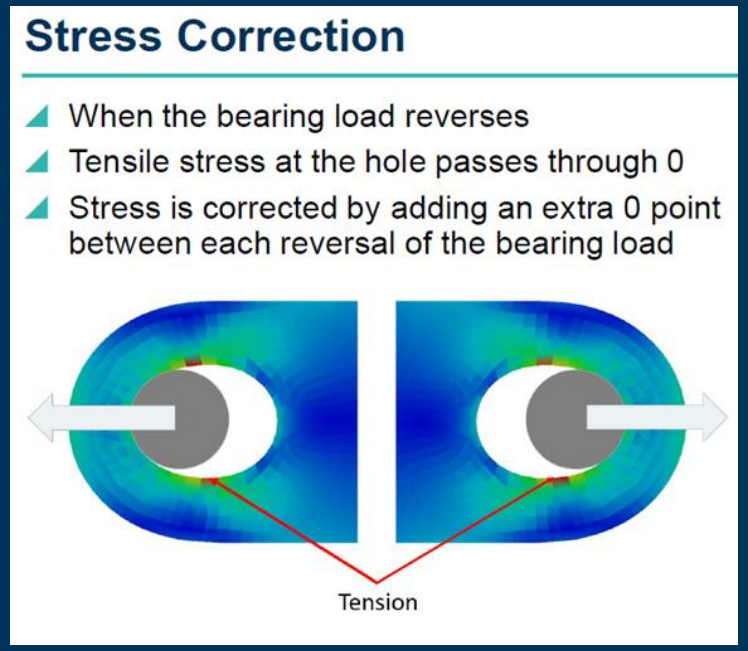
Virtual Seminar Series – Tuesday 2, 9, 16 November



Modelling Stress Severity and Bearing Bypass in nCode DesignLife from FE Stress Analysis

Presented by Mr. Paul Roberts
Product Manager
Prenscia (HBK)

Tuesday, November 2, 2021

Modelling Stress Severity and Bearing Bypass in nCode DesignLife from FE Stress Analysis

Abstract

The stress severity factor is a method used for fatigue assessment of a row of fasteners in a joint. The method requires determining the load beared (or carried) by the fastener and the load bypassing the fastener; often known as the bearing and bypass loads. The bearing load is the load transferred from a sheet and borne by the fastener, while the bypass load is the load remaining in the sheet that bypasses the fastener. These loads, and their resulting local stresses at the fastener, change from fastener to fastener as the load is transferred from one sheet to another through the rows of fasteners in the joint.

This presentation describes the FE modelling and results extraction required to determine these loads and their local stresses. The similarities and differences of this method are compared with those currently used for FE modelling and fatigue analysis of spot welds.

About the presenter, Mr. Paul Roberts, Product Manager, Prenscia (HBK)

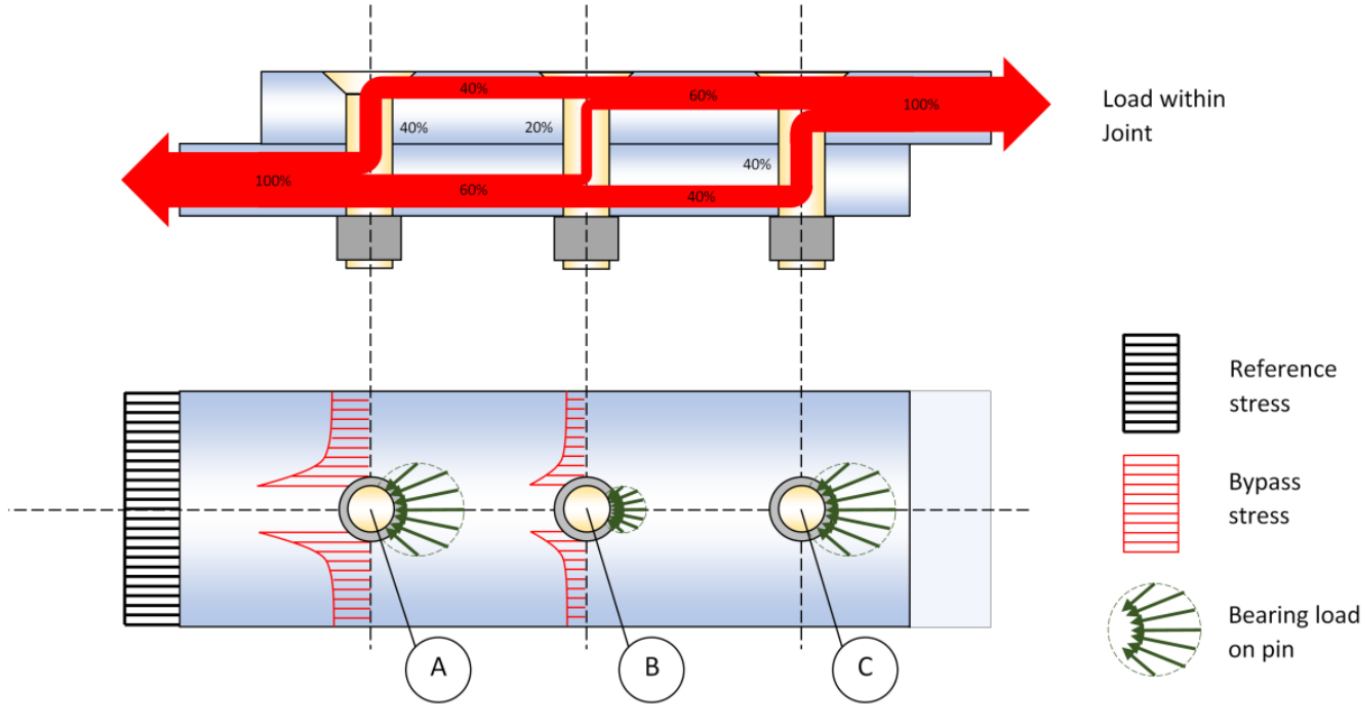
Paul Roberts has been involved with fatigue and durability analysis for the past 38 years. He has been with Prenscia (formally nCode) for a total of 15 years as an application engineer and product manager for the DesignLife product. Prior to joining Prenscia, Paul held positions in product development, testing, RLD analysis and FE based engineering consultancy at GKN Technology and Ricardo. Paul graduated with a degree in mechanical engineering from Aston University in Birmingham, UK.

