Tips and tricks for as-manufactured simulation using Moldflow and Helius with 3rd party FEA packages

Doug Kenik
VP of Product – Teton Simulation

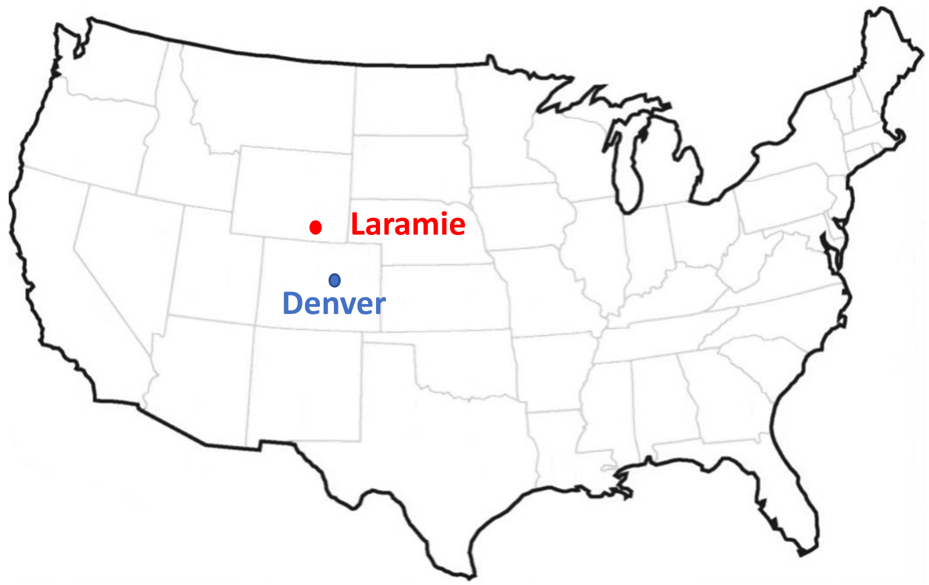
AUTODESK.

Teton

- Advanced Materials
  - Composites
  - Plastics
- Advanced Processes
  - 3D printing
  - Injection molding
  - Composites

FIREHOLE COMPOSITES
ANALYSIS SOFTWARE & SERVICES

UL IDES



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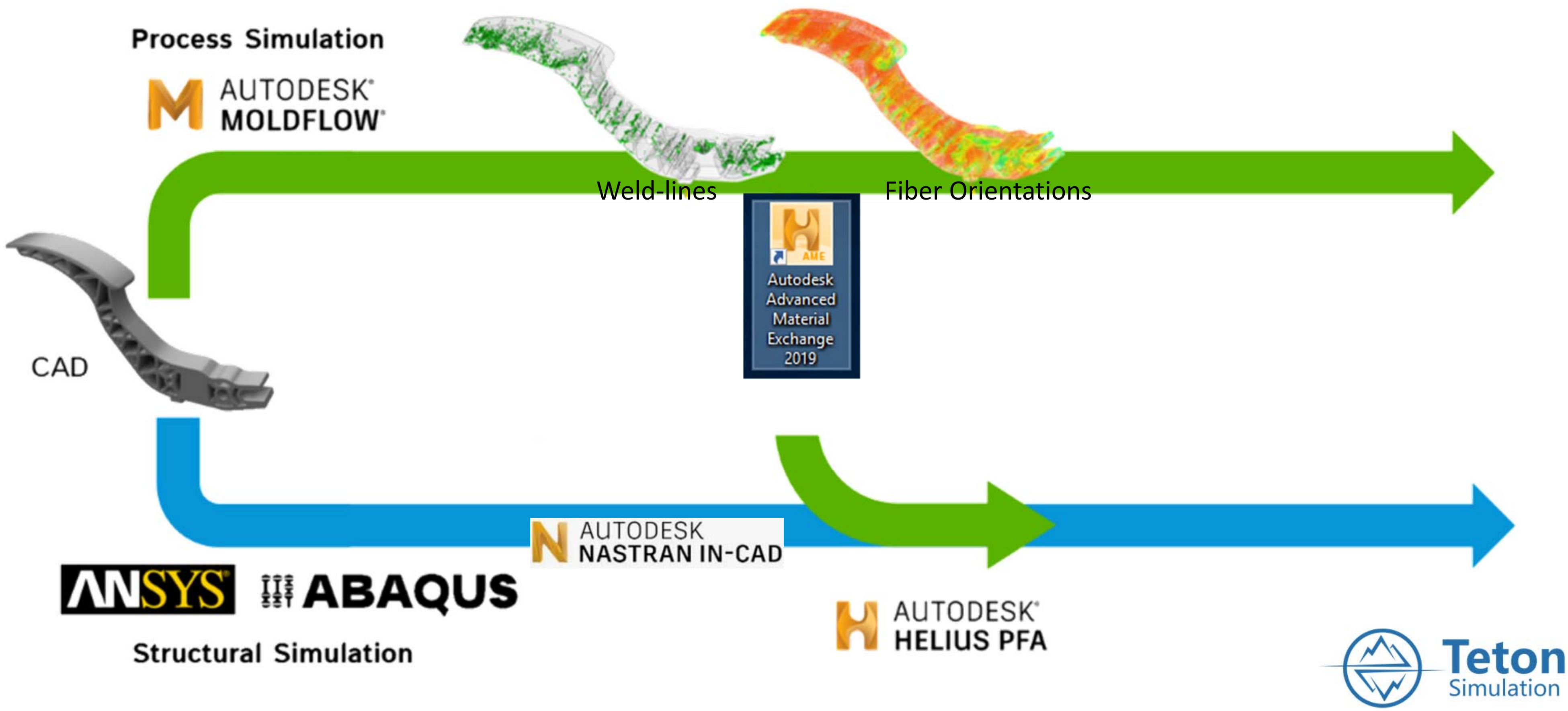
As-Manufactured Structural Analysis Workflow



Incrementing Complexity

01

Accounting for Fiber Orientations

02

When to go Nonlinear

03

Progressive Failure Analysis

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Increasing Level of Complexity

Fiber Orientations

FEA model can include contact and nonlinear geometry – **no penalty on solution time**

Nonlinear Material Properties

FEA model can include contact and nonlinear geometry – **minimal penalty on solution time**

Progressive Failure

Highly recommended that FEA model does not include contact and nonlinear geometry – **can result in model not converging**

