

New method for assessing the failure of adhesive bonds under cyclic loading

Date: 20th May 2021

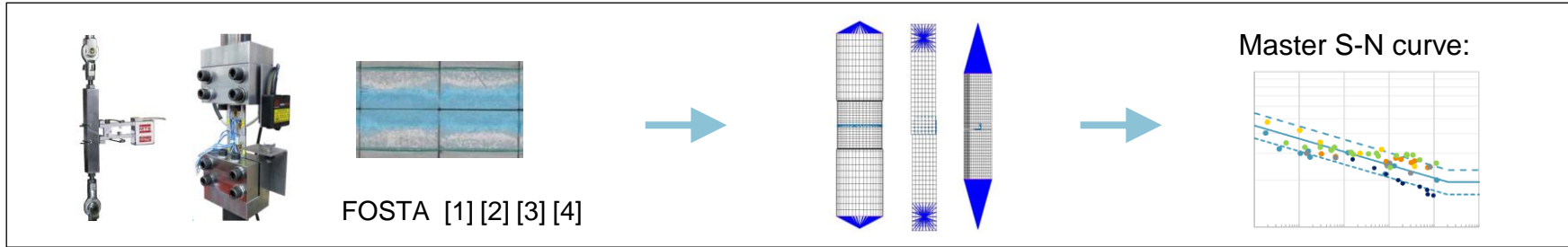
Manuel FRANK, Magna Powertrain

- 1) Fatigue Analysis in Adhesive Joints
 - Analysis Concept & Strength Data
 - Validation
 - Correlation for Stress Concentrations
- 2) Adhesive Failure for Stress Concentrations
- 3) New Method for Adhesive Assessment
- 4) Case Study: Vehicle Body
 - Fatigue Analysis (incl. FE Mesh Generation)
 - Damage Assessment (incl. Definition of Adhesives)
 - Results
 - Detailed Investigation
- 5) Conclusion

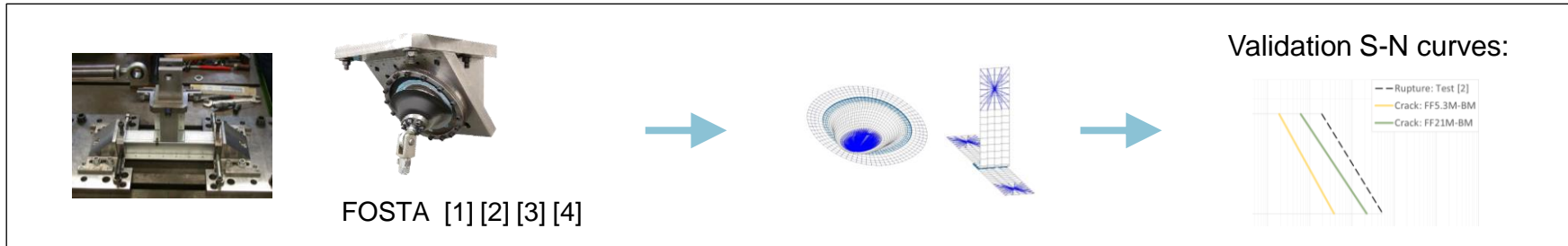
Fatigue Analysis in Adhesive Joints

Way to Assessment of Bonded Joints

1. Analysis Concept & Strength Data



2. Validation



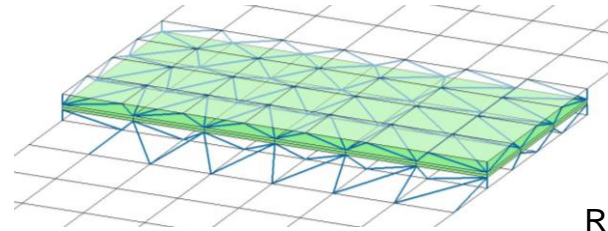
3. Calibration (+ Method Improvement, if nec.)

Analysis Concept & Strength Data

Master S-N Curve Generation: Betamate 1496V

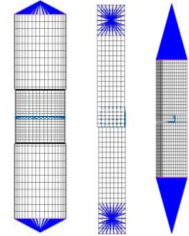


FE Modelling Guideline:



3 Stripes,
2 Coats,
hexa8

RBE3-hexa-RBE3



Influence Factors:

Stress Gradient

- Endurance Limit

Mean Stress

- Endurance Limit
- Slope/ Cycle Limit

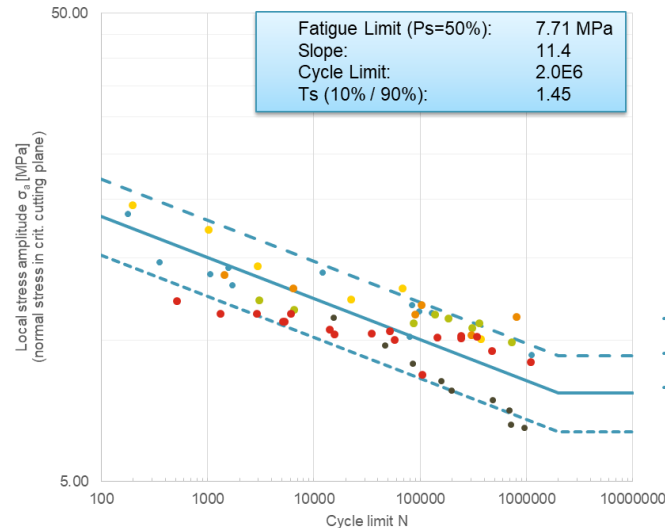
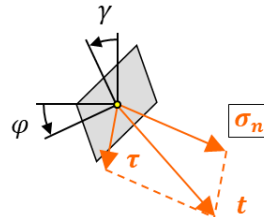
Stress Rearrangement

- Mean

Analysis Parameters:

MINER Elementary

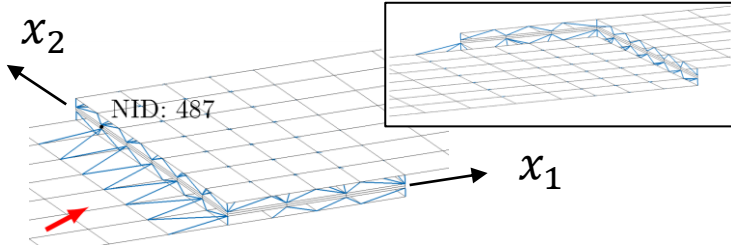
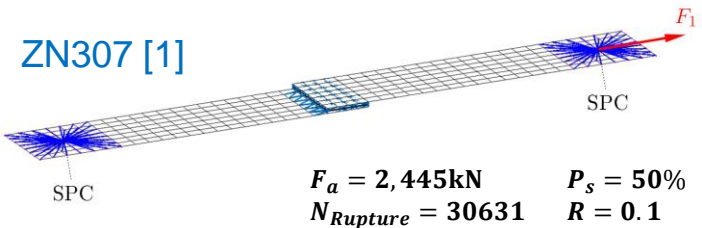
Normal Stress in Critical Plane



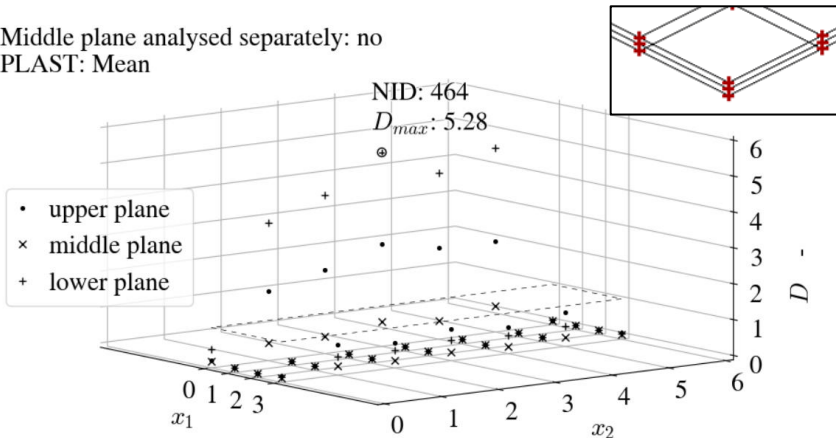
- Tube specimen tension
- Tube specimen torsion
- Tube specimen combined
- Overlap joint P653 12,5mm
- Overlap joint P796 17,6mm
- P2 P653
- Master SN curve Ps=50%
- - - Master SN curve Ps=10%
- - - Master SN curve Ps=90%

Middle Plane Assessment

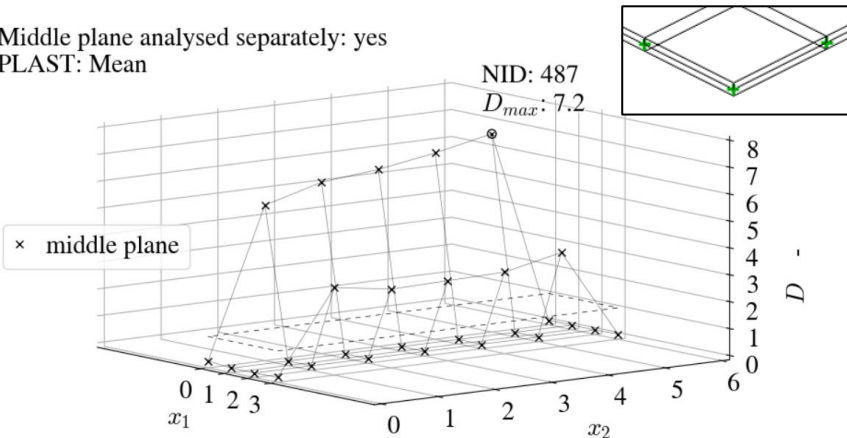
Reduction of high coupling sensitivity through assessment of middle plane



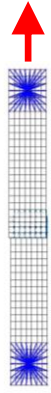
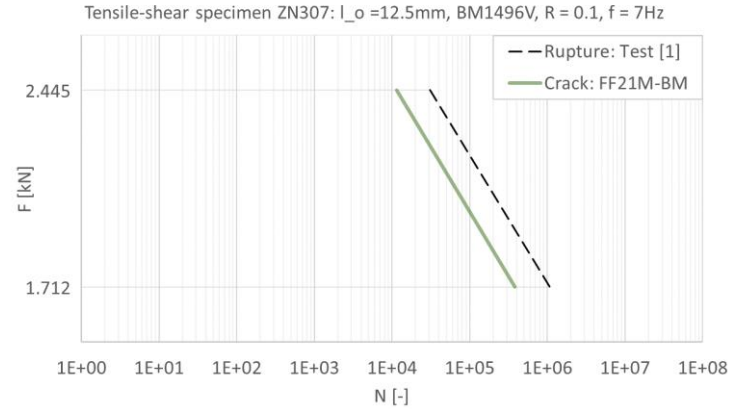
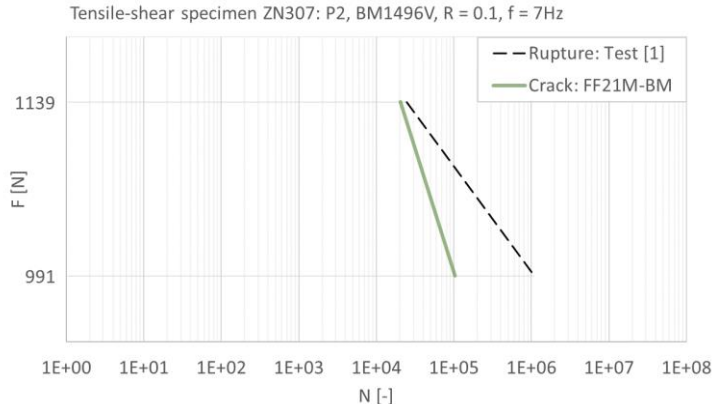
Middle plane analysed separately: no
 PLAST: Mean