Modelling Stress Severity and Bearing Bypass in nCode DesignLife

Paul Roberts
DesignLife Product Manager

Agenda

- Introduction to DesignLife
- Spot Weld analysis in DesignLife
- Stress Severity and Bearing Bypass in DesignLife
- Summary



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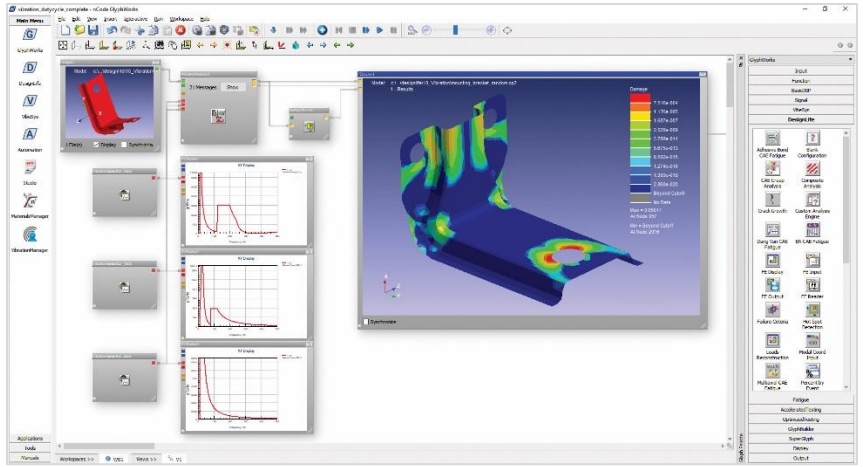
DesignLife

- Fatigue analysis technology for FEA
- Process encapsulation
- Fast, configurable, and scalable

nCode DesignLife is an up-front design tool that identifies critical locations and calculates realistic fatigue lives from leading finite element (FE) results for both metals and composites.

Design engineers can go beyond performing simplified stress analysis and avoid under- or over-designing products by simulating actual loading conditions to avoid costly design changes.



Advanced Fatigue Analysis

- Stress-Life (single, multi-curve, Haigh diagrams)
- Strain-Life (automated multi-axial corrections)
- Stress based safety factor
- Multiaxial safety factor (Dang Van)
- Spot weld fatigue
- Seam weld fatigue
- WholeLife fatigue
- Adhesive bonds
- High temperature fatigue
- Short-fibre composite fatigue
- Composite static failure criteria analysis
- Support for symmetry models
- Editing of multiple material maps
- Complete duty cycles / flight spectrums

Vibration Fatigue

- Vibration fatigue (shaker simulation)
- SN, EN, Short Fibre Composite
- Vibration Analysis of Solid Seam Welds & Seam Welds (Force results)

Test-CAE Correlation

- Strain Gauge Positioning
- Virtual Strain Gauge and Virtual Sensor
- Reconstruction of load histories
- Animation of structural deformation

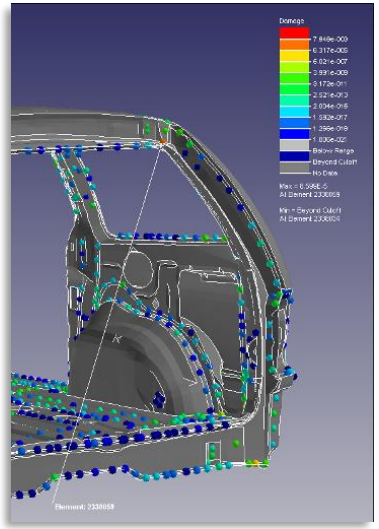
Performance

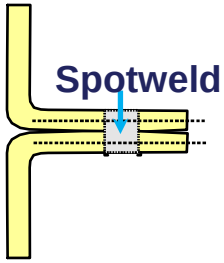
- Multiple runs in a single analysis
- Multi-processor and distributed analysis for fast results
- Multi-process translation

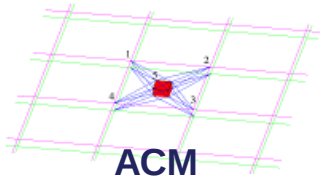
Spot Weld Analysis

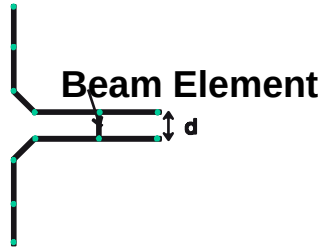
Spot Weld Fatigue

- Based on LBF method (SAE 950711).
- Spot welds modelled by stiff beam elements (e.g. NASTRAN CBAR)
- Supports CWELD, ACM formulations using solid elements
- Cross-sectional forces and moments are used to calculate structural stress around the edge of the weld spot.
- Life calculations are made around spot weld using linear damage summation and reporting worst case.
- Python for advanced customization.
- The method has also been adapted to allow the use of different FE analysis codes and mesh joining techniques