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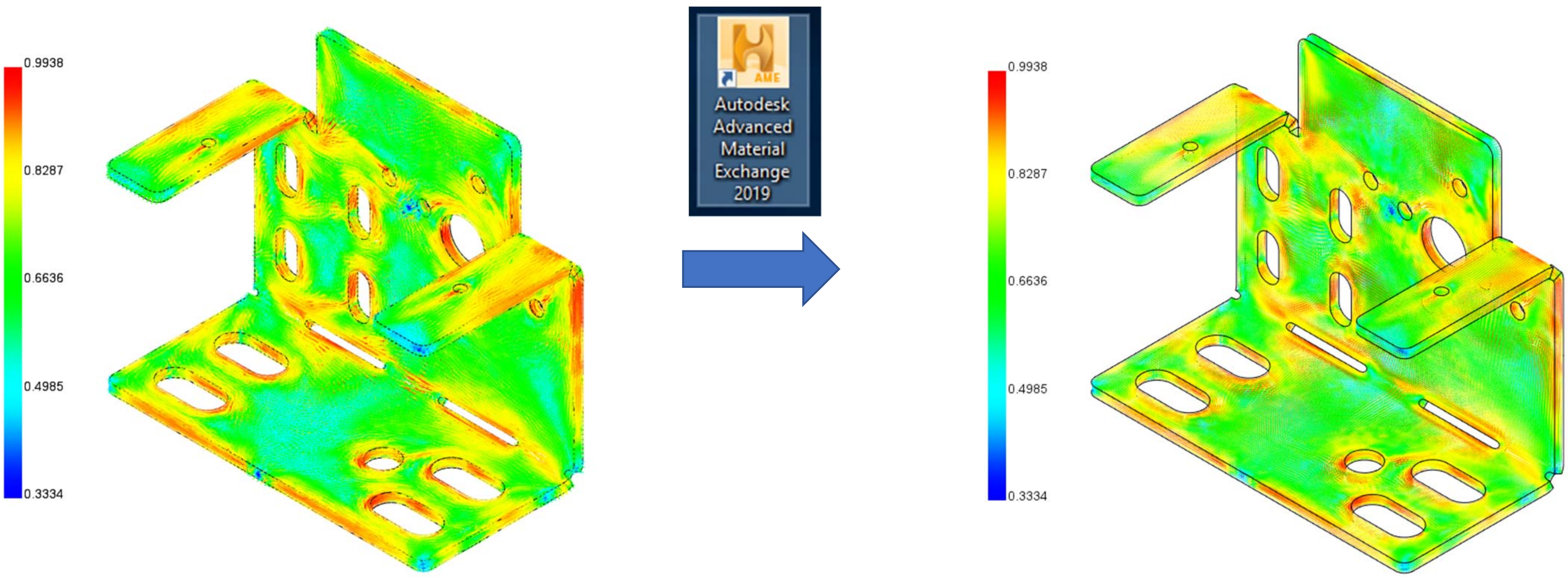
Accounting for Fiber Orientations

Fiber Orientations

Material properties vary due to fiber orientations

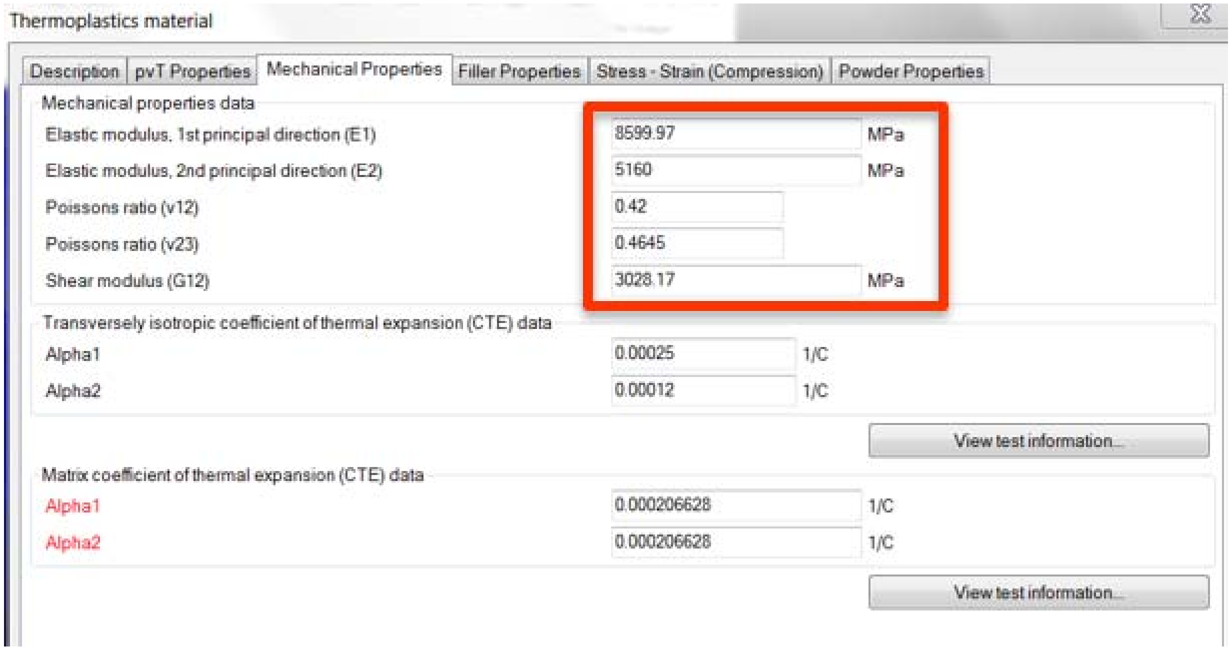
	Fibers in X direction	Random Alignment
Ex (MPa)	12000	5500
Ey (MPa)	4000	5500

The Fiber Orientations are Mapped to Corresponding Elements in FEA Model



Material Behavior

To use a linear material model, no additional material data is required



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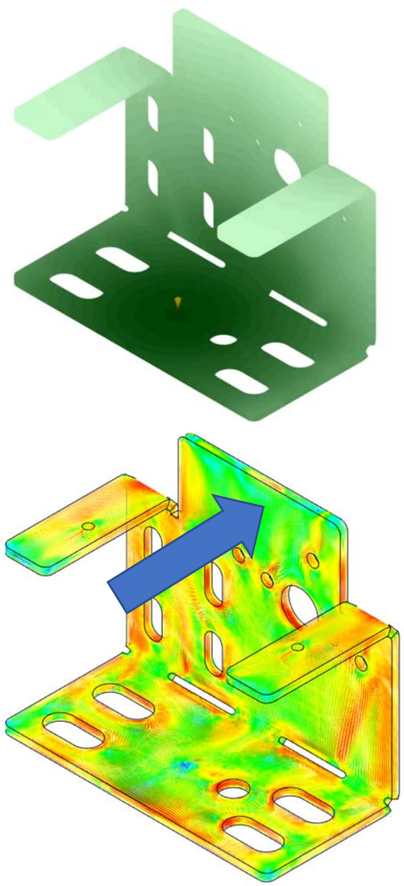
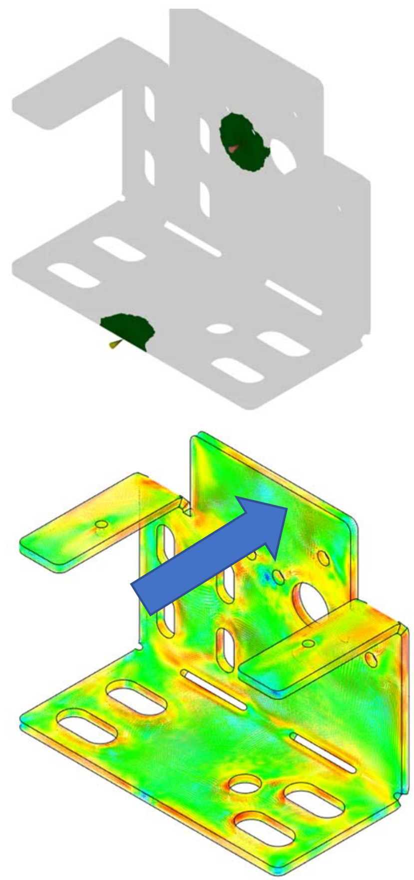
1 gate



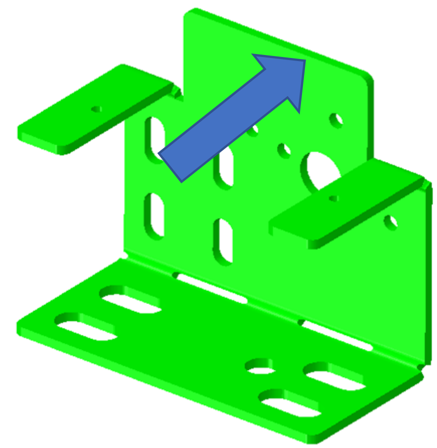
Force = 8.95
Max Stress = 108.9

2 gates



Force = 7.42
Max Stress = 105.1

Isotropic material, no fiber orientations



Force = 10
Max Stress = 154.8

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Summary – Accounting for Fiber Orientations

