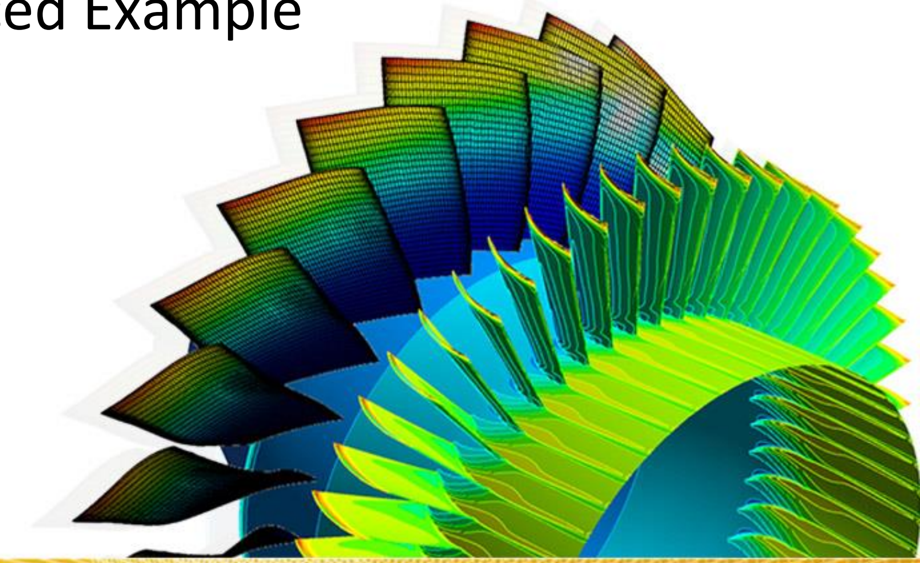
ANSYS Composite PrepPost 19.0

Workshop 10.7 – Temperature-, Shear-, and Degradation-dependent Material Properties – Advanced Example



16. Dependent Material Properties

Prerequisites:

The user is familiar with

- Standard workflow in ANSYS Workbench and ANSYS Composite PrePost
- Composite Solid Modeling
- Basics of Composite Engineering

16. Dependent Material Properties

Motivation:

Account for the effect of

- temperature,
- shear due to ply-draping,
- and material degradation due to manufacturing or other artifacts, on your material elastic and strength properties.

Controllable material properties:

- Isotropic and orthotropic elasticity
- Orthotropic strain and stress limits
- Puck constants

16. Dependent Material Properties

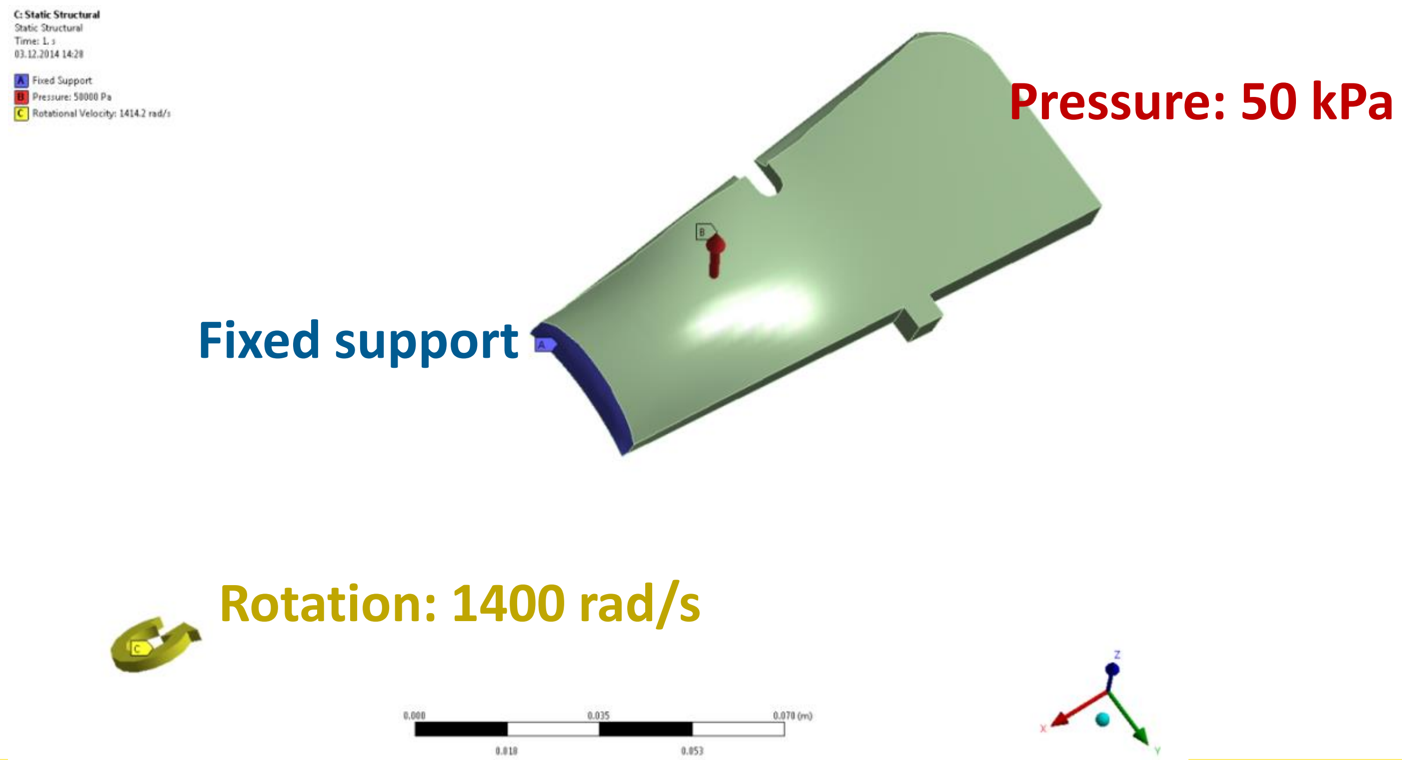
Procedure:

1. **Define material property-dependencies in Engineering Data**
2. **Set up analysis in Workbench**
3. **Define thermal condition**
4. **ACP-Pre**
   - Perform draping analysis to assess ply-shearing
   - Define local material degradation based on a table
5. **Perform analysis and postprocessing**

16. Dependent Material Properties

Simple Example: Compressor Blade

- A simplified compressor blade under pressure and rotational loading
- The blade is made up of a fictitious laminate



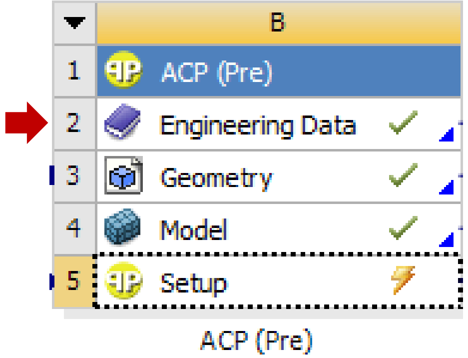
Note: The provided material data is NOT to be used with real analyses.