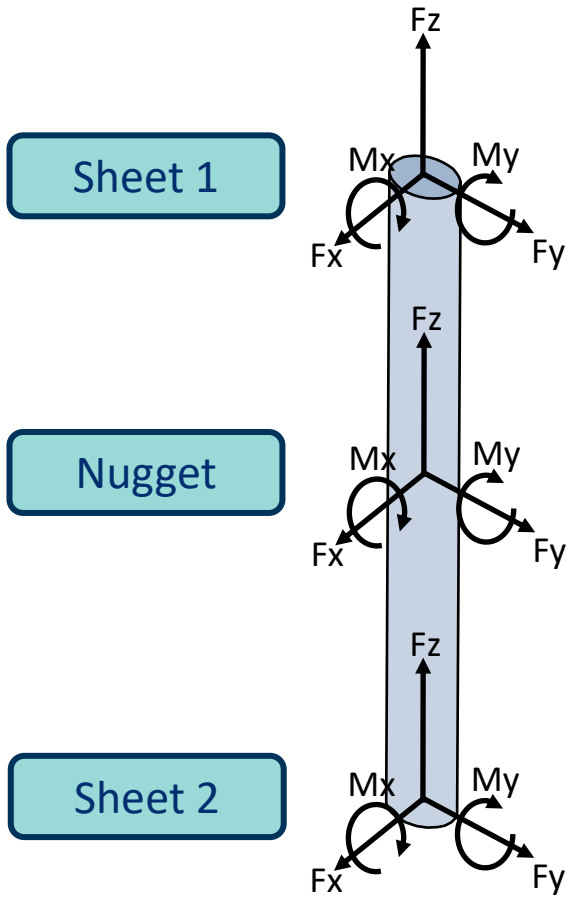






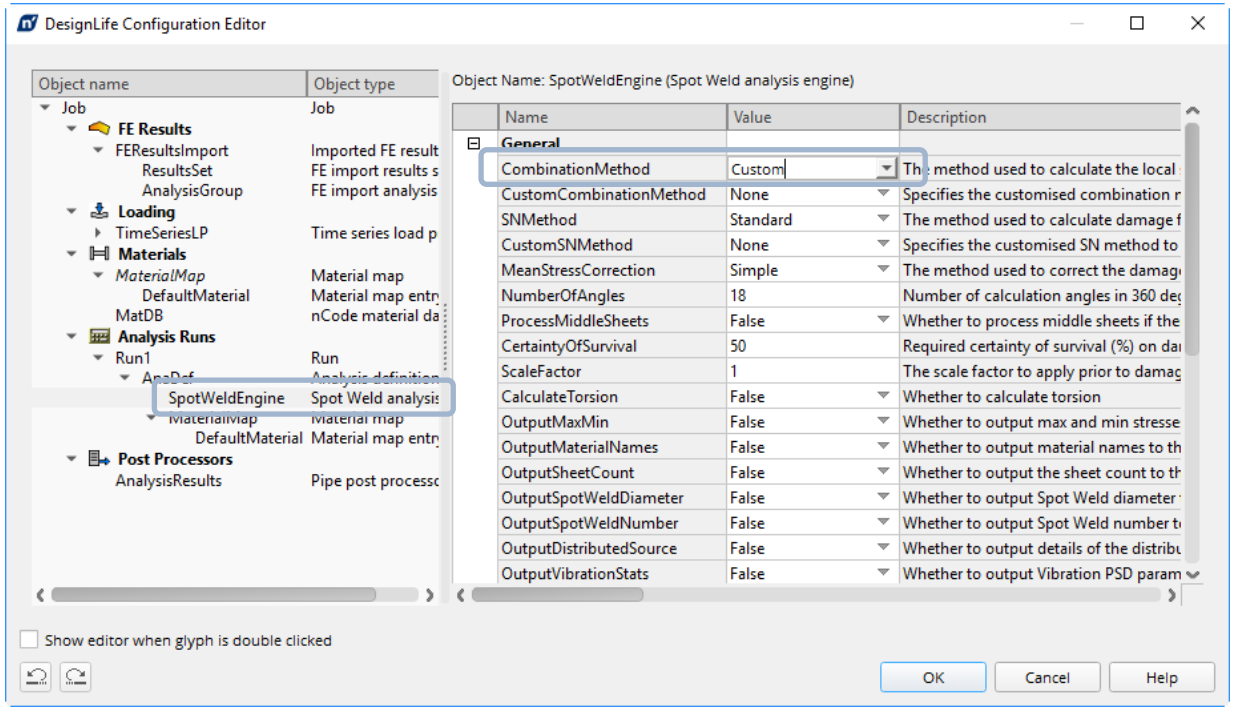
Cross-sectional forces and moments

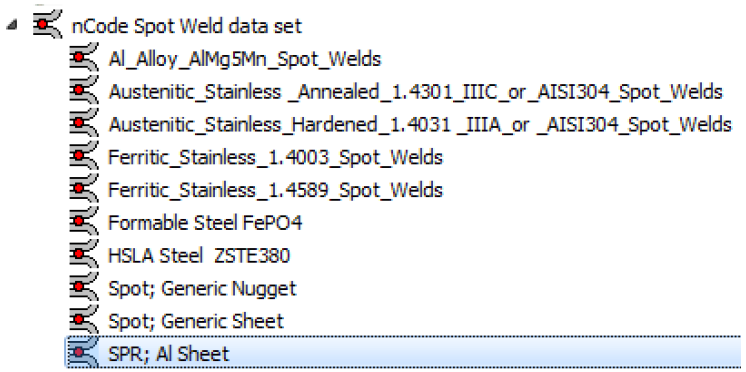
- Cross sectional forces and moments are calculated at three locations
- The structural stresses calculated from the forces and moments vary as a function of angle for shear and bending loads
- Calculations at angles around the periphery of the joint