01

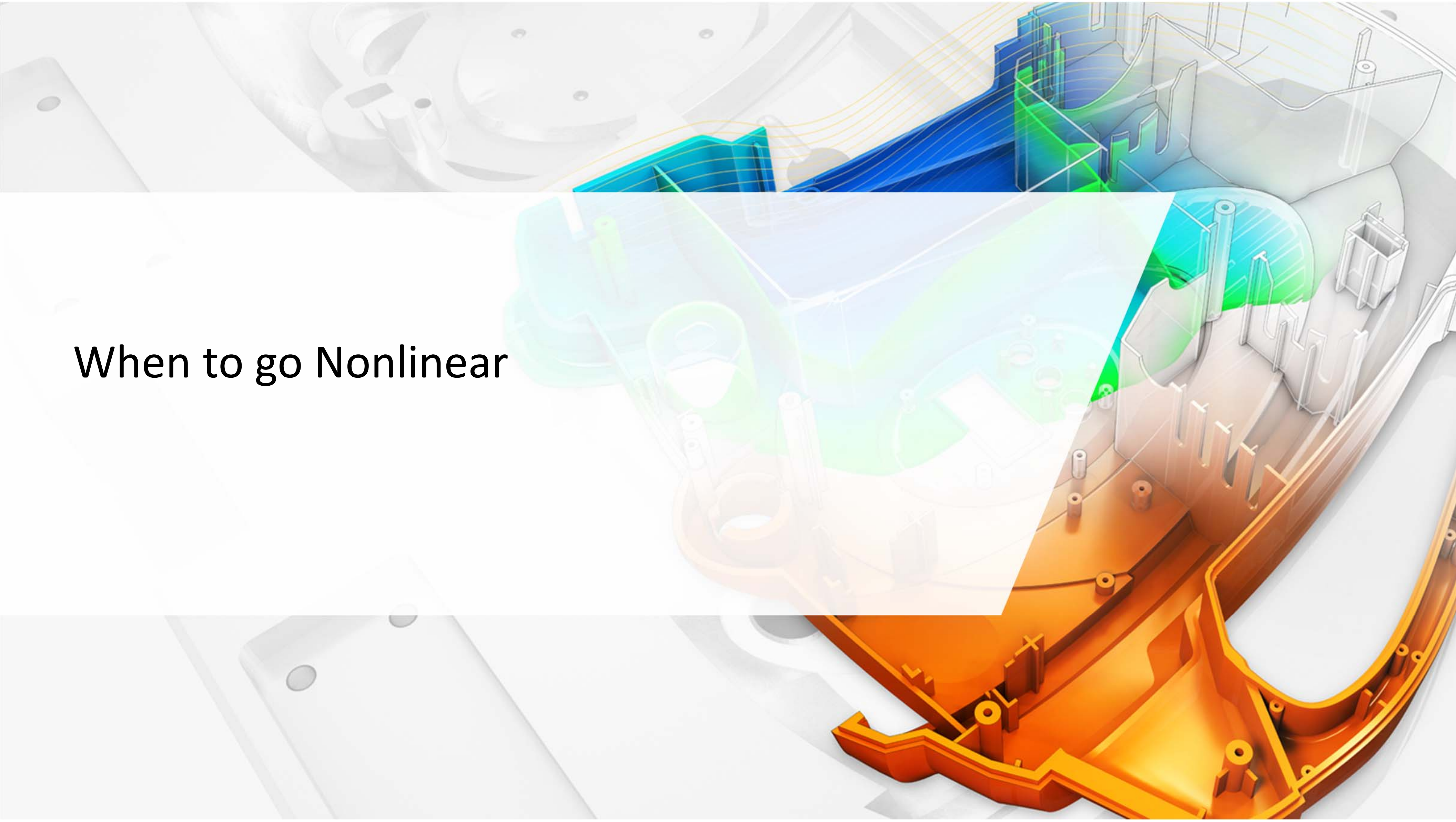
Fiber orientations can greatly affect material stiffness

02

Easy to map fiber orientations to FEA model using Advanced Material Exchange

03

Adds minimal time to your CAE process



When to go Nonlinear

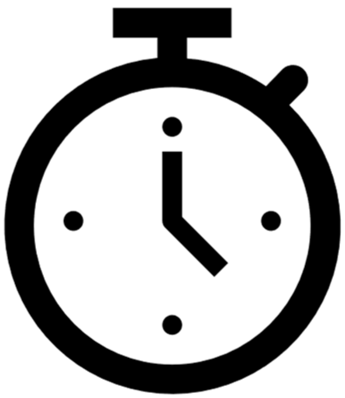
Before going through the cost and time associated with gathering nonlinear data…start with linear models

Natural Frequency and Buckling analyses uses <u>linear</u> material models and does not require nonlinear data

Identify what is driving your design for nonlinearity

When to go Nonlinear

- Assume you've done a few linear iterations
- Why would you go nonlinear?
  - Greater accuracy at higher load levels
  - Post yield behavior
  - Failure load
  - Failure mode
- Design modifications - local reinforcement



Nonlinear analyses ramp up runtime significantly!

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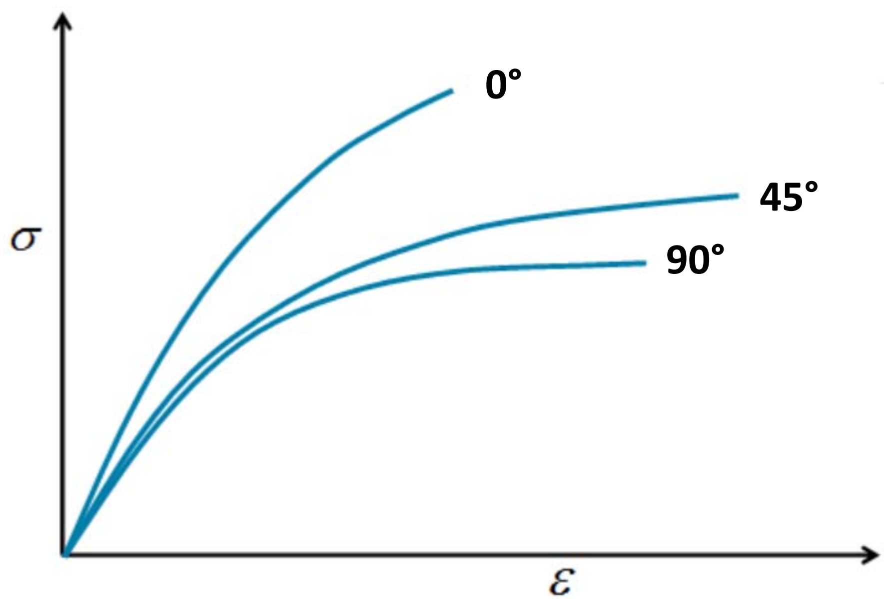
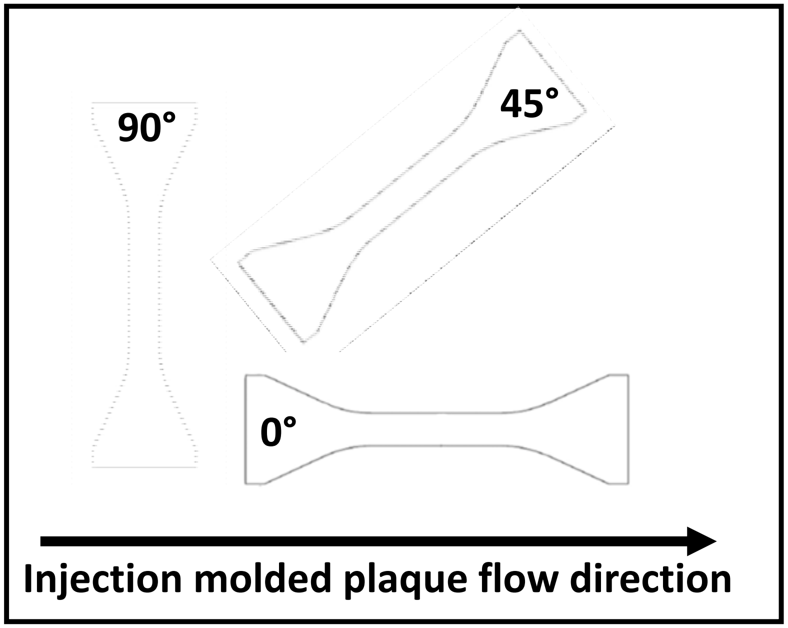
Material Behavior