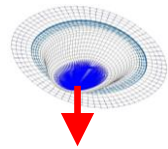
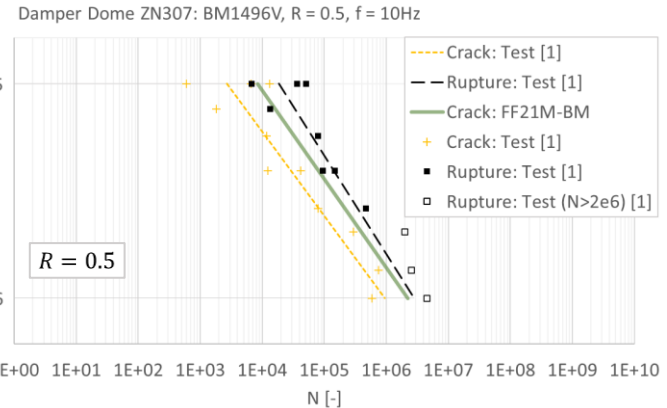
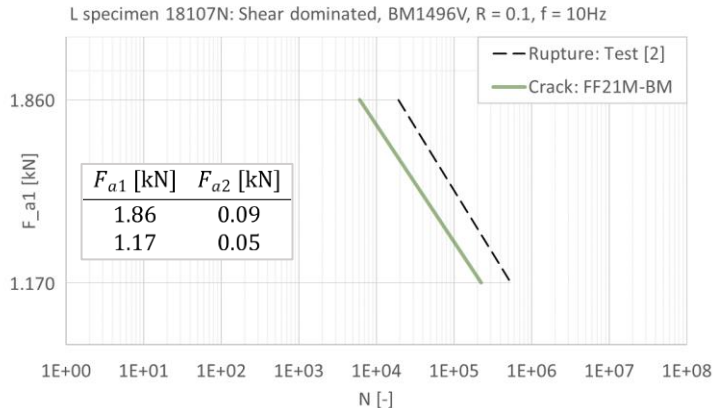
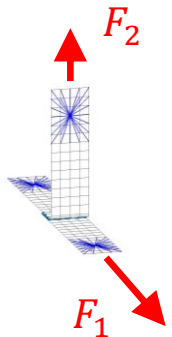
Middle plane analysed separately: yes
 PLAST: Mean



Validation

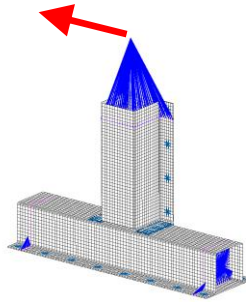
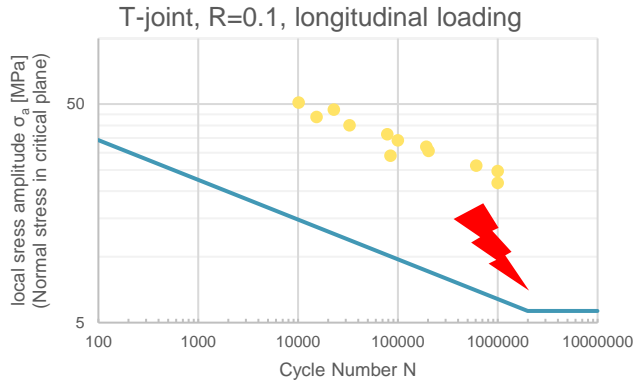


$P_S = 50\%$

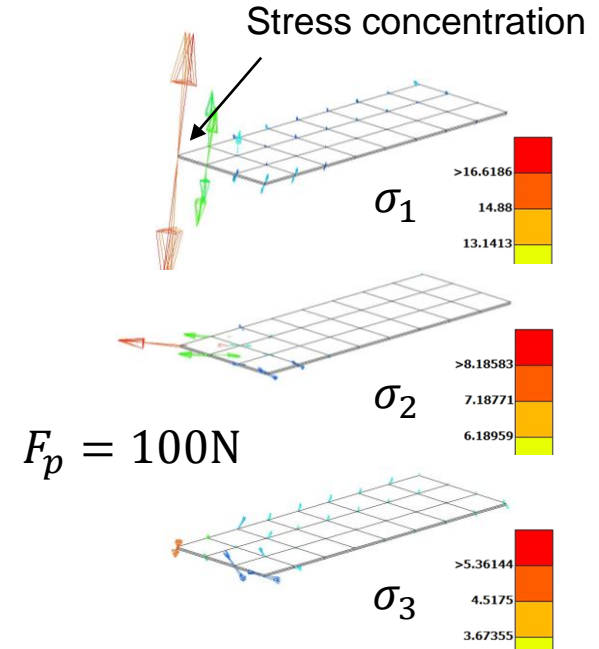
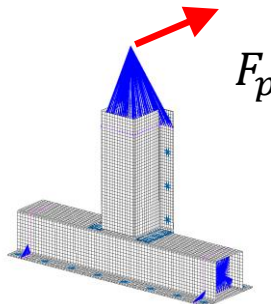
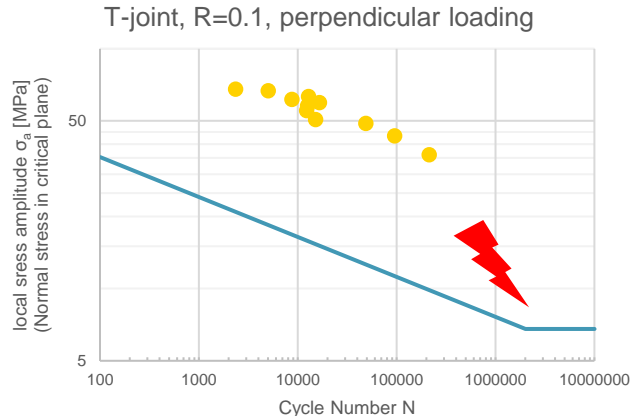