Extending Spot Weld Engine for other fasteners

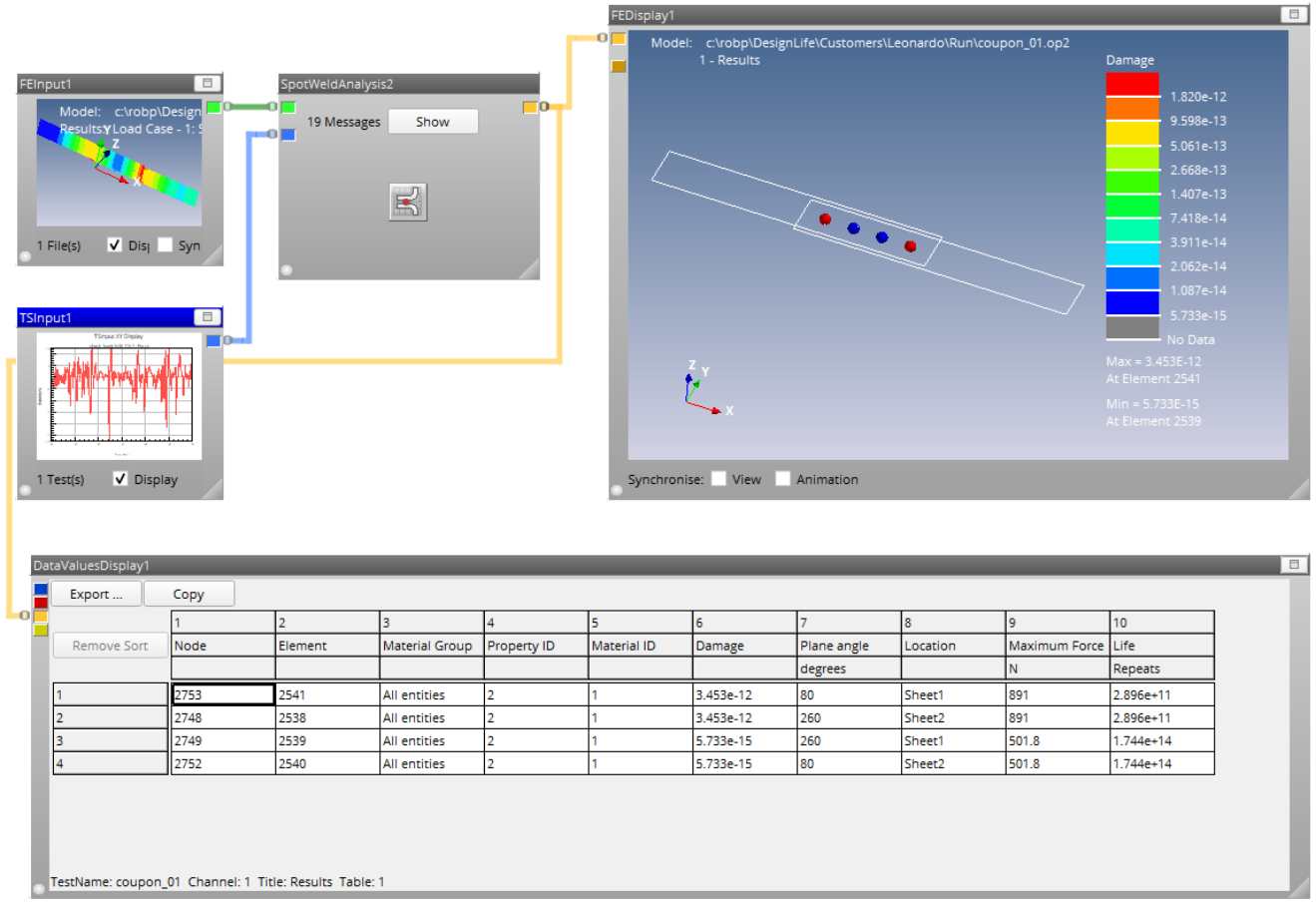
- Standard Spot weld option can be extended to analyze Self Piercing Rivets (SPR)
  - SN curve available for Aluminum sheet alloy NG5754 (1 to 3 mm thick sheet) with 5mm dia Henrob SPR's
- Custom Spot Welds uses a method defined in a user created external python code that needs to be selected using **CustomCombinationMethod** property
- Could be extended to analyze other discrete joints





Stress Severity and Bearing Bypass

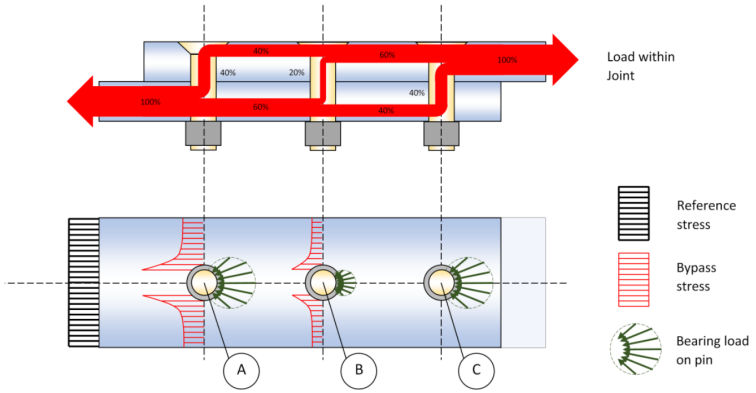
- An enhancement request for a UK aerospace OEM to implement the Bearing Bypass method within DesignLife
- Phase 1 – Development of a Prototype
  - Translation of FE results
  - Incorporation in a S-N analysis
  - Testing and validation
- Phase 2 – Productionisation
  - Select method(s) to incorporate into DesignLife
  - Complete coding and appropriate tests
  - Documentation
    - Theory
    - Worked example



	1	2	3	4	5	6	7	8	9	10
	Node	Element	Material Group	Property ID	Material ID	Damage	Plane angle	Location	Maximum Force	Life
							degrees		N	Repeats
1	2753	2541	All entities	2	1	3.453e-12	80	Sheet1	891	2.896e+11
2	2748	2538	All entities	2	1	3.453e-12	260	Sheet2	891	2.896e+11
3	2749	2539	All entities	2	1	5.733e-15	260	Sheet1	501.8	1.744e+14
4	2752	2540	All entities	2	1	5.733e-15	80	Sheet2	501.8	1.744e+14

FE modelling

- Initially using methods support by the DesignLife spot weld solver
- Beams connecting shells (directly or via connector elements)
- ACMs connecting shells



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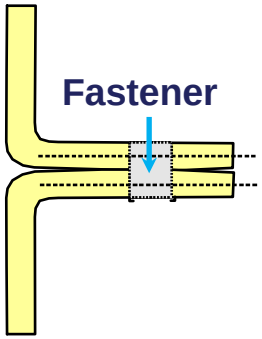