To use a nonlinear (plastic) material model, additional material data is required





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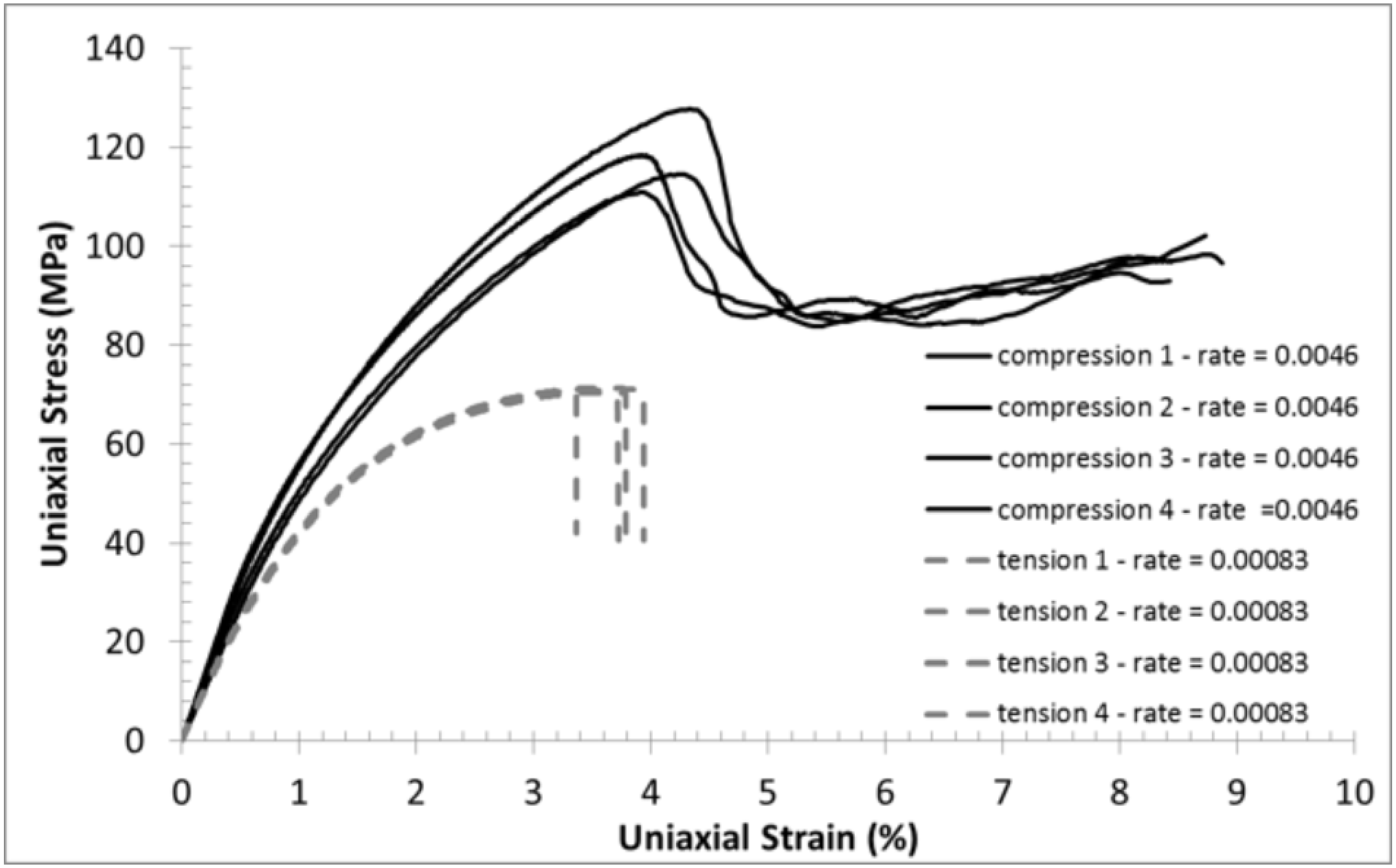
Material Behavior – Tension/Compression



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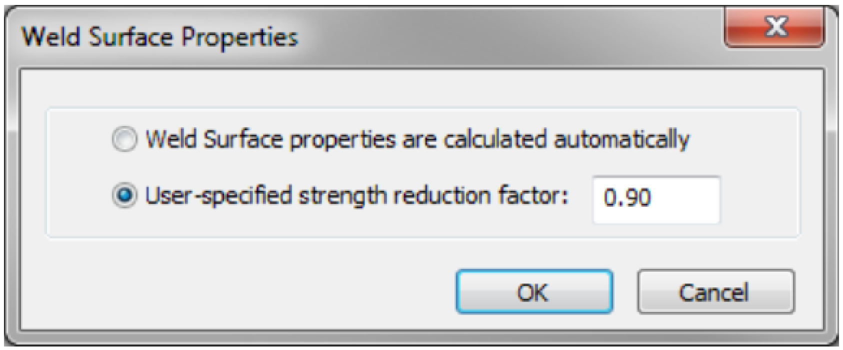
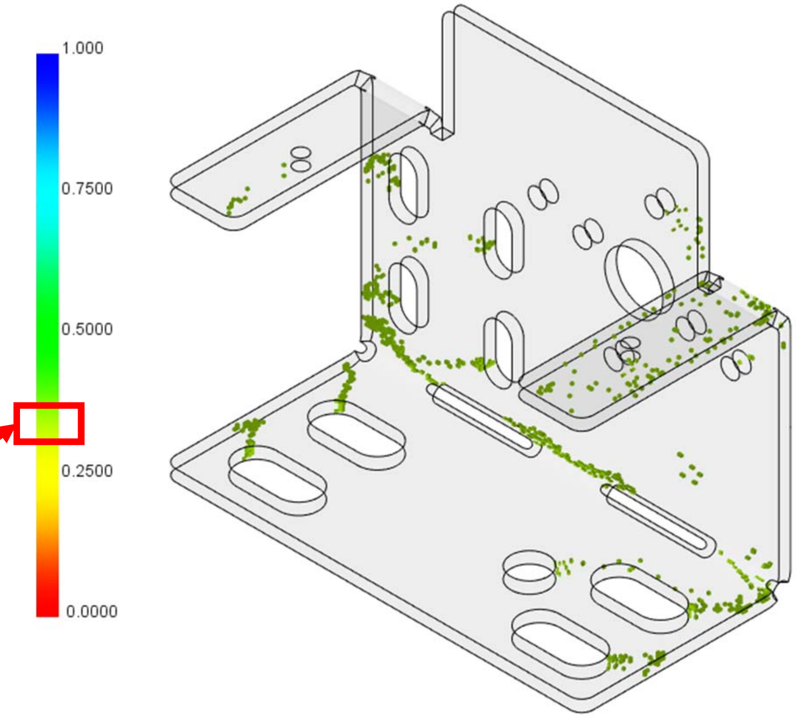
Weld Lines