Correlation for Stress Concentrations

Correlation for Stress Concentrations



- Rupture in test
- FEMFAT result
- $P_S = 50\%$



→ *New MP1 specimen tests*
 → *New assessment approach?*

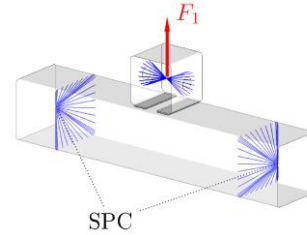
Failure for Stress Concentrations

... by tests on MP1 specimen

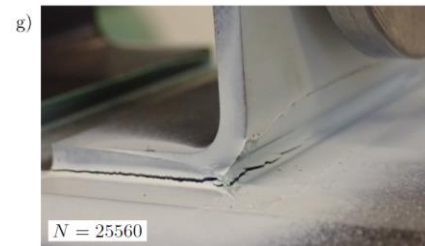
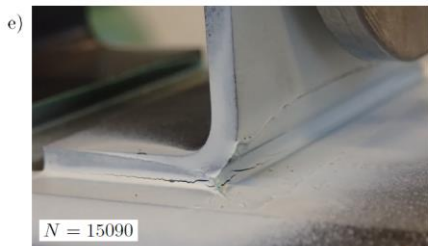
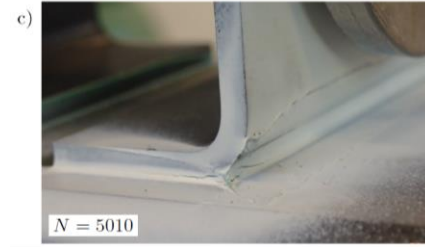
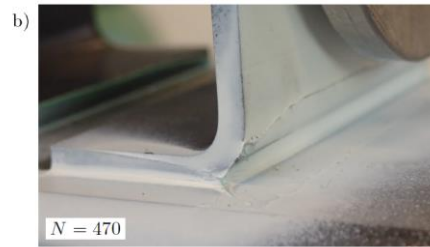
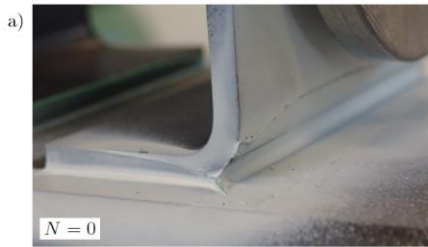
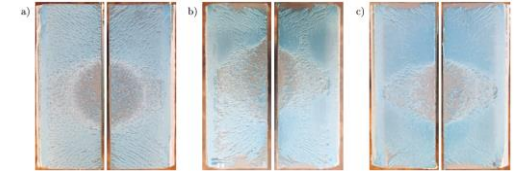
Test MP1 Specimen: Crack Propagation



SikaPower 493
Small bead
Force perpendicular
 $R = 0$



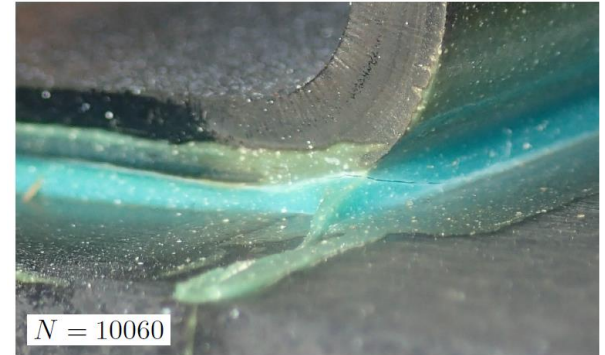
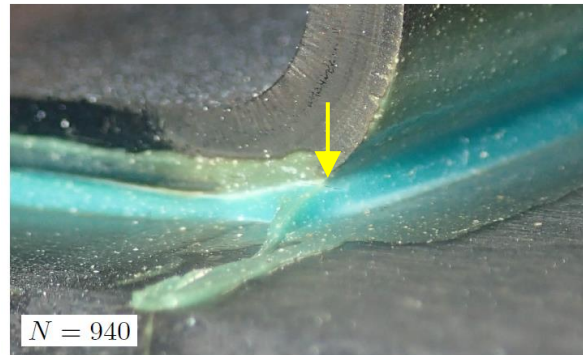
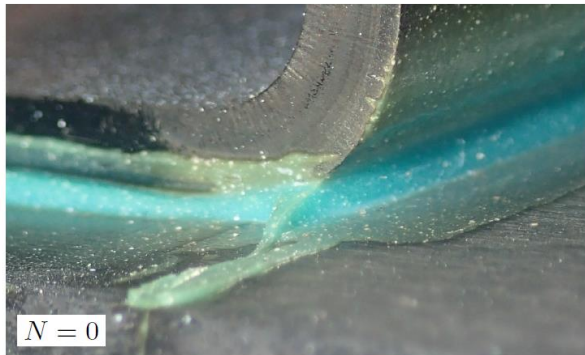
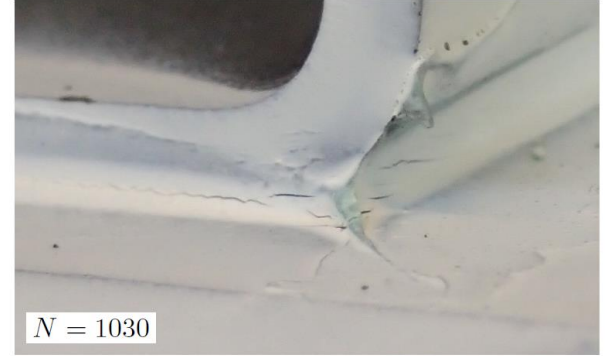
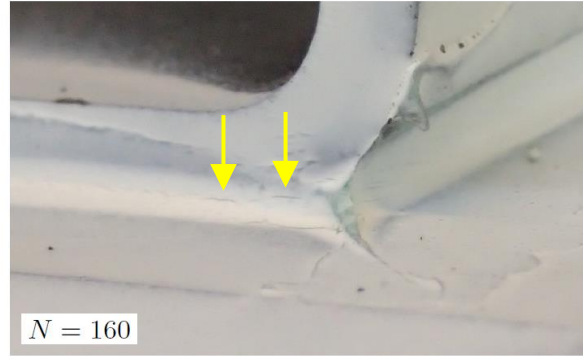
Cohesive Fatigue Failure