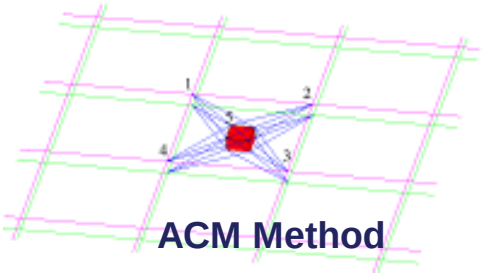

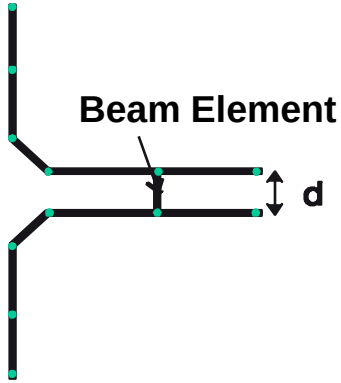

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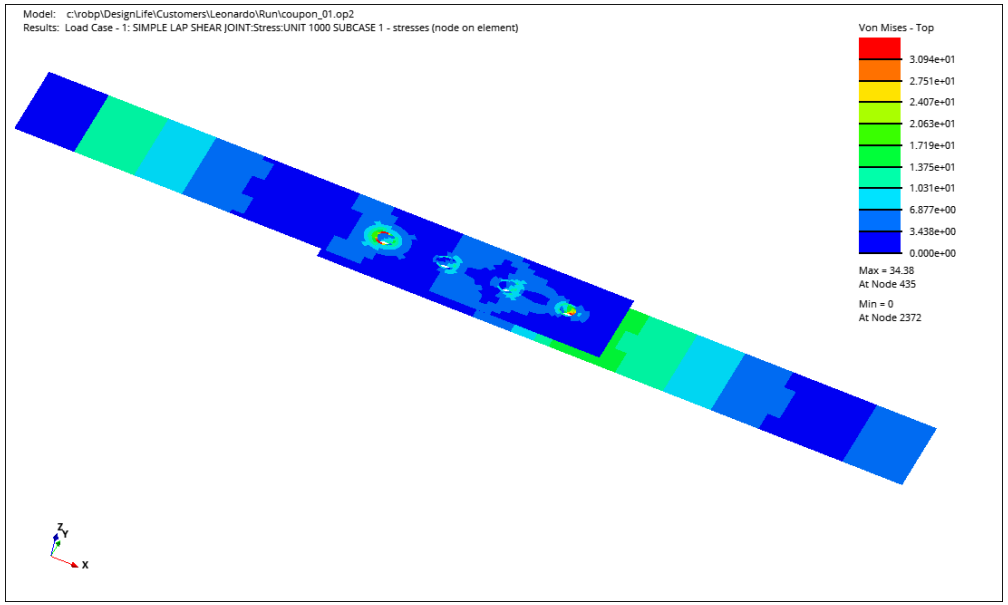
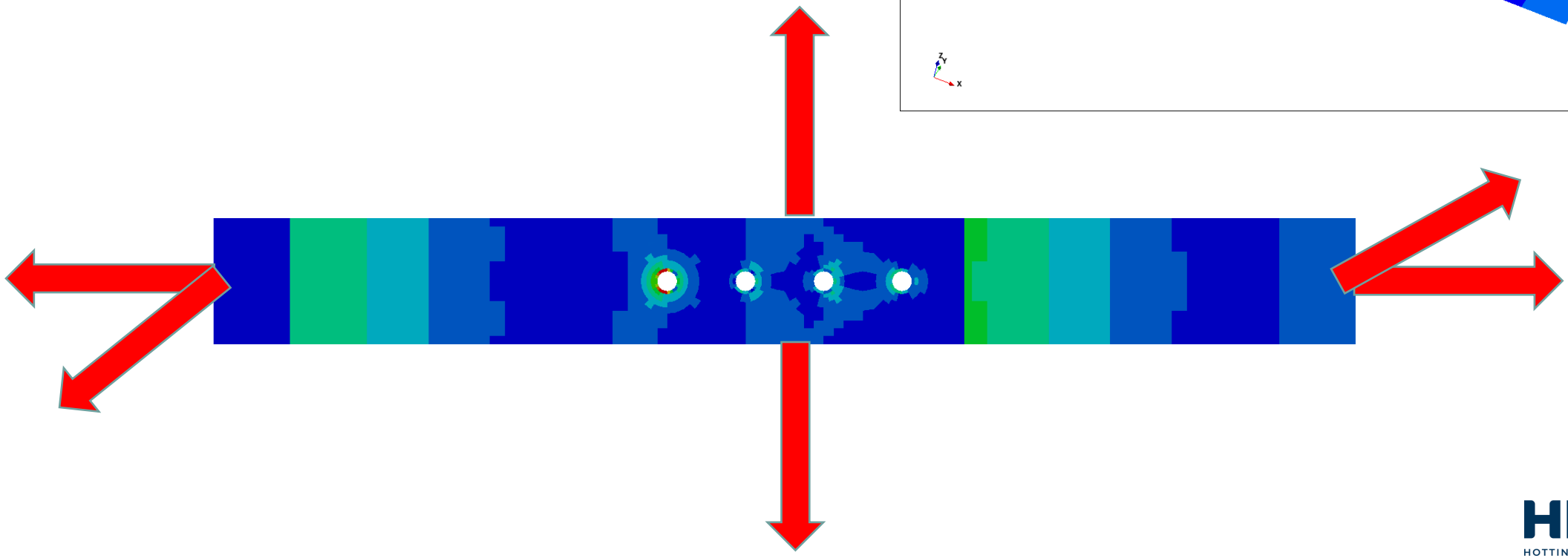
FE results translation

- Requires the translation of both forces and shell stresses
  - beam element forces
  - ACM nodes
  - Stresses from the attached shells



