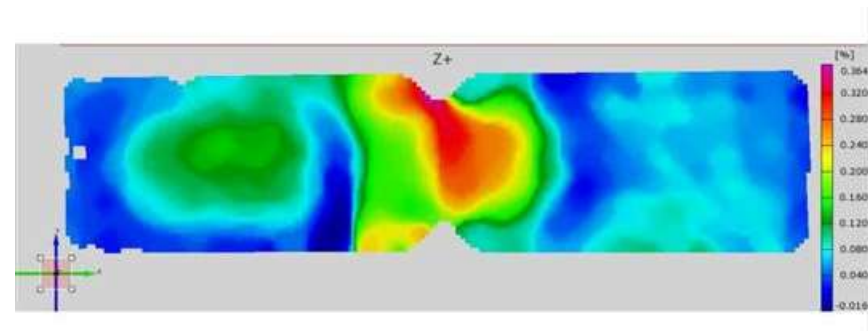


Data must be valid

- **It must produce a correct simulation result**
- **Preferably compared to a real test**



Abaqus simulation



ARAMIS DIC experiment

Dissemination— User Specific Dashboards

Material data is used differently

- **Purchasing**
- **CAD**
- **Expert CAE**
- **Test Lab**
- **IT/Administration**

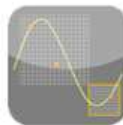
App suite for each expert is different



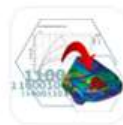
GridView



Manage
My Database



Design Data



CAE Modeler



Material
Model Library



Data Loader



Messages



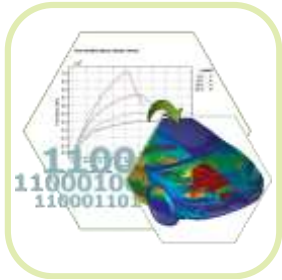
Activity Tracker



Free
Databases



Experiment
Designer



CAE Modelers

- **Take raw data and convert to material parameters**
- **Write material cards to different CAE**
- **Manage software version changes**



Model Libraries

- **Manage material cards**
- **Export project cards**
- **Card version control**

Control and Management

Traceability between material card and material data

Assignment of roles for different experts

- **materials engineer**
- **CAE expert**
- **Designer**
- ...

Exposing the right data for each expert

Sequestration of material data and material cards

Version control

Activity logging

Expandability

New materials are being explored

New processes are being explored

Each new material-process combination = a different material model

Need user ability to add:

- **new materials, processing, compositions**
- **new properties**
- **new CAE Models**



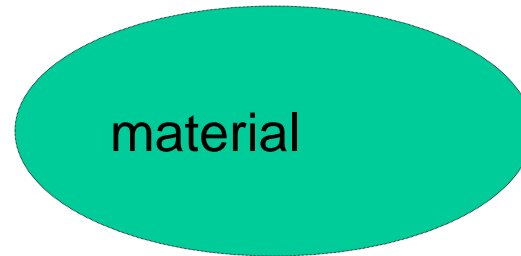
proven expandability
 is a requirement for
 future-proofing