16. Dependent Material Properties

Step 1: Define Material Properties’ Dependence

- **Activate required dependencies**

⊟ Orthotropic Elasticity	Tabular		
Young's Modulus X direction: Scale	1		
Young's Modulus X direction: Offset	0	Pa	
Shear Modulus XZ: Offset	0	Pa	
⊟ Field Variables			
Temperature	Yes		
Shear Angle	Yes		
Degradation Factor	Yes		
⊟ Orthotropic Stress Limits			



- **Fill in property table**

Table of Properties Row 28:

	A	B
1	Degradation Factor	Shear Angle (deg)
2	0.8	0
3	0.8	5
4	0.8	10
5	0.9	0
6	0.9	5
7	0.9	10
8	1	0
9	1	5
10	1	10

	C	D	E	F	G
1	Temperature (C)	Young's Modulus X direction (Pa)	Young's Modulus Y direction (Pa)	Young's Modulus Z direction (Pa)	isson's Ratio X
2	22	5.916E+10	5.916E+10	7.5E+09	0.04
3	45	5.6202E+10	5.6202E+10	7.125E+09	0.038
4	65	5.4427E+10	5.4427E+10	6.9E+09	0.0368
*					

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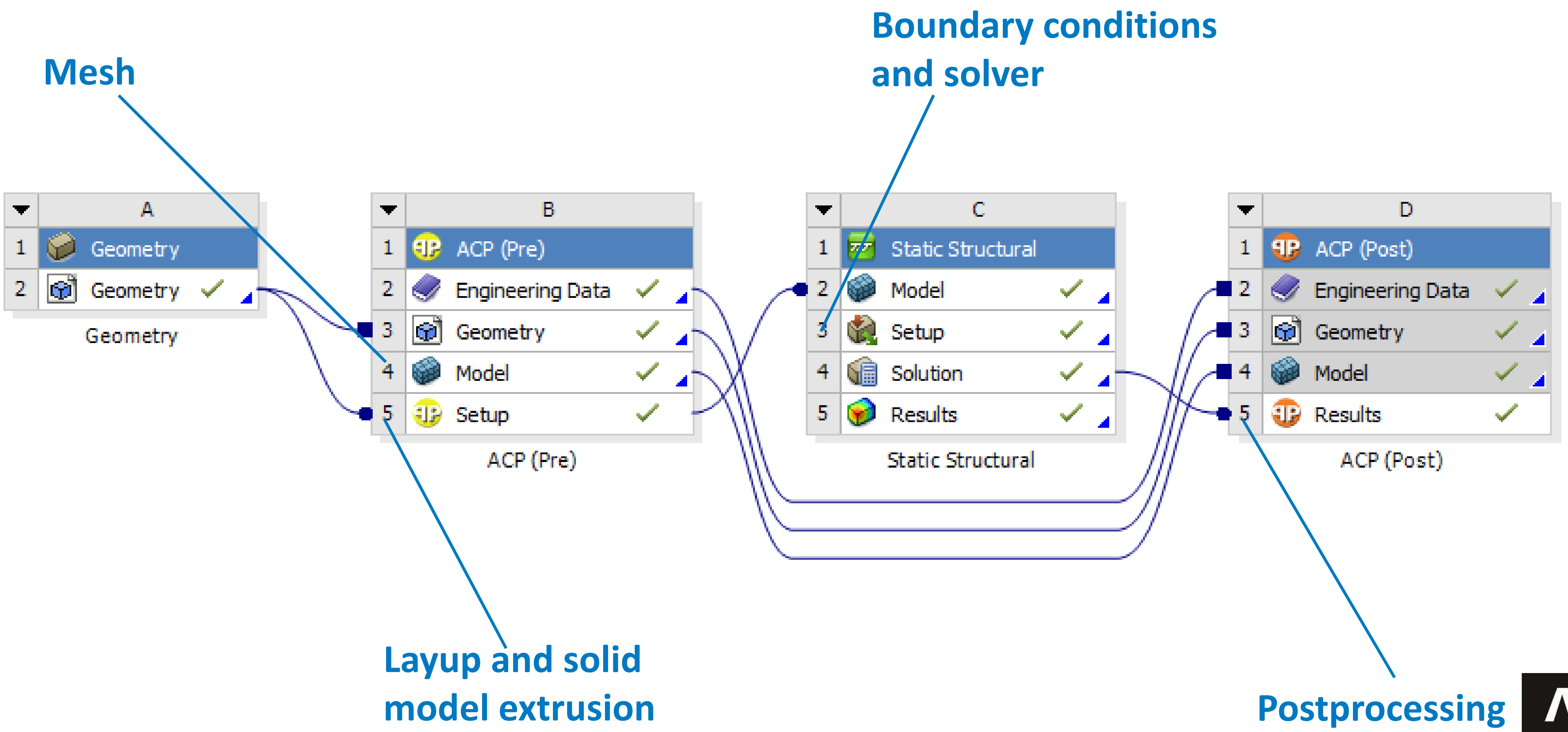
Step 2: Define Analysis as Usual