- What to do with complex load histories



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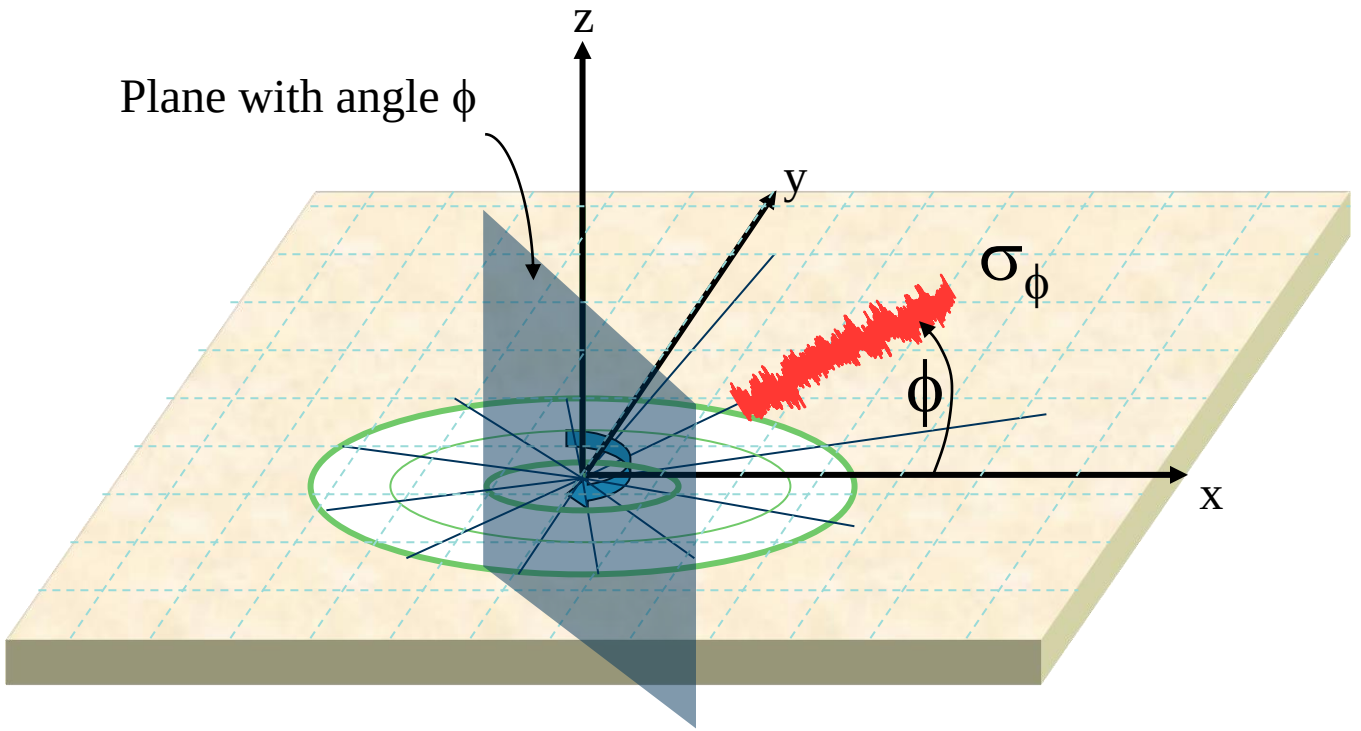
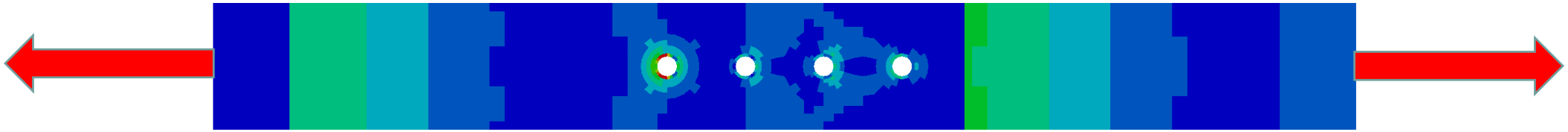
Complex loads

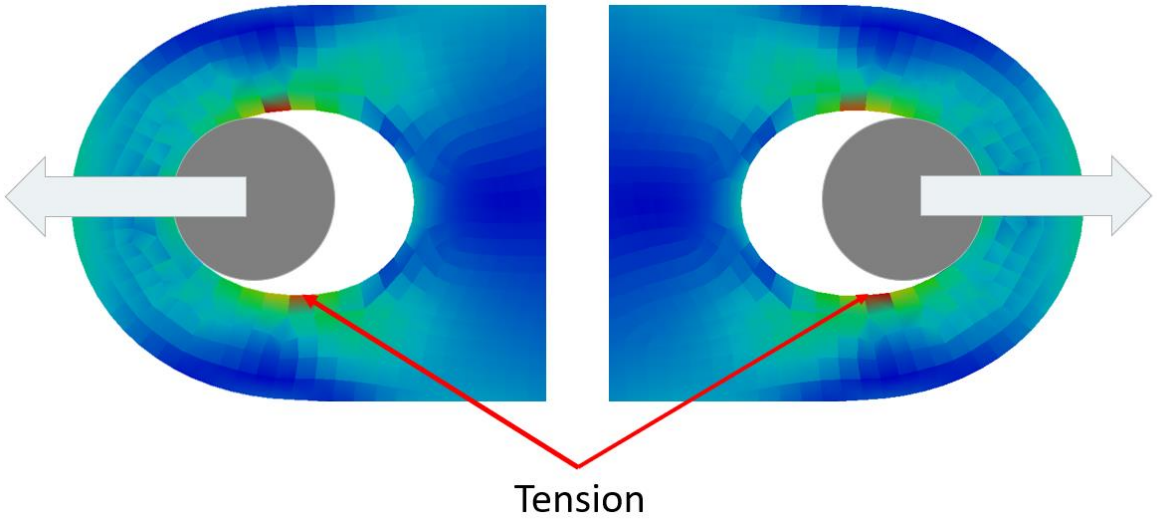
- Simple loads
- Complex loads
  - Multiple angles between 10 and 360
  - Calculation on each plane
  - Default output for worst plane