Vision- projecting the material into its environment

Capture the true nature of the material

- **Correctly**
- **Completely**

Compositions
Layups
Welds
Coatings



Processing & Sequence

Cast
Forged
Heat treated
Injection molded

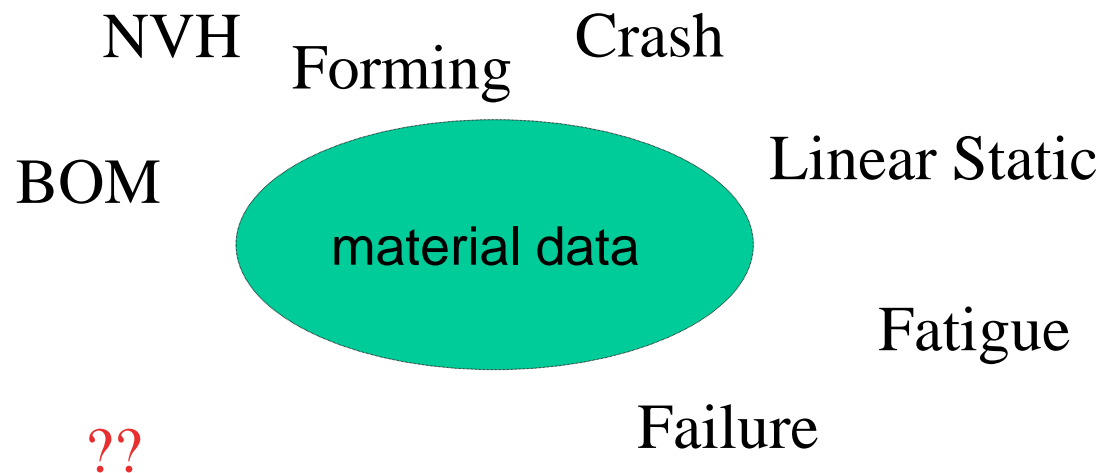
Environments

Fuel soaked
Heat aged

Vision- projecting the material into design/CAE

Consistency & fidelity across various simulations

- **It is the same material after all**



Implications for the Crash CAE Expert

Material modeling space can be complex

- **Physical complexity**
- **Mathematical complexity**
- **Data conversion complexity (material parameter generation)**

A different expertise than CAE

- **Usually an expert reference source...institute, reference lab...**

Suggested philosophy

- **First, do it right**
- **Then use and reuse**

Good material modeling practices

Material is appropriate

- **Is this the actual material being simulated?**
- **Composition, processing, processing sequence...**

Material data

- **From traceable source (ISO 17025)**
- **Clean, with minimal noise**

Data is relevant to the simulation

- **Follows material laws**

Testing

Use of conventional methods

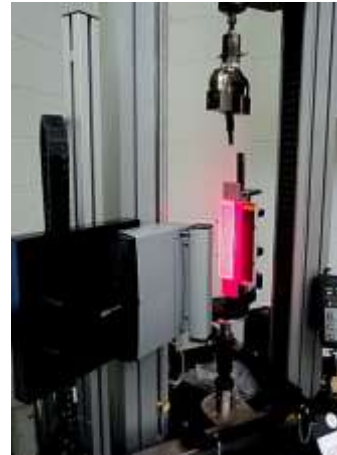
Layering in DIC for advanced measurements

Meeting design timelines



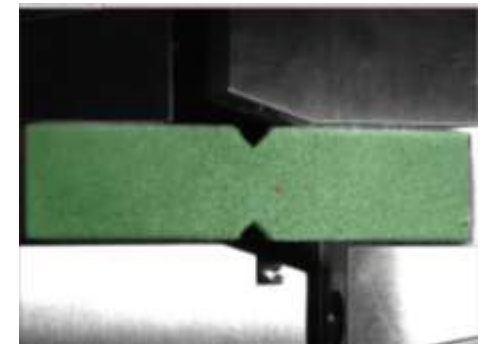
Contact extensometry

- conventional
- quick
- traceable



Video extensometry

- advanced
- quick
- traceable



Aramis DIC

- complex
- slow

Material Parameter Conversion

Raw data must be transformed to material parameters

- **Simple - just collect and deploy**
- **Medium – discretize curve and calculate**
- **Complex - fit equation, obtain parameters**

How a CAE Modeler works: locating relevant data

Each material model has different data requirements

The CAE Modeler first finds the required data

Example:

- **Rate Dependent Model = Tensile stress-strain at many strain rates**
- **Hyperelastic Model = Uniaxial, shear and biaxial stress-strain data**
- **Visco-elastic Model = Stress relaxation curve**

Create Model for Ansys

Select Database

Select the CAE Model Tutorial

Apply Material Constr

Class		Supplier
<input type="text" value="Any"/>	<ul style="list-style-type: none"> ANSYS Elastic ANSYS Elastic ANSYS Fatigue ANSYS Hyperelastic ANSYS MISO ANSYS Rate Dependent ANSYS Thermal ANSYS Thermal Exp 	<input type="text" value="Any"/>