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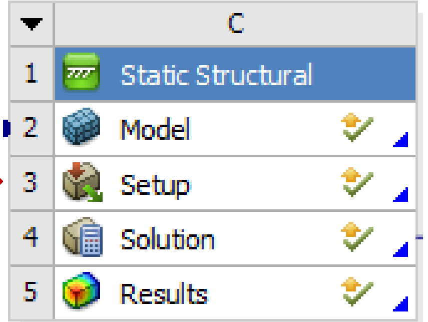
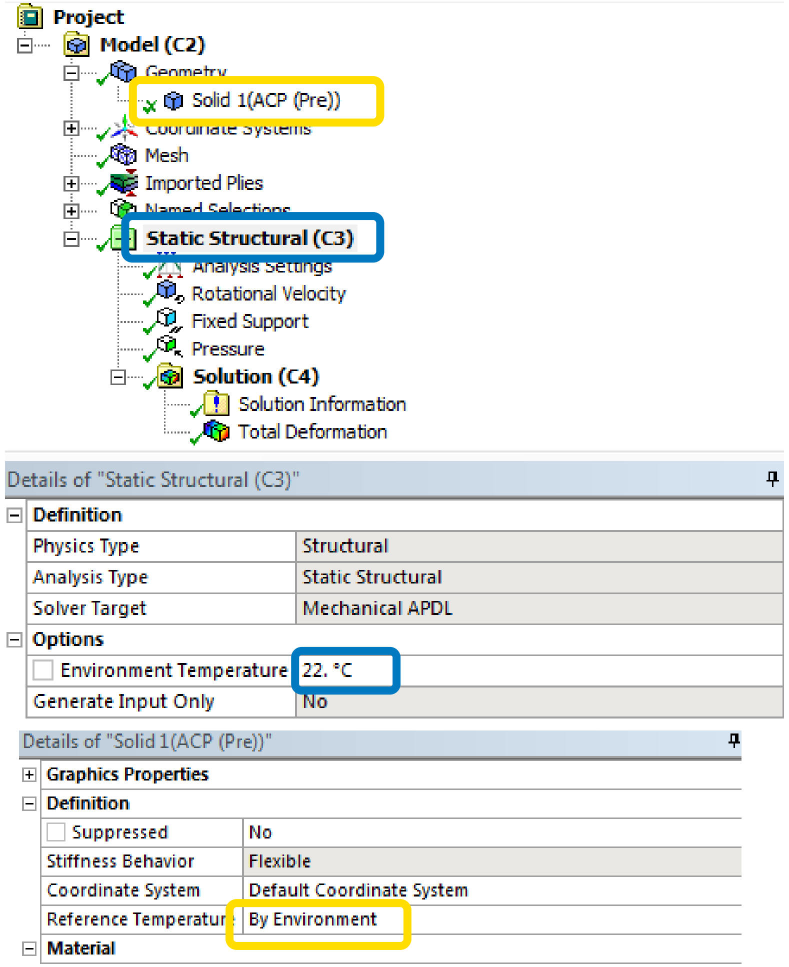
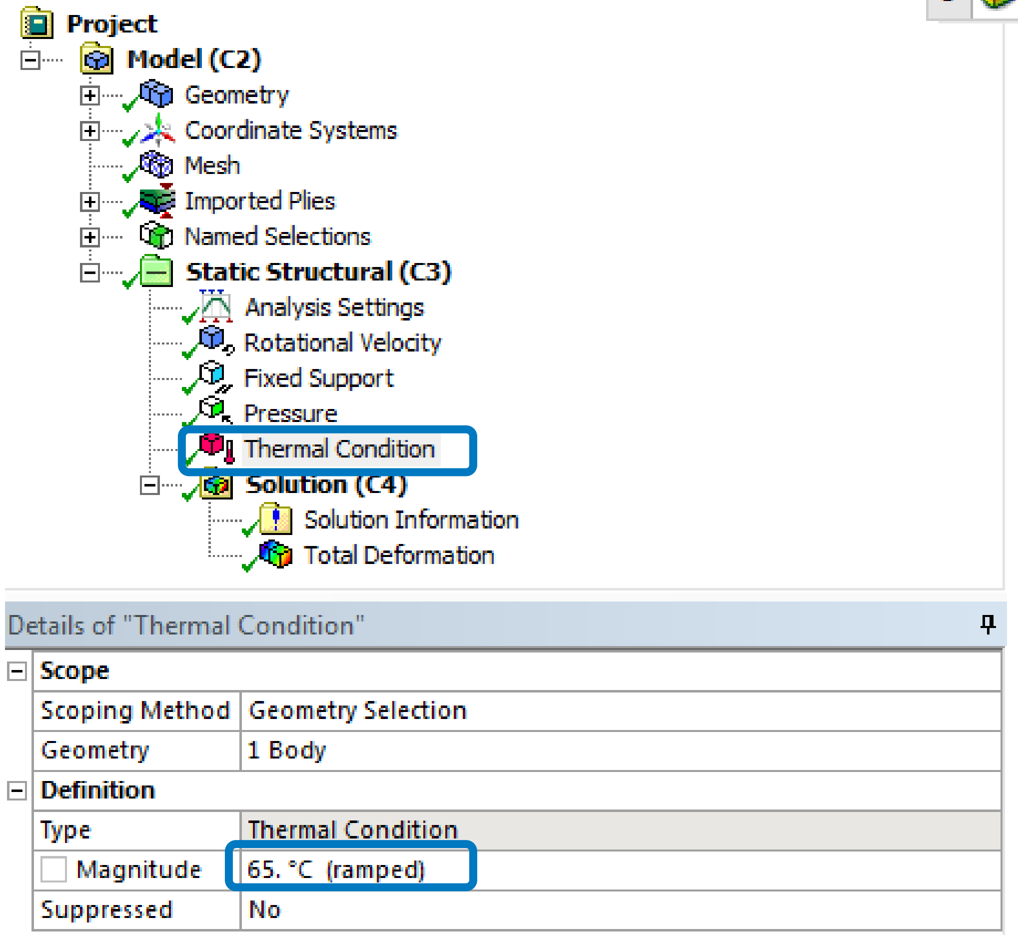
Step 3: Define Thermal Loading