Test MP1 Specimen: Failure Criterion

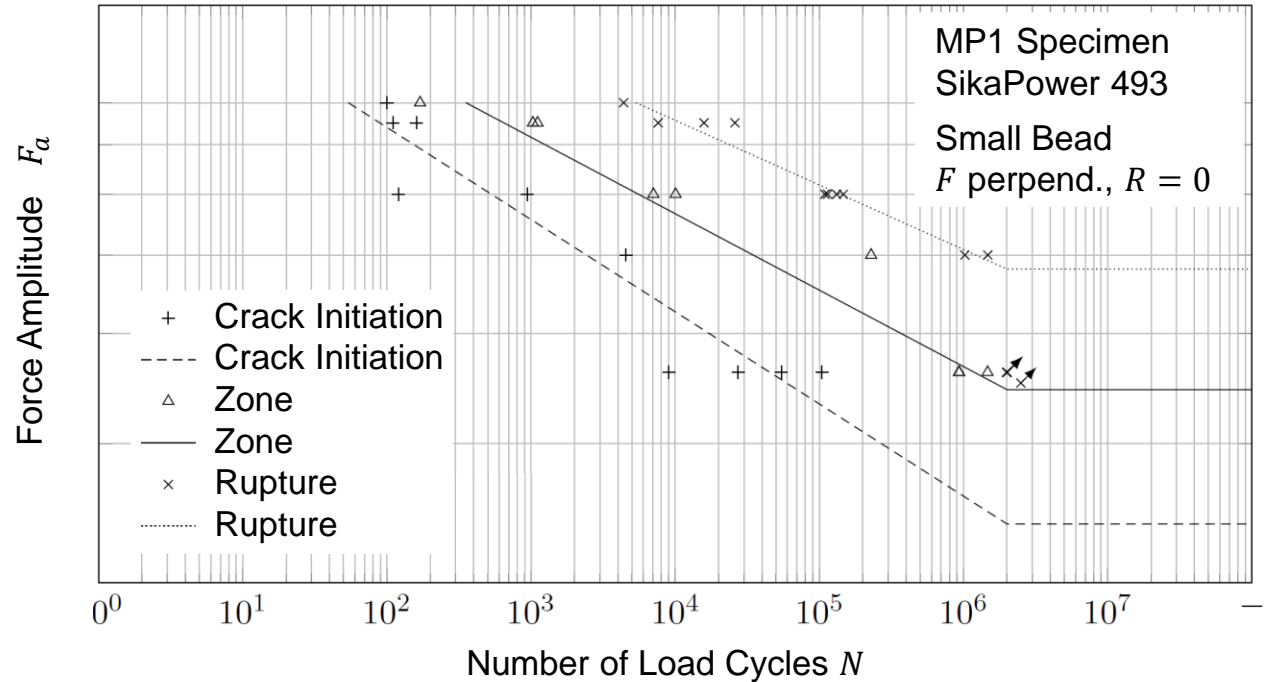
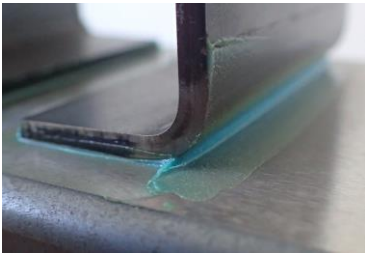
Crack Initiation:

Zone:



Test MP1 Specimen: S-N Curves

SikaPower 493, Small bead, Force perpendicular, $R = 0$



New Method for Adhesive Assessment

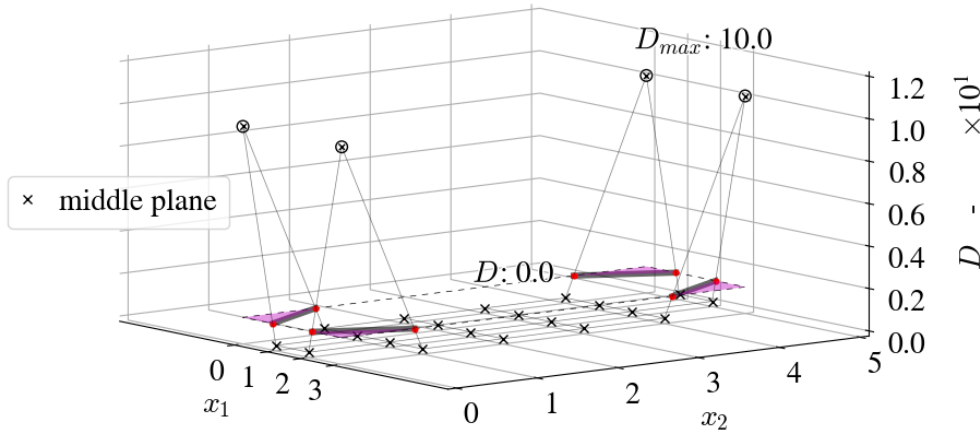
... against Zone Failure

New Method for Adhesive Assessment

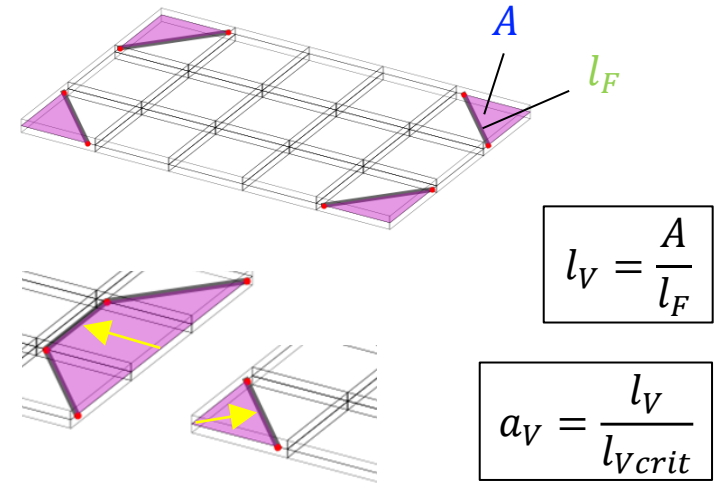
Determination of Equivalent Length l_V from **Intersection Area A** and **Front Length l_F** of **Virtual Cracked Zones**