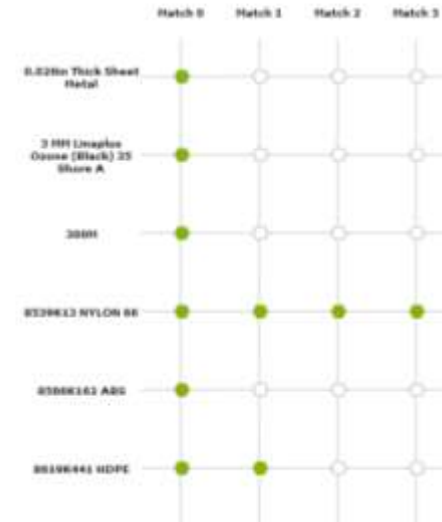
Get [ANSYS](#) for your software.

How a CAE Modeler works: candidate materials

Only materials containing required
data for that model are presented



Note: Some MBD wizard searches are highly restrictive to permit the necessary downstream data-processing. A failed search does not necessarily mean that the data you need is not within Materiality. More data may be found by doing a Property Search. Additional manual data processing may be needed to make it ready for your end-use application.



How a CAE Modeler works: transform rate-dependent data to LS-DYNA MAT24

The screenshot shows a web browser window with the URL https://my.matereality.com/Export/SelectExportFormat.aspx?rid=113_634707042678001250&orid=15_634707042468313750&STemplate=LS-DYNA+MAT_024&Material=Makrolon-. The page title is "Makrolon 7435 - LS-DYNA MAT_024 Calibration". The CAEmodeler logo is in the top left. There are three tabs: "Material", "Raw Data", and "CAE Model" (which is active). Below the tabs is a section titled "Select the output format" with a dropdown menu. The menu options are:

- LS-DYNA (a): m,s,kg,N,Pa
- LS-DYNA (a): m,s,kg,N,Pa
- LS-DYNA (b): mm,s,tonne,N,MPa (highlighted)
- LS-DYNA (c): mm,ms,kg,kN,GPa
- CSV
- Excel
- MATLAB
- MatML

 A blue callout box on the right side of the interface contains the text:

Select LS-DYNA unit system
 Then start conversion

How a CAE Modeler works: fitting elasto-visco-plasticity



CAE Modeler
First pass model
auto-fit including
rate dependency
and initial plasticity

How a CAE Modeler works: manual tuning by CAE expert

Makrolon 7435 - LS-DYNA MAT_024 Calibration - Google Chrome

https://my.matereality.com/Export/ModelCalibrator.aspx?rid=41_634387892879612500&orid=15_634387892816643750&PropResList=62522-586344%2c586345%2c586352%2c5...

Makrolon 7435 - LS-DYNA MAT_024 Calibration

CAEmodeler

Material Raw Data CAE Model

Update

View Model

Download

Strain Rate (/s)	Stress Ratio
0.06929	1
0.2665	1.0545454545454545
2.665	1.1090909090909091
26.65	1.0363636363636363

Stress Strain Data

X Linear X Log Y Linear Y Log Unzoom Zoom Select Update Model

Stress (Pa)