Set the body temperature by environment and the environmental temperature



Set thermal load



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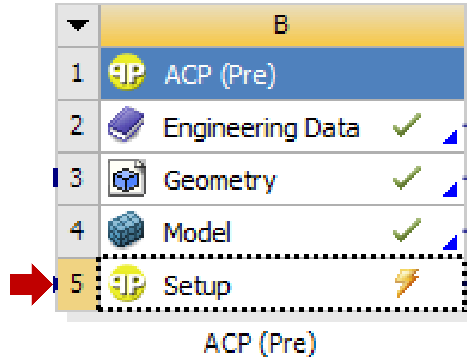
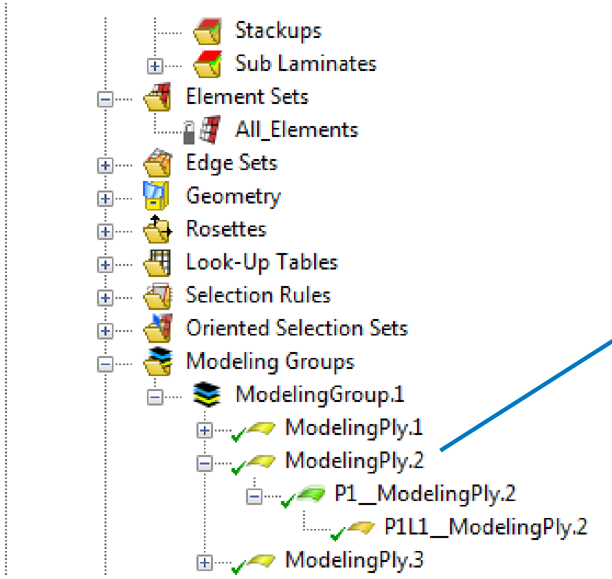
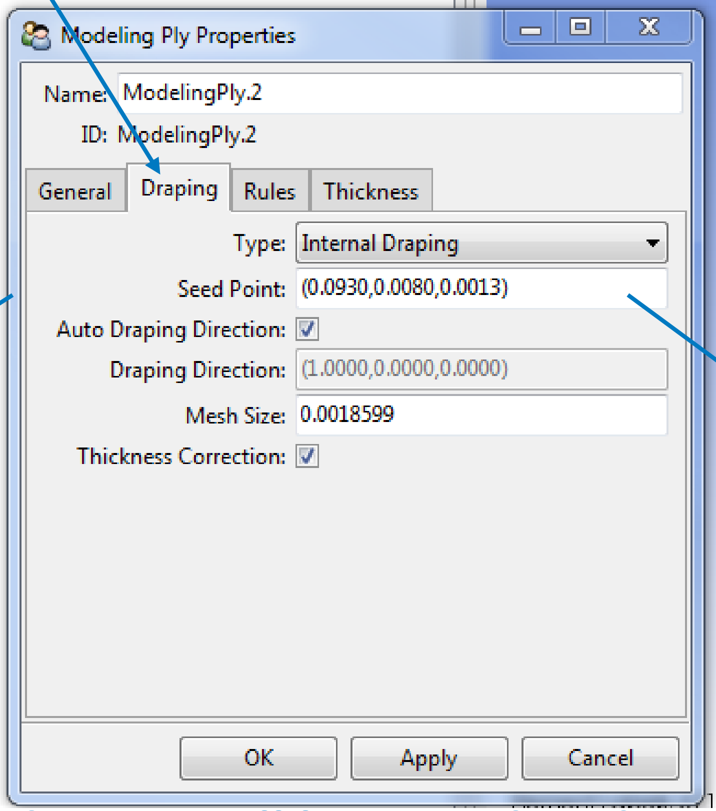


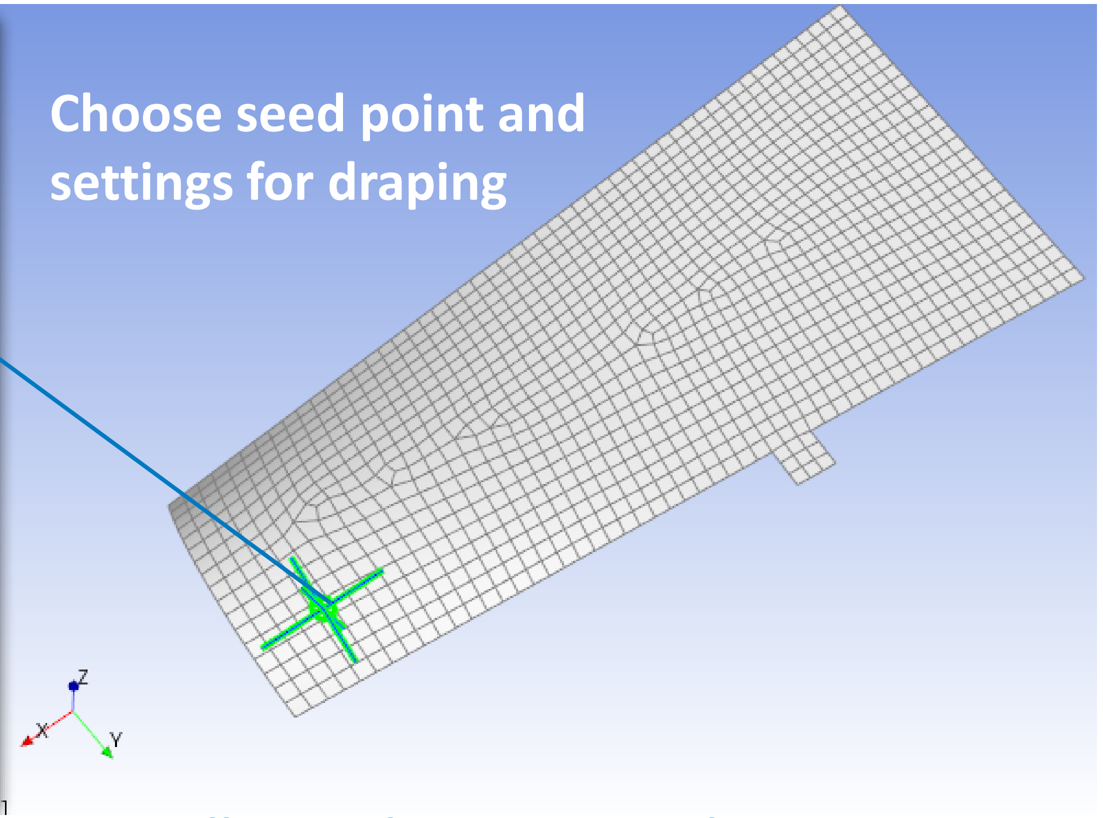
Step 4: Define Draping

Set up draping per modeling ply





Choose seed point and settings for draping



The resulting shear due to draping will be considered automatically in subsequent analyses when evaluating local material properties.