→ *Result of Interest: Degree of Utilization a_V*

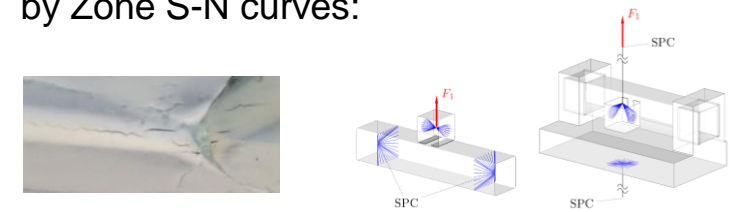
Middle plane analysed separately: yes
PLAST: Mean

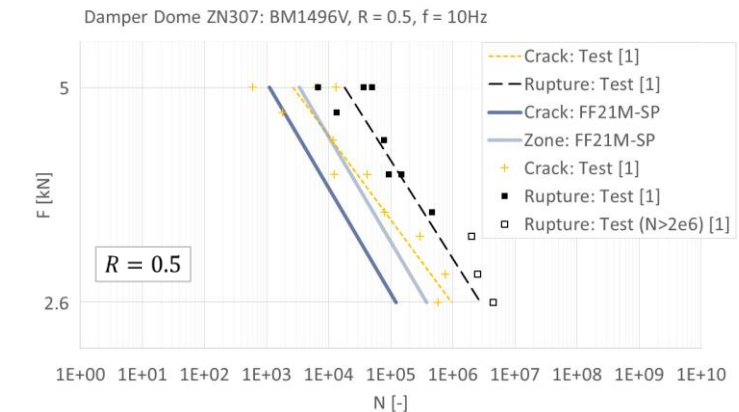
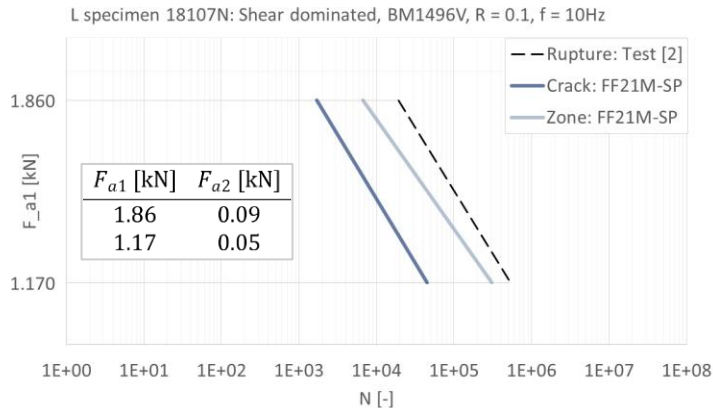
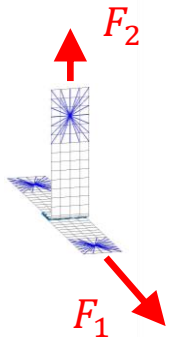
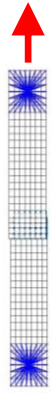
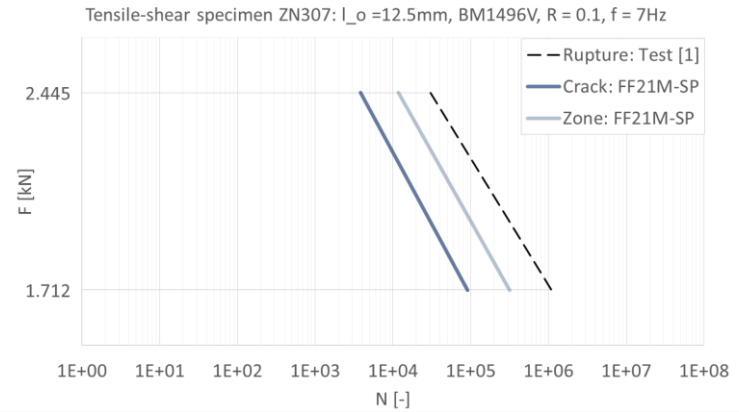
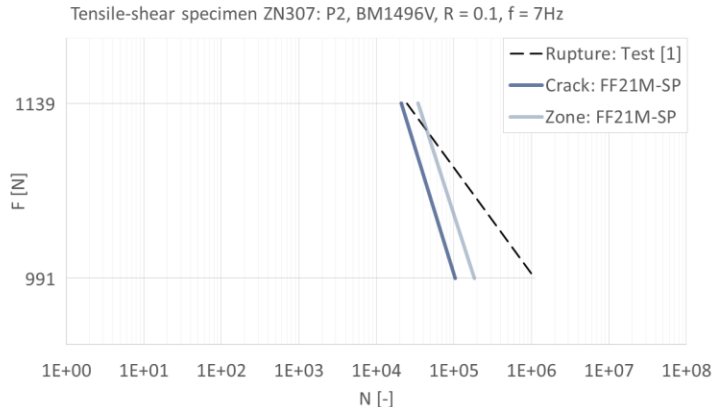


✓ *Method implemented in Standalone Tool **ClARP***

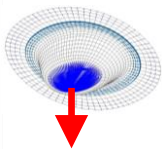


Critical Length l_{Vcrit} calibrated by Zone S-N curves:





$P_S = 50\%$



Case Study – Vehicle Body

Case Study – Vehicle Body



FE Model



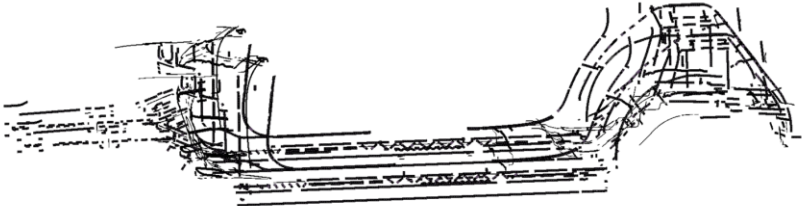
FE Analysis



Fatigue Analysis



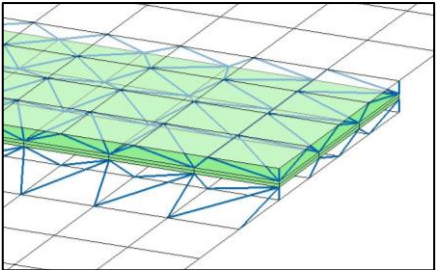
Damage Assessment



BIW with 1310 Adhesive Joints

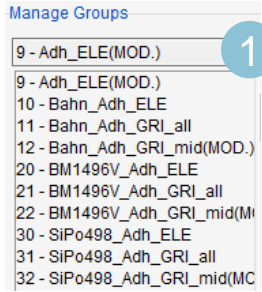
FEMFAT

ClaRP

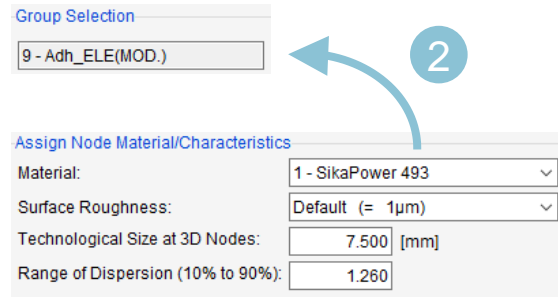


Fatigue Analysis

Groups:



Node Characteristics:

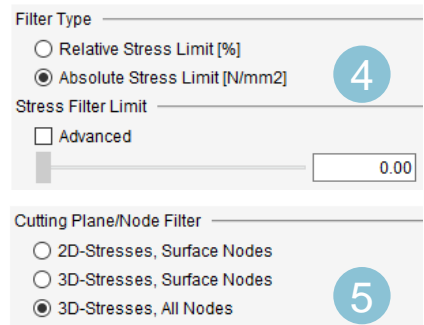
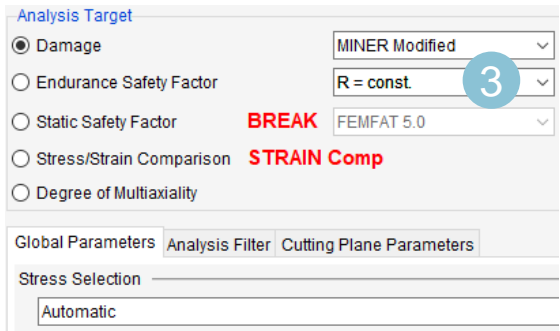


1 Add Nodes of `*_Adh_GRI_mid` to Elements of `Adh_ELE` to create the Analysis Group

*Add `*_Adh_ELE` to `*_Adh_GRI_mid` for separate analysis of the adhesives*

2 Assign the available Material `SP493_FEMFAT54_ClaRP211.ffd` to the Analysis Group

Analysis Parameters:



3 Select `R = const`

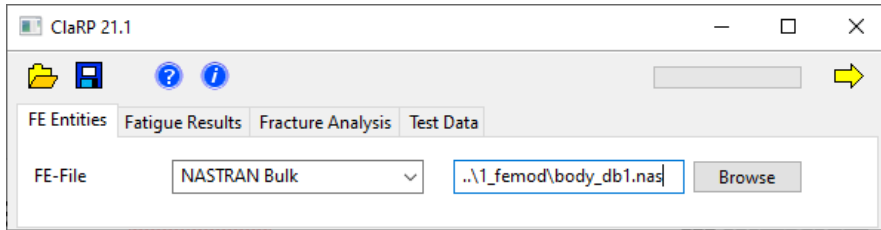
4 Set `Abs. Str. Limit` to `0 N/mm2`

5 Select `3D-Stresses, All Nodes` (for MAX only)

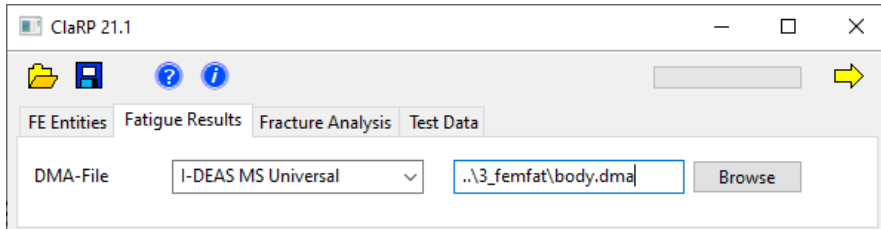
Damage Assessment

GUI Mode:

1. Select FE Entities:



2. Select Fatigue Results:



3. Save & Run the job

Batch Mode:

Job File (*.crp):

```
Version: ClaRP 21.1

# FE
FE_File: ..\..\1_femod\example.nas      # file path

# FF
FF_File: ..\..\3_femfat\max\example.dma # file path
```

Run the job (*.bat, *.que, ...):

```
rem -----
set CP=CALL "C:\path2\software\clarp\win\ClaRP.exe"
rem -----
%CP% --crp C:\path2\projects\project1\job1.crp
%CP% --crp C:\path2\projects\project2\job1.crp
```