1.0e+8
9.0e+7
8.0e+7
7.0e+7
6.0e+7
5.0e+7
4.0e+7

Tune stress ratios to improve rate dependency fit

Click **Update** to apply your changes

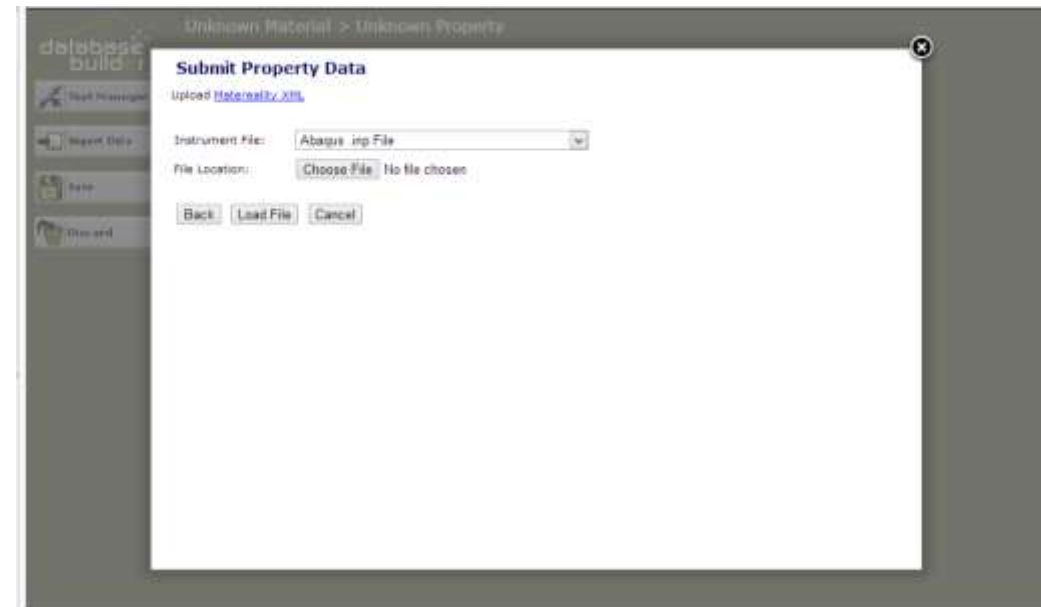
How a CAE Modeler works: Fitting complex hyperelastic equations

Data fitting of complex equations
Storage of equation coefficients
Deploy to CAE



How a CAE Modeler works: Reverse CAE Modeling

- Import CAE material card
- Convert to “raw data”
- Store “raw data”
- Run CAE Modeler
- Write a different CAE material card



How a CAE Modeler works: Writing outputs

CAE Modeler manages

- **Writing time-consuming exotic formats**
- **Format changes with software version**
- **Eliminates data entry error**

CAE Expert needs to define

- **Terms not known**
- **Some terms assumed**
- **Impact on simulation = unknown**

```

** Output generated by Matereality
** Abaqus Plastic Model
*MATERIAL, name=Delrin8753K13
*ELASTIC
3607.59123689013, 0.2413, -10
3183.7938807461, 0.323571664399527, 23
2174.59568965032, 0.39415, 60
****
*PLASTIC
46.381708640637, 0,-1.000E+01
59.3182190072696, 0.0028490427305577354,-1.000E+01
71.8736400512504, 0.01017006174294555,-1.000E+01
76.7156702762688, 0.016802750802138691,-1.000E+01
79.8204244473178, 0.0246331420035193,-1.000E+01
83.7520014704219, 0.042400203020399568,-1.000E+01
88.44580120706, 0.07511425176203515,-1.000E+01
101.286187380666, 0.18221125102592156,-1.000E+01
**
41.2027474277636, 0,2.300E+01
48.0138087197766, 0.0021790259049776321,2.300E+01
57.359137021248, 0.00867790936047107,2.300E+01
62.9873556601982, 0.017373626682723388,2.300E+01
66.4967793306663, 0.027568865979447788,2.300E+01
70.9009392980115, 0.05004465060490744,2.300E+01
76.72575710626, 0.096883146480115784,2.300E+01
91.876816291205, 0.24545717623947155,2.300E+01
**
30.11774647629, 0,6.000E+01
38.66825030697, 0.0039035831184979289,6.000E+01
48.5300393483556, 0.017108653508792655,6.000E+01
53.3730143012474, 0.03494428420354867,6.000E+01
60.661535633334, 0.095585277502911209,6.000E+01
74.9317547325, 0.26978649975467672,6.000E+01
81.885009651224, 0.35258702479111464,6.000E+01
92.151413540012, 0.46612695216059519,6.000E+01
**

```

The CAE Model Library: Save and deploy your work

- Store expert-created material cards
- Manage version control
- Manage CAE software version changes