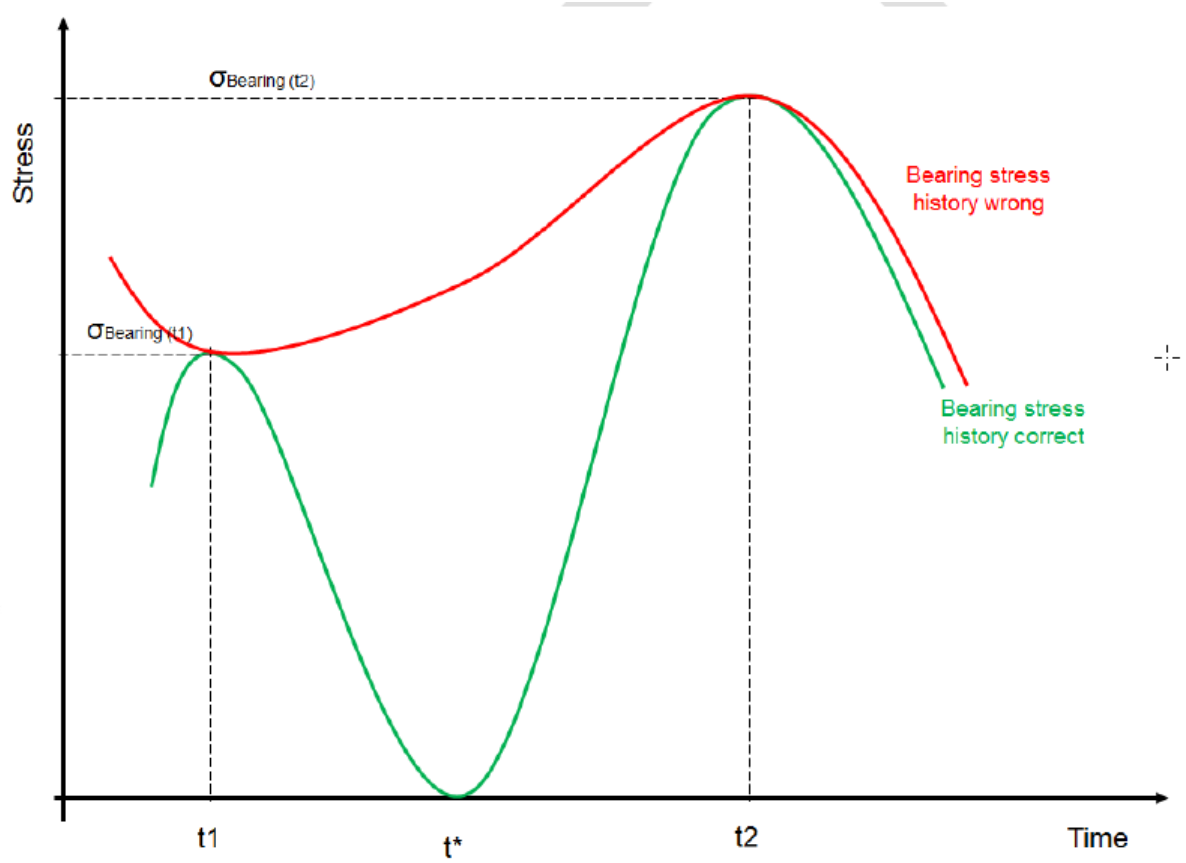




Stress Correction

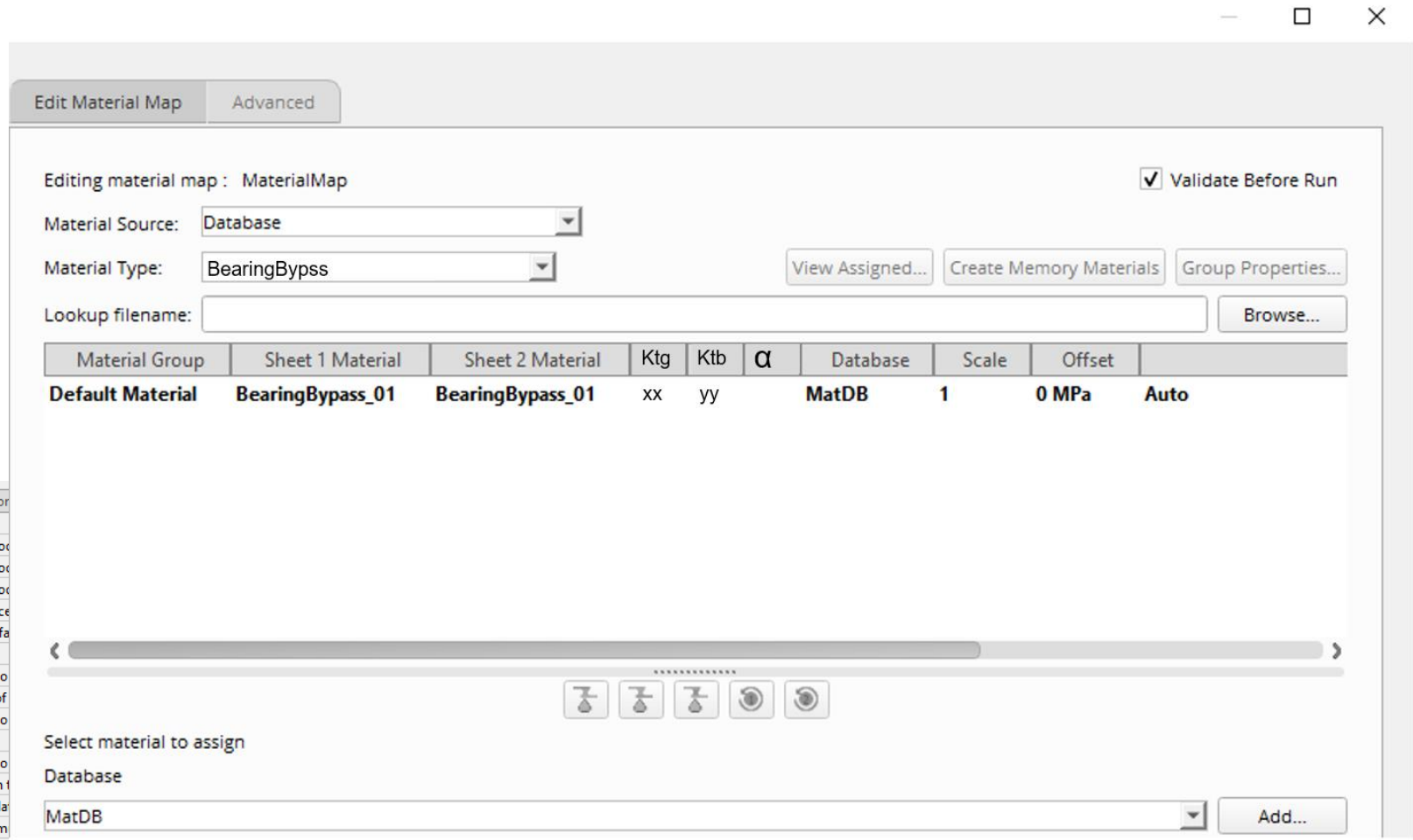
- When the bearing load reverses
- Tensile stress at the hole passes through 0
- Stress is corrected by adding an extra 0 point between each reversal of the bearing load