Strength Reduction Factor = **0.34**
Specific to 30% Glass Filled PP
(Default is 0.9)



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Example Weld Surface Strength Reduction Factors

Amorphous Resin	Reinf.	%	Filler	%	η % (UTS)	Crystalline Resin	Reinf.	%	Filler	%	η % (UTS)
PC	-	-	-	-	99	PA66	-	-	-	-	97
PC	GF	10	-	-	90	PA66	GF	10	-	-	93
PC	GF	30	-	-	65	PA66	GF	30	-	-	61
PC	GF	40	-	-	55	PA66	GF	40	-	-	52
PC	-	-	Milled Gl	30	92	PA66	LGF	30	-	-	58
PC	GF	30	PTFE	15	60	PA66	CF	30	-	-	47
SAN	-	-	-	-	80	PA66	-	-	Glass Bd	30	95
SAN	GF	30	-	-	40	PP	-	-	-	-	86
SAN	GF	30	Flame Ret	10	45	PP	GF	30	-	-	34
PSU	-	-	-	-	100	PPS	-	-	-	-	83
PSU	GF	30	-	-	62	PPS	GF	40	-	-	20

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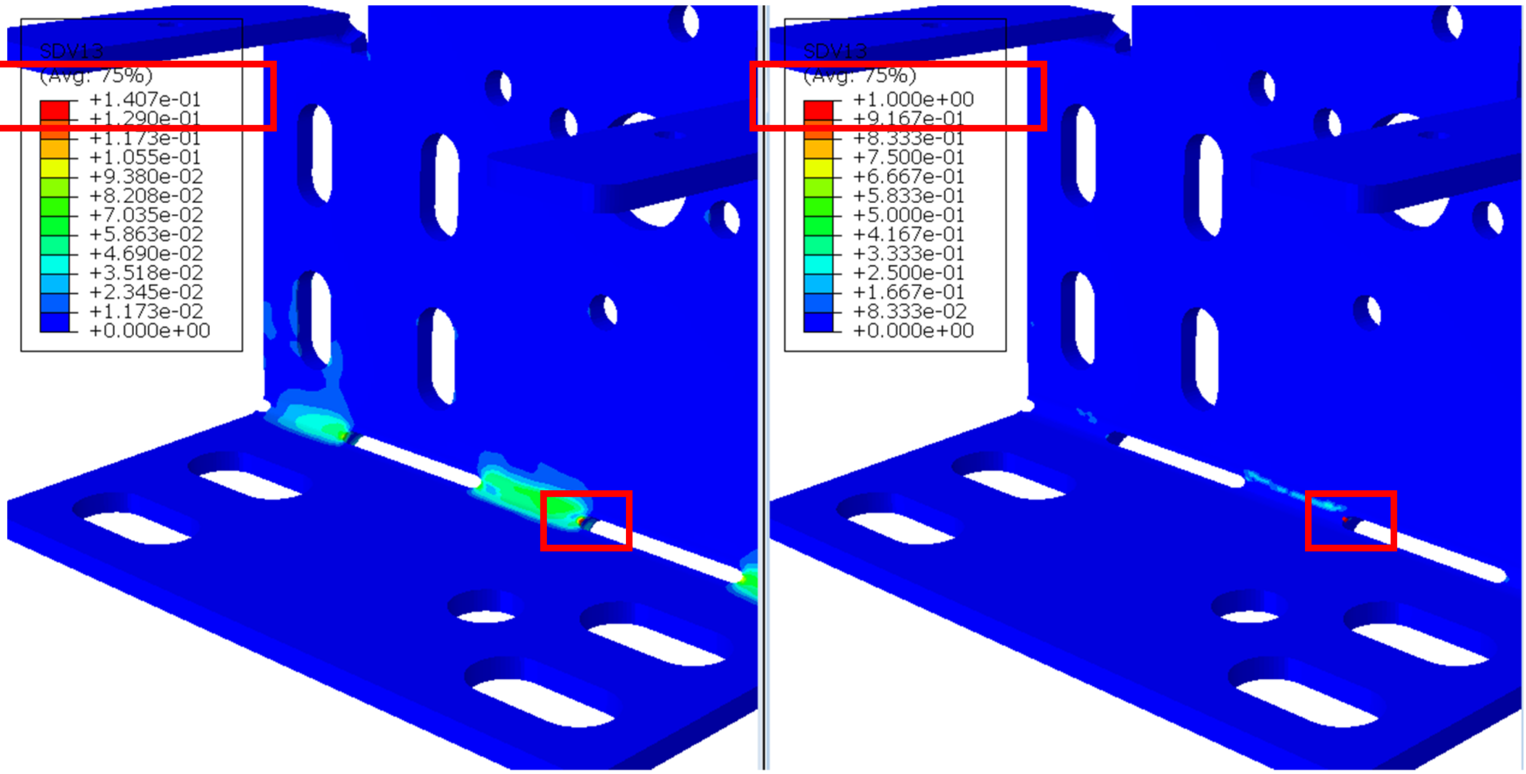
Effect of Weld Line on Failure Load



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Summary – Accounting for Material Behavior

01

Nonlinear material data greatly increases your FEA model accuracy

02

Easy to add nonlinear data using Advanced Material Exchange

03

Nonlinear analyses are more time consuming so make sure there is a need and take advanced of optimized settings