My CAE Models

Created Models | Saved Models

Display: 10 Search: [] First Previous 1 2 3 4 5 Next Last

	Materialname	Modellname	Format	Created
⬇ ⬆ ⬇ ⬆	ET33K111 UHMWPE	ANSYS MISO	ANSYS Workbench 13	5/4/2011 9:57:12 AM
⬇ ⬆ ⬇ ⬆	Dalvik ET33K13	ANSYS Elastic	DM - ANSYS Workbench	3/18/2011 11:42:14 AM
⬇ ⬆ ⬇ ⬆	SANTOPRESS 55 Durometer	ANSYS Hyperelastic	ANSYS Workbench 13	11/7/2011 3:00:33 PM
⬇ ⬆ ⬇ ⬆	LATEX 40 Durometer	Solidworks Hyper	Solidworks	12/17/2012 12:28:34 PM
⬇ ⬆ ⬇ ⬆	ET29K13 NYLON 66	SolidworksFastform	Solidworks	10/16/2012 10:34:12 AM
⬇ ⬆ ⬇ ⬆	Durethan A 30	ANSYS Elastic	ANSYS Workbench 13	4/29/2011 9:22:52 AM
⬇ ⬆ ⬇ ⬆	EPICHLOROHYDRIN 50 Durometer	ANSYS Hyperelastic	ANSYS Workbench 13	5/4/2011 10:40:08 AM
⬇ ⬆ ⬇ ⬆				

CAE Validation: Comparing experiment to simulation

Cohabited datasets

- **experiment and simulation data share same platform**

My Database

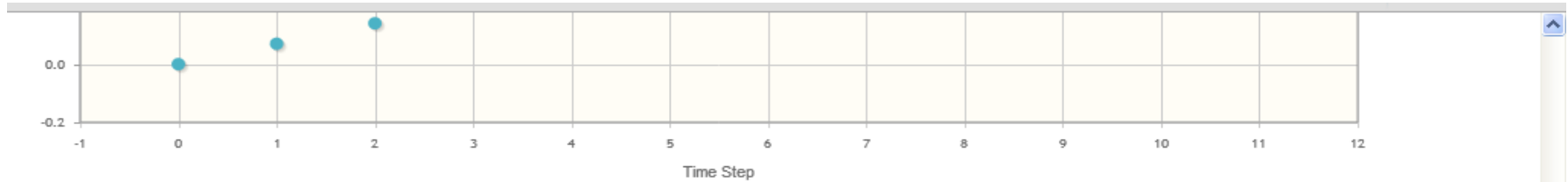
Published Unpublished In Error Downgraded

Display 10 First Previous Next Last 1 to 2 of 2

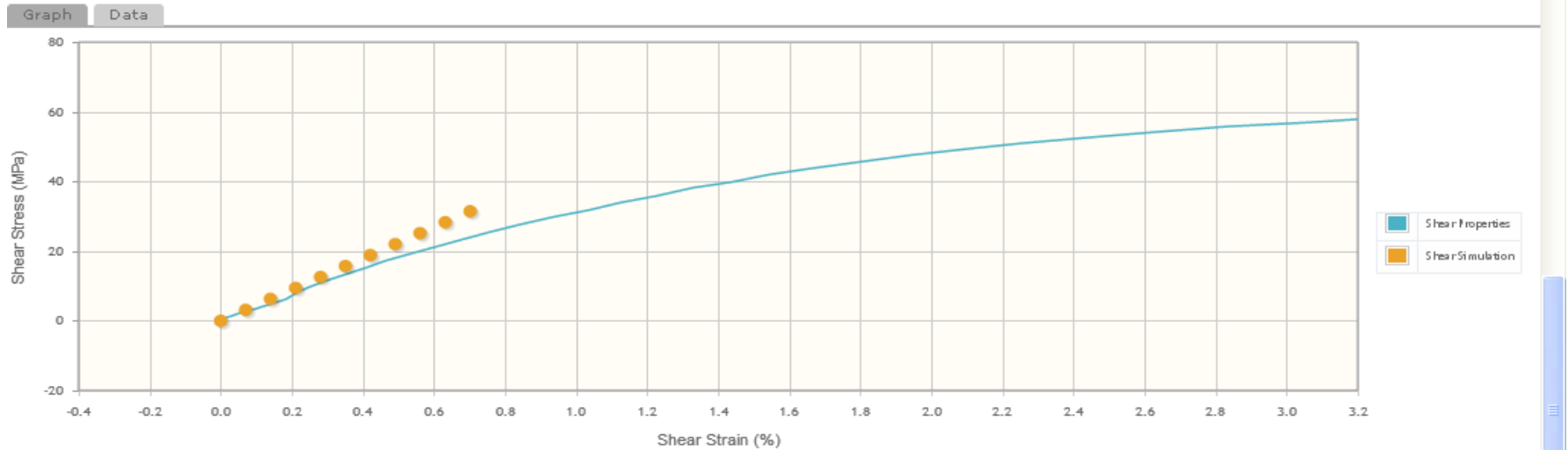
Test Date	Project ID	Sample ID	Sample Name	Material	Property	Access	Visibility
2013-2-26	NAFEMS	21524		8181K26 Carbon Composites	Shear Properties	Private	Visible
2013-2-26	NAFEMS	21524		8181K26 Carbon Composites	Shear Simulation	Private	Visible