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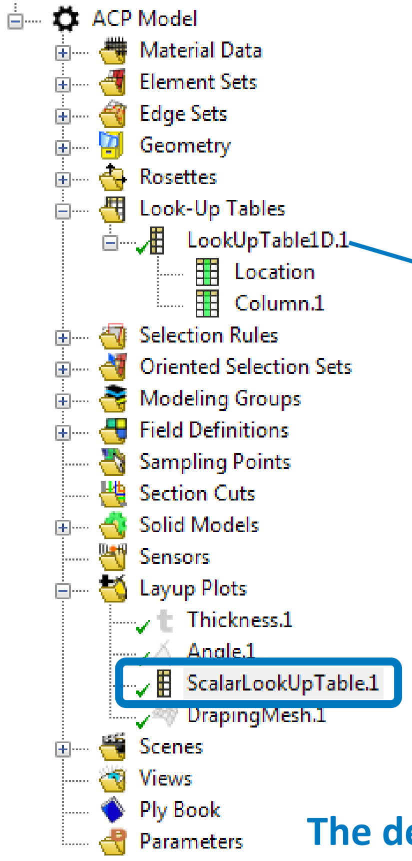
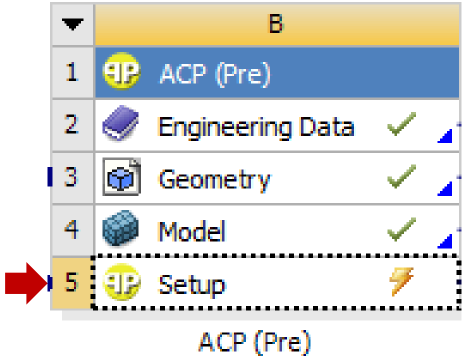
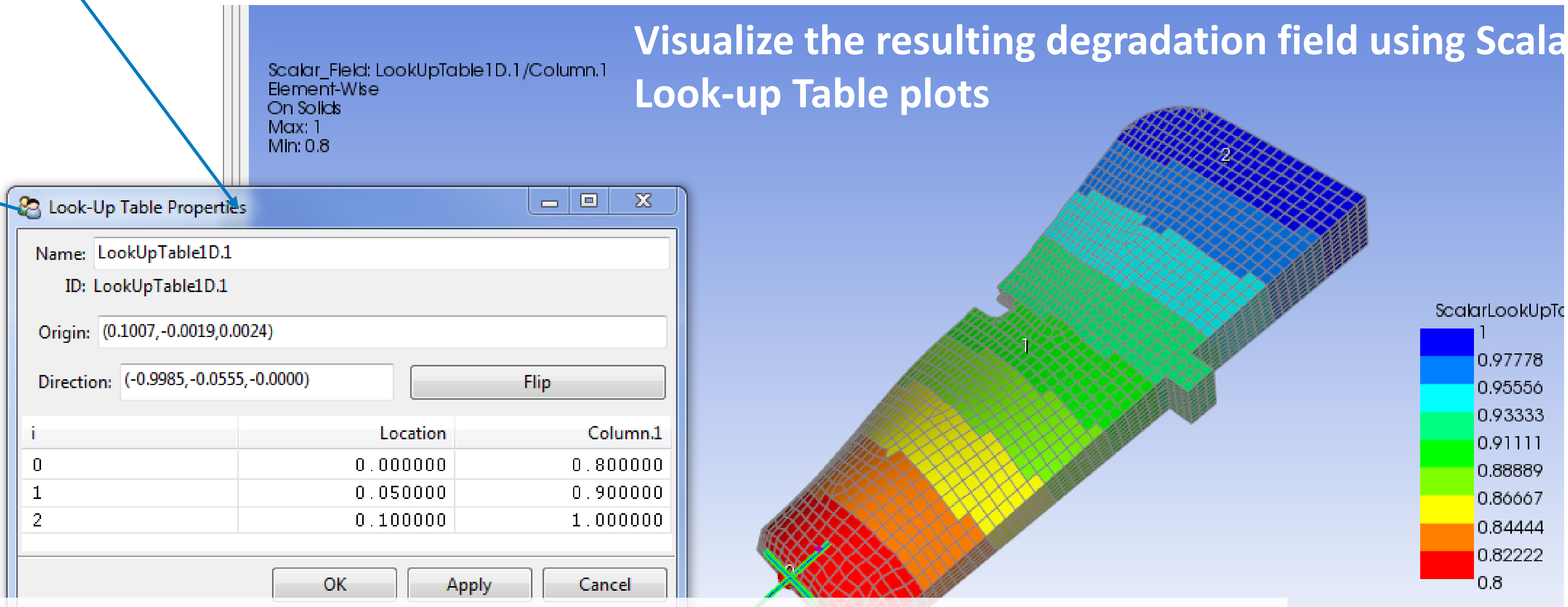
Step 5: Define Degradation

Use a 1D or 3D look-up table to define your degradation field





Visualize the resulting degradation field using Scala Look-up Table plots



i	Location	Column.1
0	0.000000	0.800000
1	0.050000	0.900000
2	0.100000	1.000000

The degradation field is interpolated from the defined table to the element centroid of each shell or solid element. Thus the resolution of the degradation factor field is at *element-level*.