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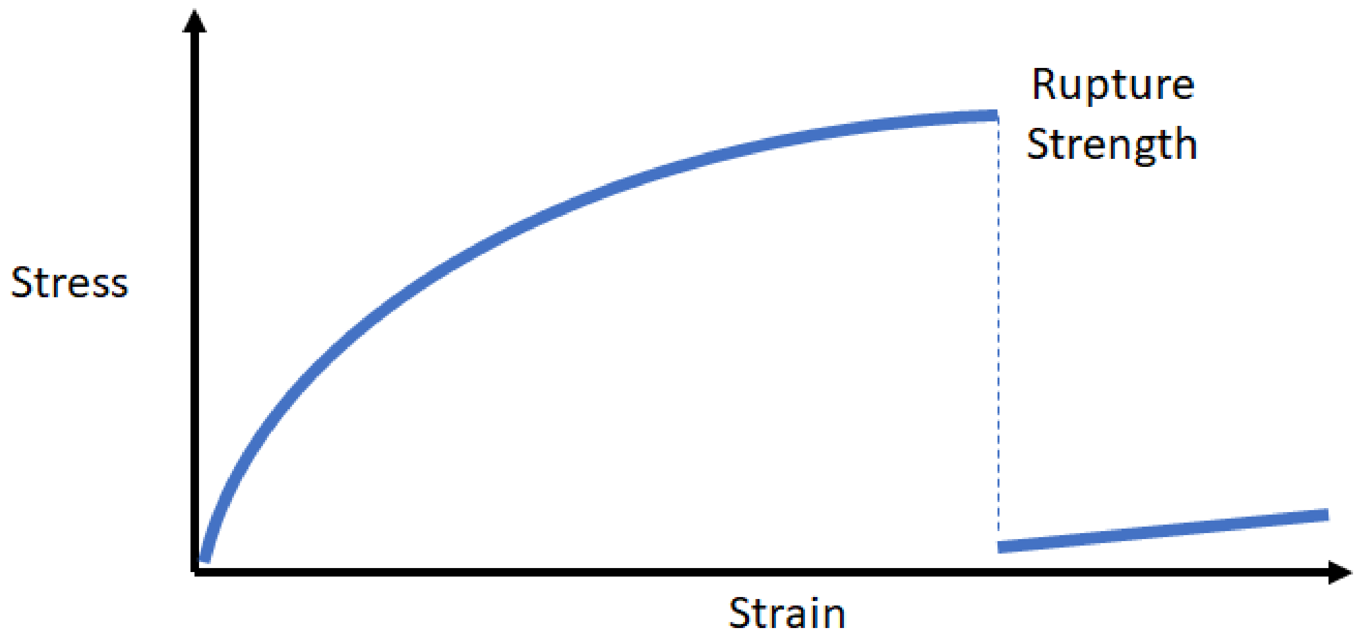
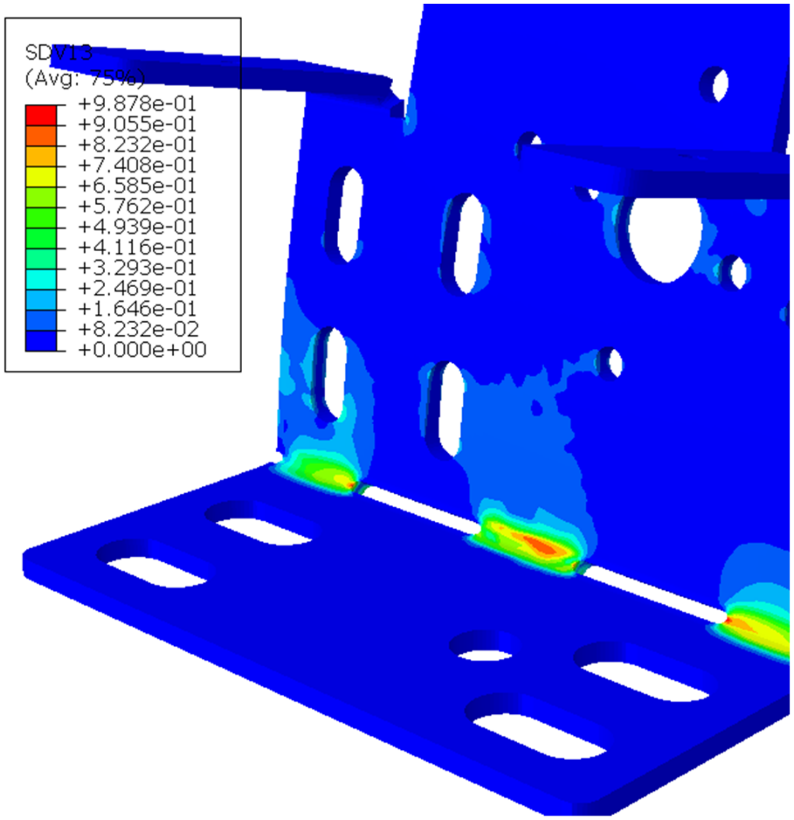
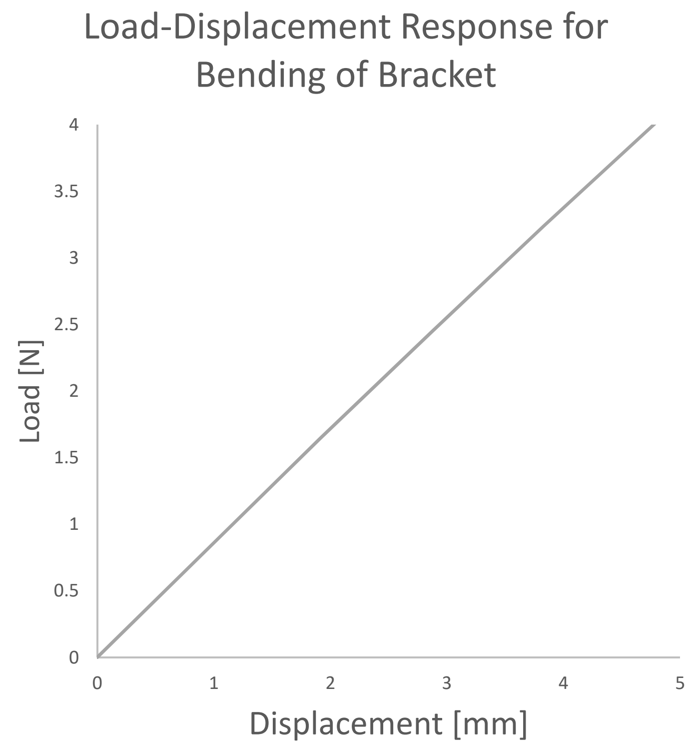
Progressive Failure Analysis

What is Progressive Failure?



When to Run a Progressive Failure Analysis





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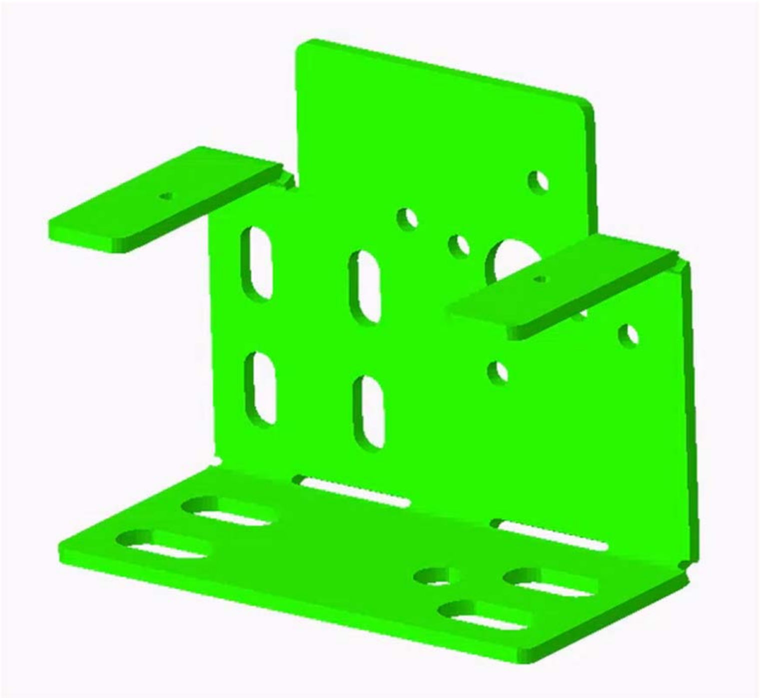
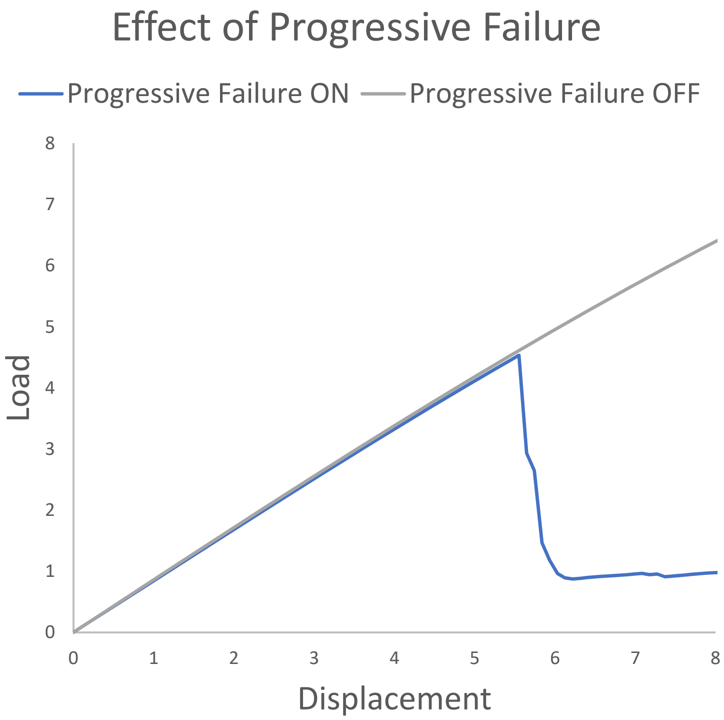
When to Run a Progressive Failure Analysis