Validation

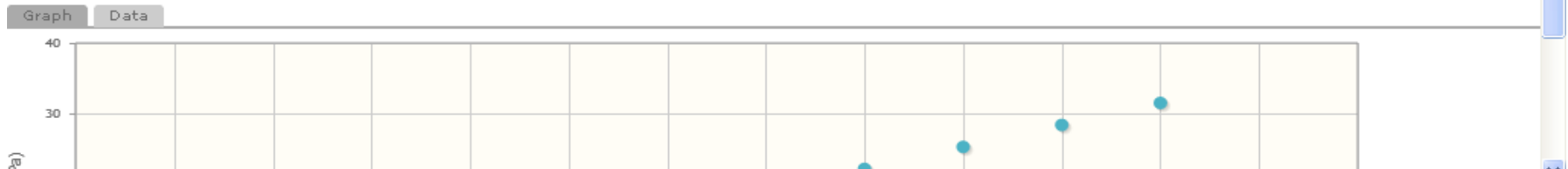
Auto-comparing experiment and simulation



Shear Stress v. Shear Strain Curves



Shear Stress v. Time Step

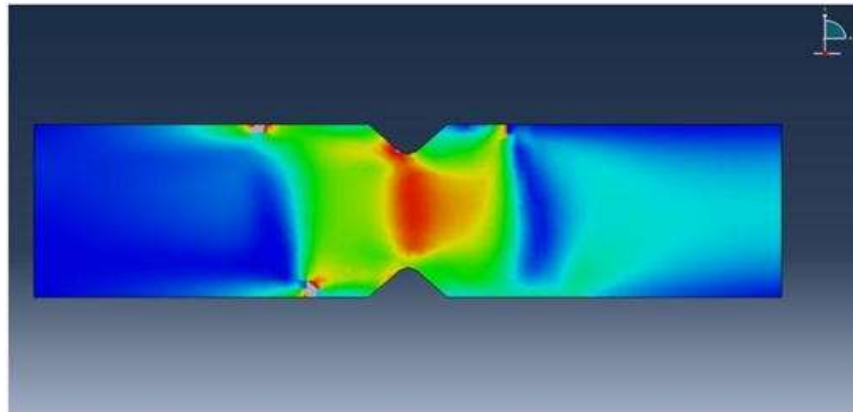
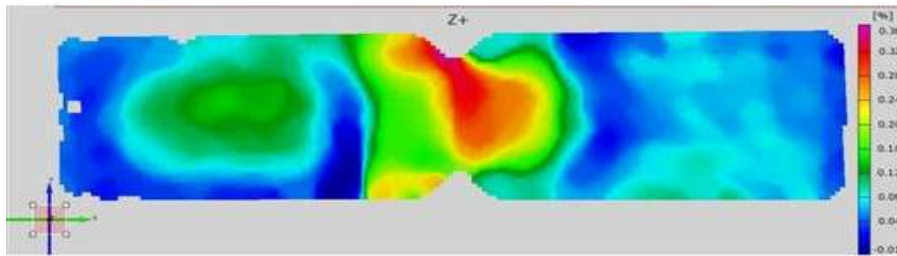


Validation: Comparing strain field images

Effect of Experiment

Shear Field Image

12 direction 0.2mm r1



What is your materials strategy?

Material data

- **Precisely measured**
- **Perfectly managed**

Thank you!