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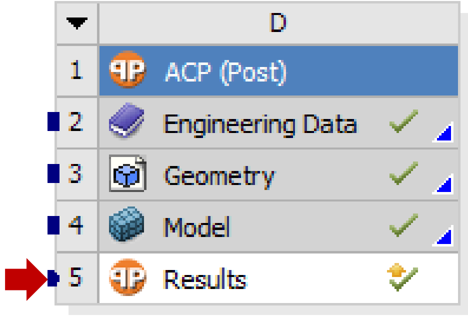
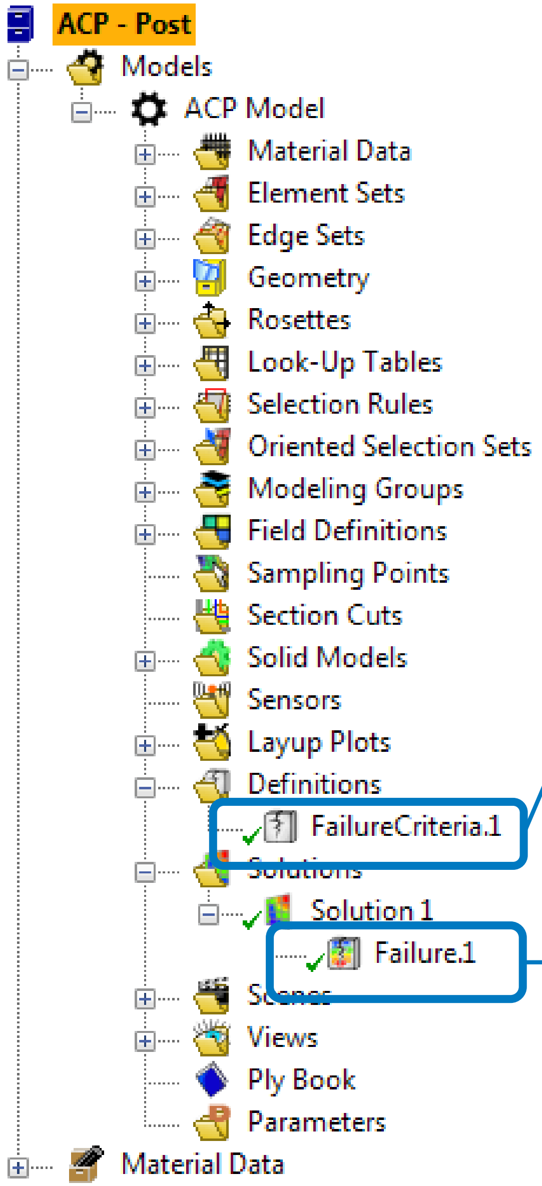
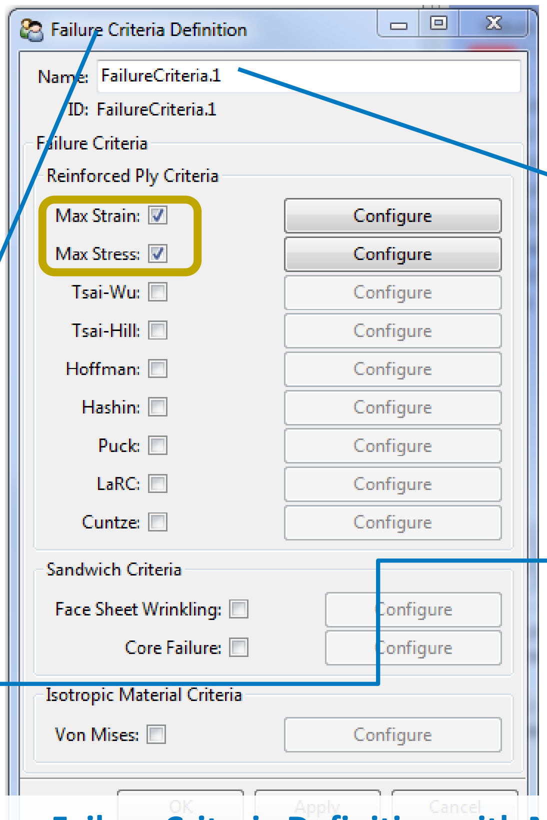
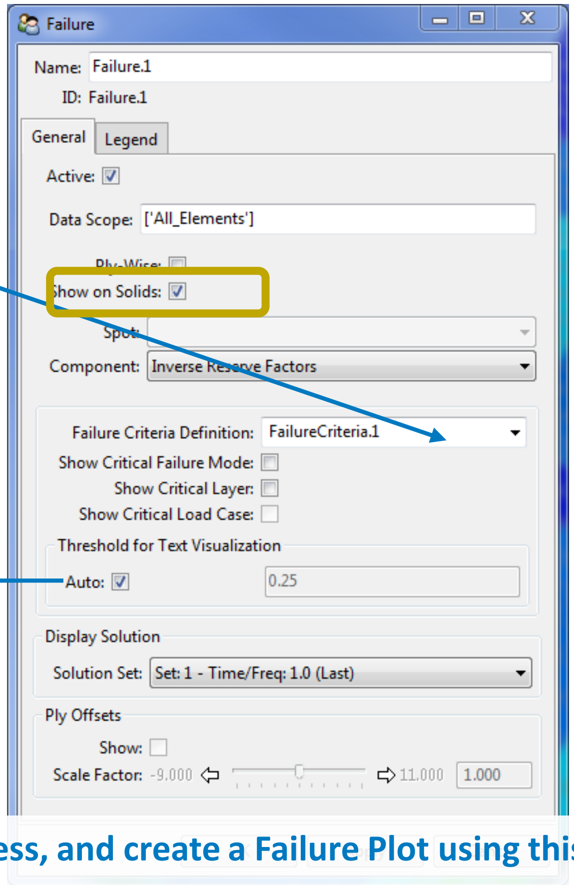


Failure Analysis:
Max Strain and Stress







Set up a Failure Criteria Definition with Max Strain and Stress, and create a Failure Plot using this definition showing the results on the solid elements.