Additional parameters

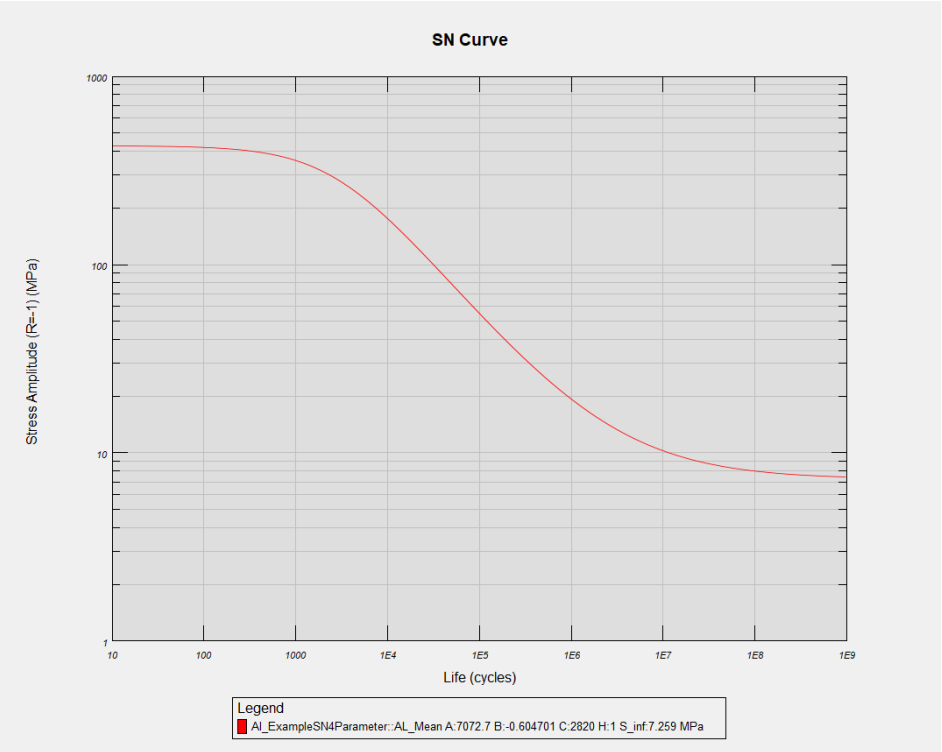
- Additional parameters are required for the bearing bypass calculation
  - K_{tg}
  - K_{tb}
  - α
  - β
  - Out-of-plane bending limit
  - etc
- Set for each:-
  - Analysis
  - Material
  - Joint



	Name	Value	Description
⊟	**General**		
	CombinationMethod	Standard	The method
	SNMethod	Standard	The method
	MeanStressCorrection	Simple	The method
	CertaintyOfSurvival	50	Required ce
	ScaleFactor	1	The scale fa
⊟	**SpotWeld**		
	CalculateTorsion	False	Whether to
	NumberOfAngles	18	Number of
	ProcessMiddleSheets	False	Whether to
⊟	**Advanced**		
	BackCalcMode	None	Whether to
	CheckStaticFailure	False	The action t
	DamageFloor	0	The calcula
	MaxDamage	1E30	The maxim
⊟	**DutyCycle**		
	EventProcessing	Independent	How to process separate events in duty cycles
	OutputEventResults	False	Whether to output results per event or not for duty cycle processing
⊞	**OutputColumns**		

S-N analysis

- Initially link the calculated stress to the S-N solver
- Default to use the 4-parameter SN method (DEF STAN 00-970 Part 1 Section 3)
- Possible calculation of the Stress Severity Factor with the addition of reference far field stress
- Output all relevant statistics from the calculation
  - Input parameters (e.g. K_{tg} ,K_{tb},α, β)
  - Calculation results
  - Calculation checks (e.g. out-of-plane bending)



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Summary

nCode

Summary

- The DesignLife spot weld method is being used as a basis for the bearing bypass method
- Prototype translation methods have been implemented to allow a calculation based on both forces and stresses
- The 4-parameter SN method has been implemented (DEF STAN 00-970 Part 1 Section 3)

Prenscia

Thank you!
Questions?

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Q&A

- (no questions)

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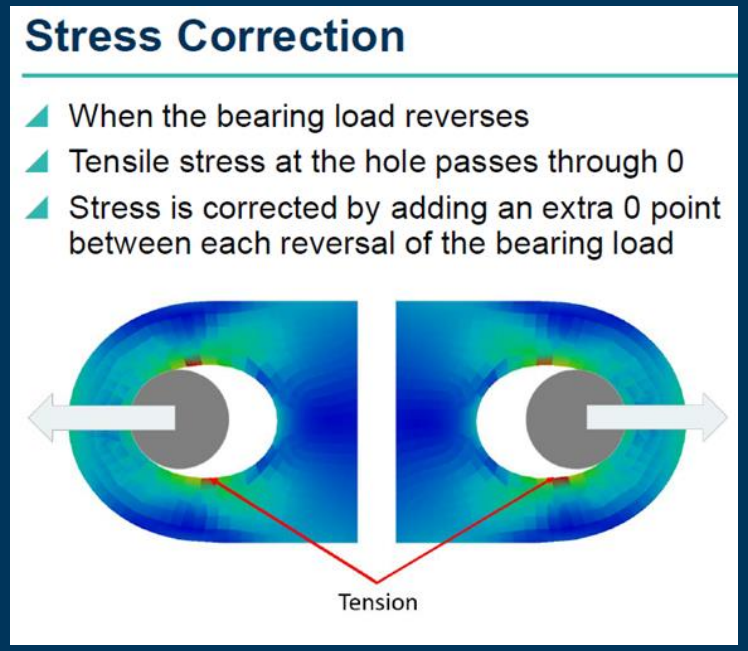

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