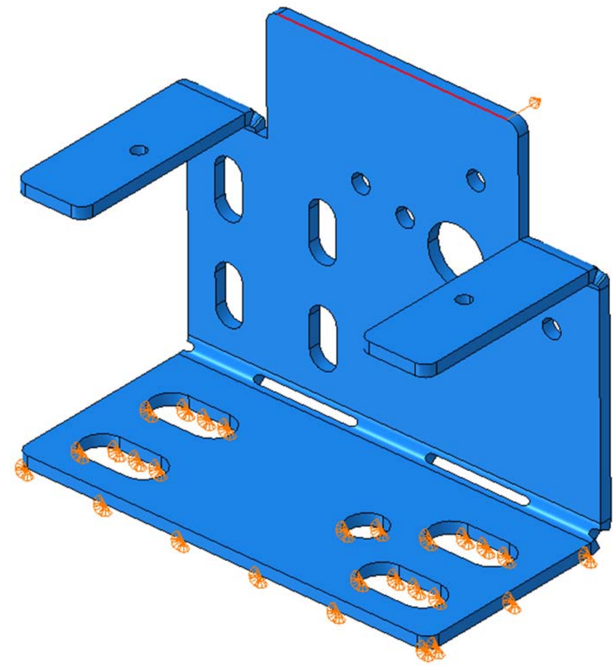


TIP – Progressive Failure Analysis

Progressive Failure Analyses are computationally intensive, so there are ways to optimize the analysis set-up to maximize efficiency

Minimize Model Nonlinearity

Turn off geometric nonlinearity



Replace contact with BCs or constraints

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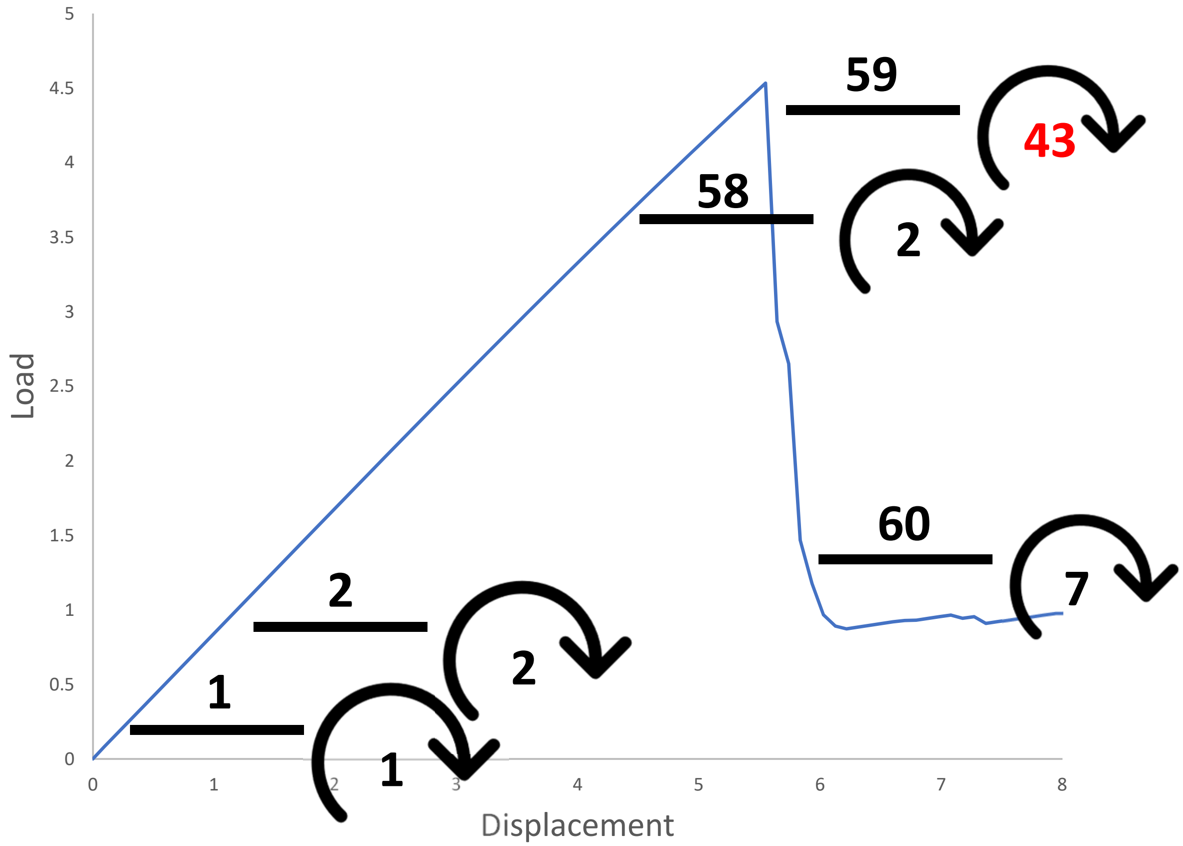
Solver Controls



INC	ATT	SEVERE DISCON ITERS	EQUIL ITERS	TOTAL ITERS	TOTAL TIME/ FREQ
1	1	0	1	1	0.0100
2	1	0	2	2	0.0200
3	1	0	1	1	0.0300
58	1	0	2	2	0.580
59	1	0	43	43	0.590
60	1	0	7	7	0.600
61	1	0	15	15	0.610
62	1	0	6	6	0.620

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Need more answers?