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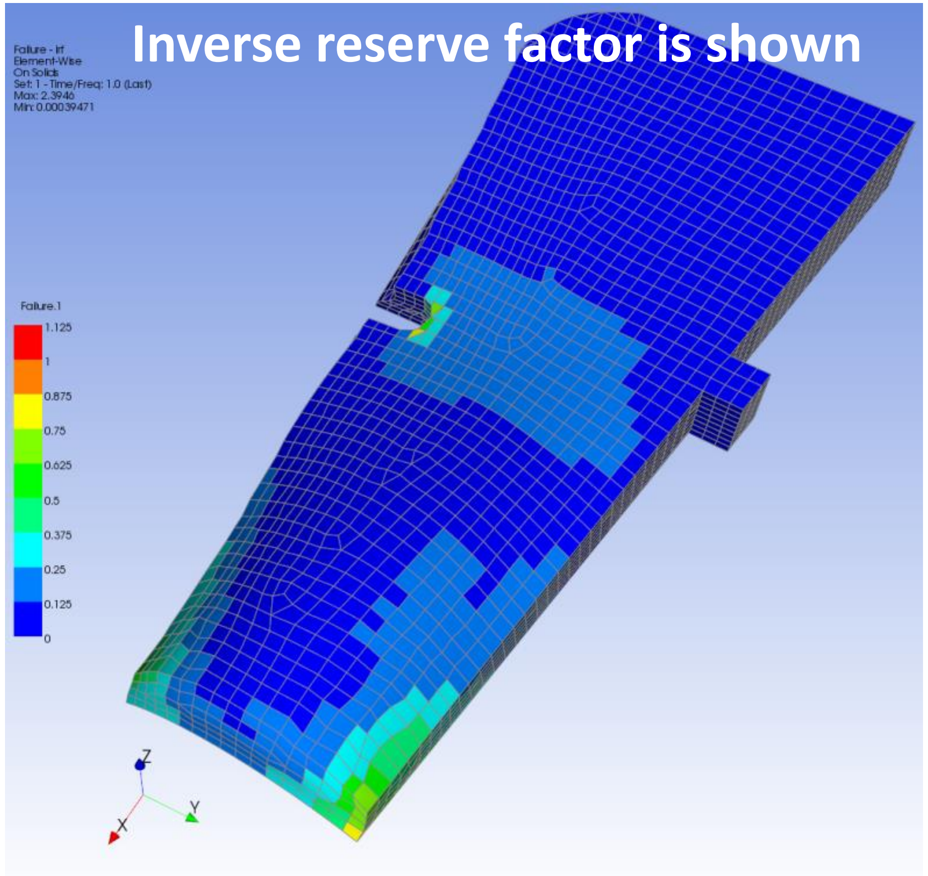
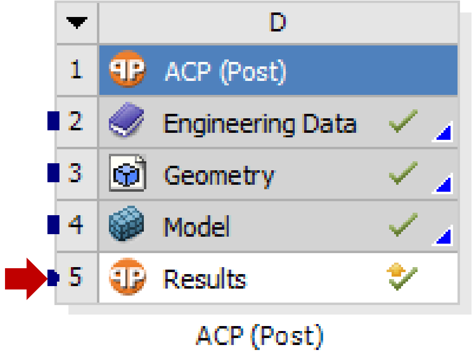
Failure-Analysis: Basic Data





At 22°C, without considering any ply-shearing or degrading of the blade, the root and notch regions experience higher loading with a few elements having an IRF above 0.75 (not critical).

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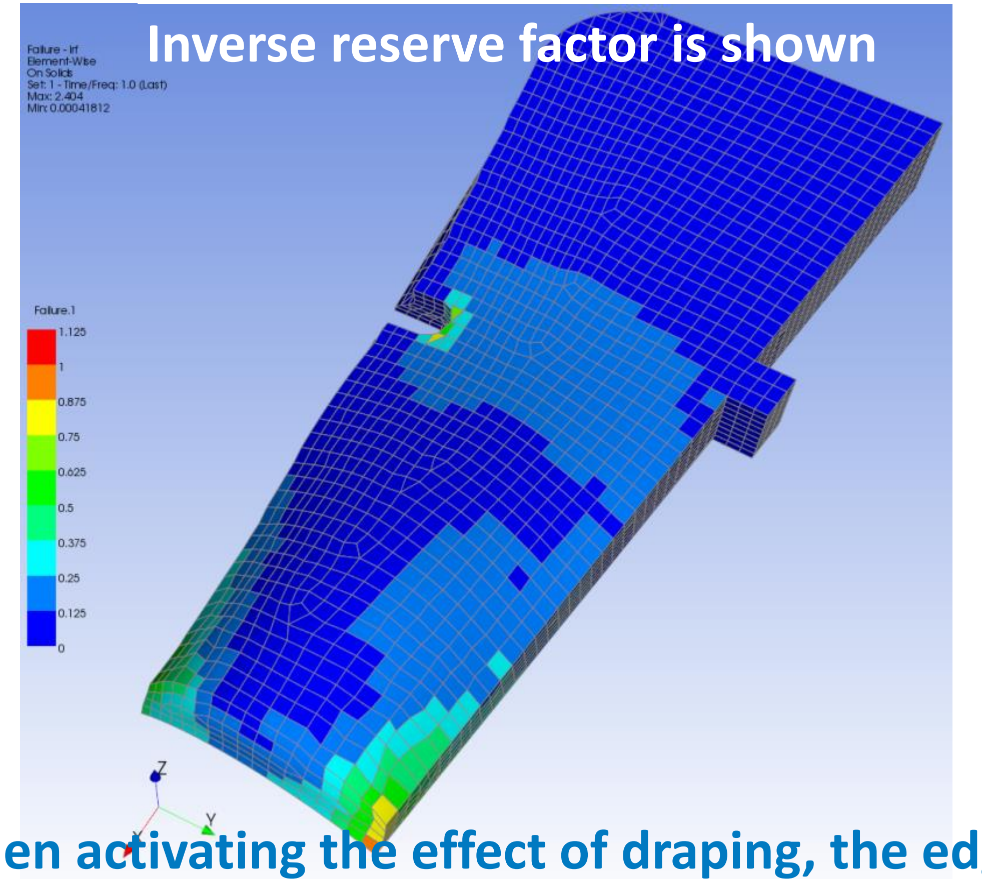
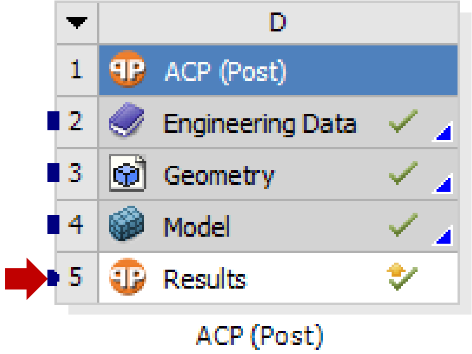
Failure-Analysis: Basic Data





When activating the effect of draping, the edges of the root show increased IRFs due to ply-shearing in these regions. However, the effect of shear due to draping is not pronounced for this geometry.

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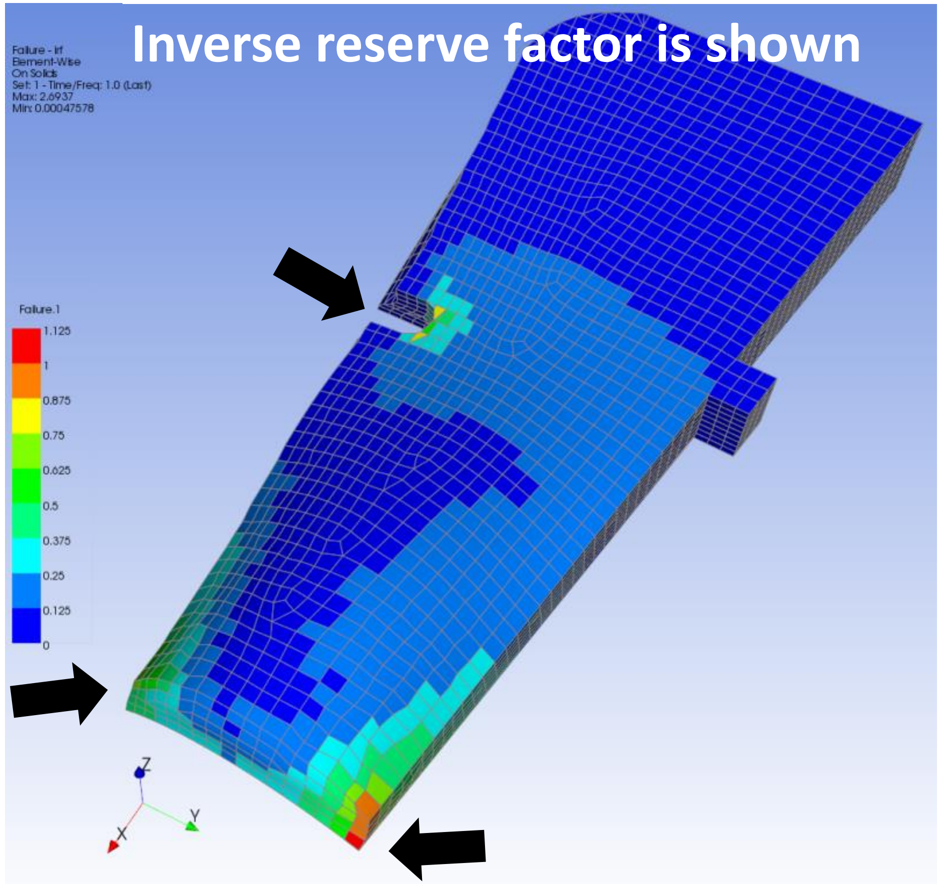
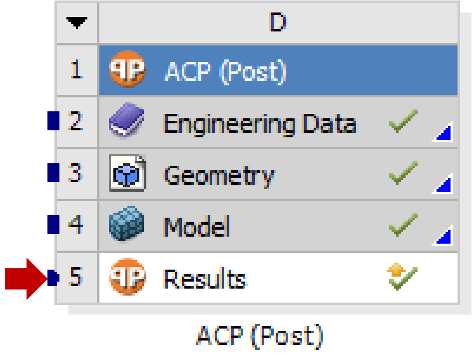
Failure-Analysis: Basic Data





By adding the effect of increased temperature on the material properties, IRFs in the root and notch region further increase and for a first time become critical.

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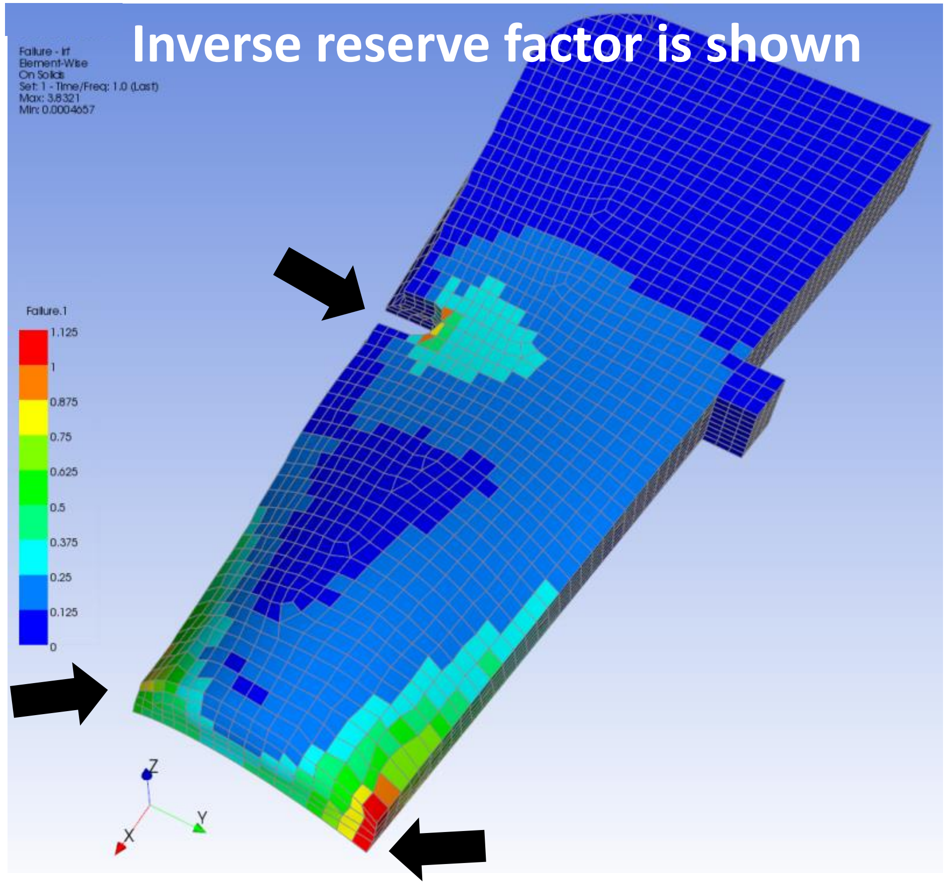
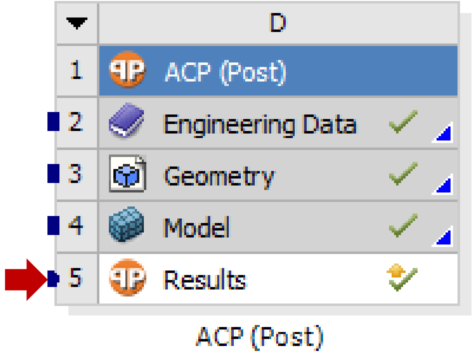
Failure-Analysis: Basic Data





Finally, by considering degraded material properties, the critical regions identified by the IRF extend clearly.

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Summary

- **ANSYS Composite PrePost R19.0 provides the ability to easily include elasticity and strength property-dependence of your material on *temperature*, *ply-shearing*, and *degradation*.**
- **The procedure works for shell- and solid based workflows.**
- **The effects can be activated or deactivated individually on material- and analysis-level.**
- **The key-challenge is to identify the material properties (elasticity and strengths) at different operating points (materials testing).**