Consulting

Training

doug.kenik@tetonsim.com

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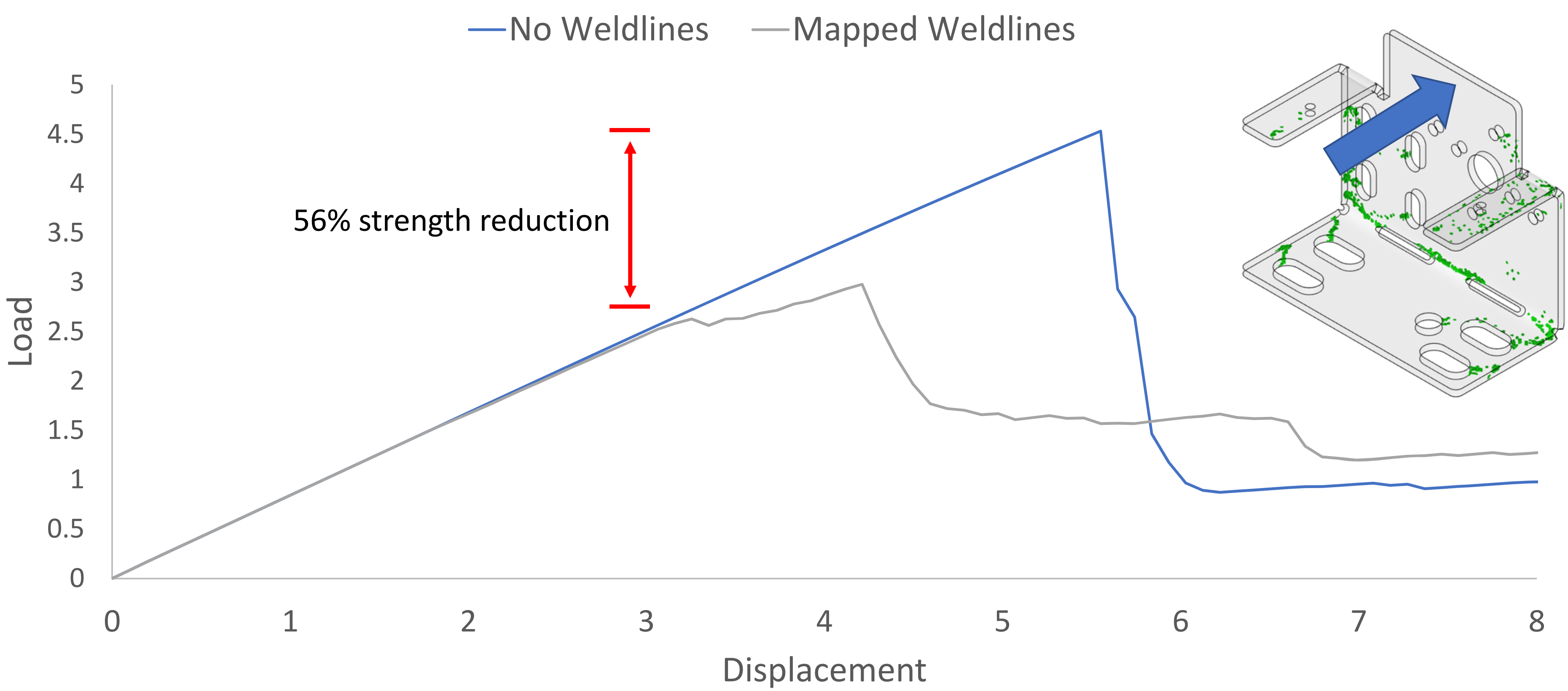
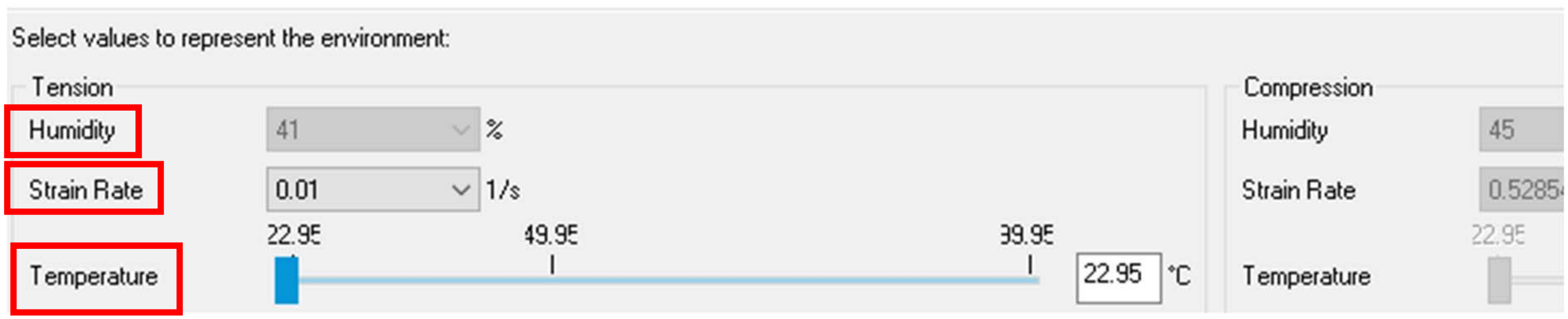
doug.kenik@tetonsim.com
www.tetonsim.com

Effect of Mapping Weld Surfaces to FEA Model



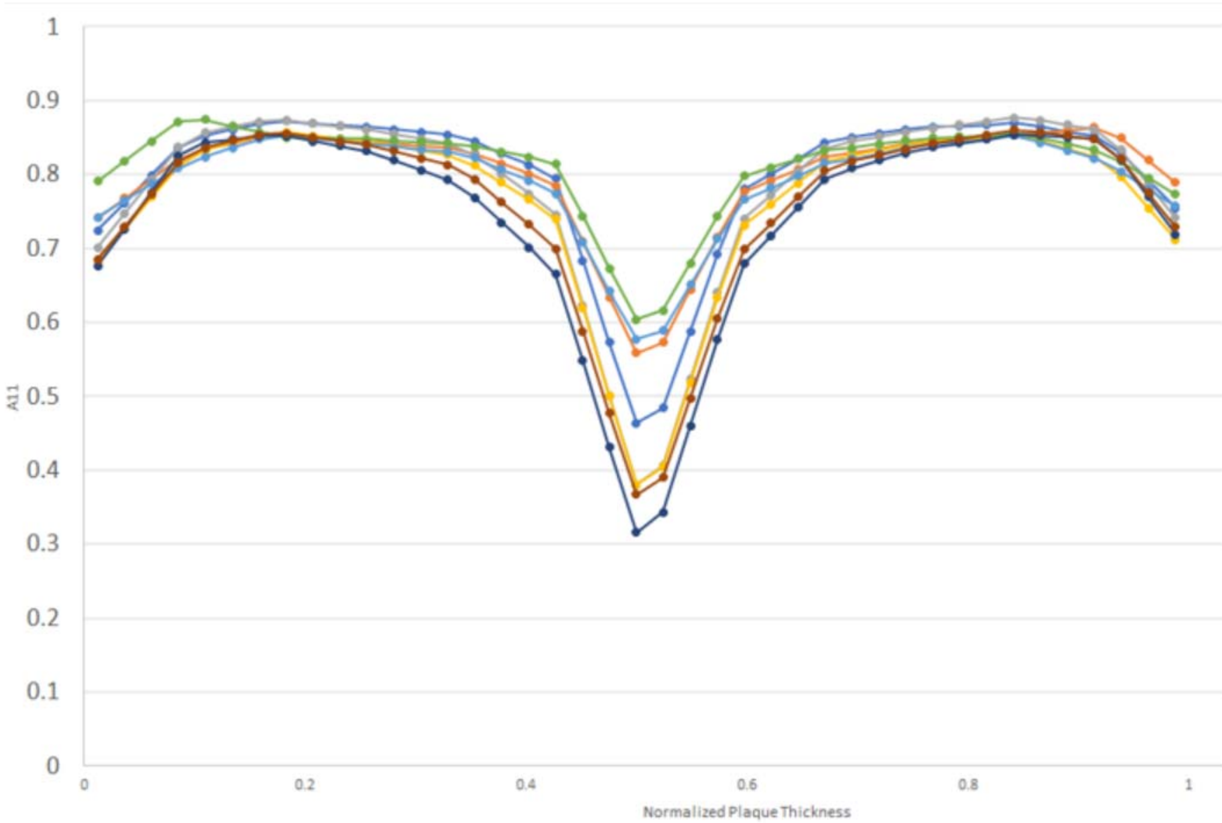
Material Behavior – Additional Environmental Influence



Humidity/Strain Rate: Nonlinear data can be defined at multiple humidity and strain rate levels

Temperature: Nonlinear data can be defined at multiple temperature levels and can be interpolated

TIP - Mesh Density



Fiber orientations vary through the thickness

The number of elements through the thickness needs to be high enough to capture this

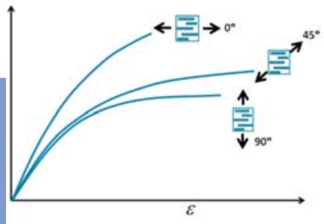
5 is a reasonable minimum – more is always better

TIP – What About Residual Stresses?

Residual stresses are always present

…but difficult to account for…

Material data comes from test coupons that have residual stresses but the first data point is always zeroed out (stress-strain curve starts at zero)



Solution

Don't account for residual stresses in your part – this may seem inadequate, but as long as you're accounting for the "Big 3" (fiber orientations, nonlinear material behavior, and weld lines) good correlation typically occurs

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