Standard Database:

```
# Database      : Adhesive Layer Assessment on FE-Structures
# Content      : Critical Lengths of Virtual Cracked Zones

# Program      : ClARP
# Version      : 21.1

# Material Data : SikaPower 493
# =====

# Source       : ECS - Test MP1 specimen: Zone, EP1_k_s0, Mid_M_a3250_R0
# Last Modification : Mar 14 2021
Identifier    : SP493
Critical Length : 2.12044

# Requirements for validity of Critical Length
# Material Data in FEMFAT Analysis ..... SikaPower493_FEMFAT54_ClaRP211.ffd
# Last Modification of ffd-File ..... Mar 14 2021

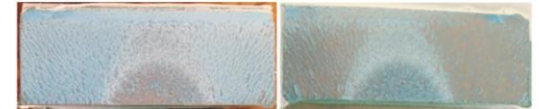
# Material Data : Betamate 1496V
# =====

# Source       : ECS - Test MP1 specimen: Zone, EP2_k_s0, Mid_M_a3250_R0
```

If your Material is not included, choose an available with similar properties (before FE Analysis):

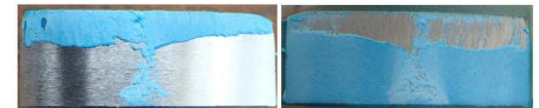
SikaPower 493

Long cohesive crack propagation phase for grinded + degreased parts



Betamate 1496V

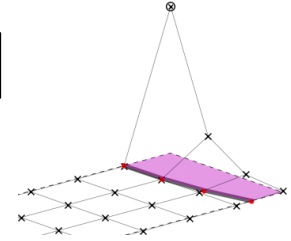
Small cohesive crack propagation phase for grinded + degreased parts



Results

Assessment result in the report file (*.rrp):

Computation time: 14s



ANALYSIS REPORT

```

-----
Program       : ClaRP
Version      : 21.1
Date         : Di Apr 13 16:31:22 2021
Analysis Content : Adhesive Layer Assessment on FE-Structures
                : ... based on Fatigue Analysis Results from FEMFAT
Notice       :
Comment      :
    
```

General Input Data

```

-----
ClaRP Input
C:\FEMFAT\body\4_clarp\body.crp

ClaRP Database
C:\FEMFAT\body\4_clarp\body.drp

ClaRP Allocation Table
C:\FEMFAT\body\4_clarp\body.drpa
    
```

```

FE Input
C:\FEMFAT\body\1_femod\body_db1.nas
    
```

```

FEMFAT Result
C:\FEMFAT\body\3_femfat\body.dma
    
```

```

Status
Analysed Adhesive Layer Planes
  Fatigue Analysis ..... Middle Plane
  Fracture Assessment ..... Middle Plane
Scaling ..... Linear
Report
  Zones per Layer ..... All
  Sorting ..... Utili. Deg.
  Number of Load Cycles ..... 1
    
```

```

Limits
Damage from Crack Initiation ..... 1.0 [-]
    
```

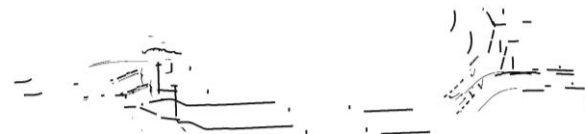
Virtual Cracked Zones Data

```

-----
Virtual Cracked Zones Types ... combined types are possible
ci ... D > 1 at i corner nodes
ei ... D > 1 at i edge nodes
mi ... D > 1 at i middle nodes
    
```

In Scope

Adh. ID	Zone ID	Zone Type	Dmax	Node ID (Dmax)	Asse. Mat.	Equiv. Len.	Utili. Deg.	ClaRP Res.
85	3	c2e3	1.578E+04	4260471	SP493	3.53003E+00	1.66476E+00	not OK
117	3	c2e3	1.057E+04	4363734	SP493	3.51498E+00	1.65767E+00	not OK
2	1	c2e2	2.378E+02	4398927	SP493	3.33234E+00	1.57153E+00	not OK
121	1	c2e2	4.228E+02	4474239	SP493	3.22838E+00	1.52250E+00	not OK
86	1	c2e2	2.752E+01	5477385	SP493	3.21192E+00	1.51474E+00	not OK
12	1	c2e3	4.935E+03	5572658	SP493	3.14312E+00	1.48229E+00	not OK
42	1	c2e3	3.153E+03	5570711	SP493	3.13976E+00	1.48071E+00	not OK
89	3	c2e2	2.231E+02	4328595	SP493	3.01723E+00	1.42293E+00	not OK
118	1	c2e2	8.232E+01	4435071	SP493	2.90110E+00	1.36816E+00	not OK
40	1	c2e2	1.911E+01	5616679	SP493	2.89957E+00	1.36744E+00	not OK
116	1	c2e2	1.083E+01	4356714	SP493	2.77718E+00	1.30972E+00	not OK
33	1	c2e2	1.967E+01	5643278	SP493	2.76410E+00	1.30355E+00	not OK
7	1	c2e5	4.102E+02	5641541	SP493	2.75993E+00	1.30159E+00	not OK
46	1	c2e5	1.902E+02	5643488	SP493	2.42202E+00	1.14222E+00	not OK
15	3	c1e2	3.098E+02	4329963	SP493	2.36398E+00	1.11485E+00	not OK
49	1	c2e2	4.111E+01	5570918	SP493	2.36396E+00	1.11484E+00	not OK
124	3	c2e2	7.393E+02	4388406	SP493	2.35127E+00	1.10886E+00	not OK
50	5	c1e2	3.005E+01	4440378	SP493	2.26355E+00	1.06749E+00	not OK
45	2	c1e4	7.585E+01	5643932	SP493	2.18922E+00	1.03244E+00	not OK
6	1	c2e6	9.527E+01	5642828	SP493	2.18041E+00	1.02828E+00	not OK
50	3	e4	1.598E+02	4440198	SP493	2.05837E+00	9.70725E-01	OK



20 critical Zones
with $a_V > 1$

Results:

Sika Power 493

$$P_S = 50\%$$



80	2	e1	1.435E+02	4440142	SF493	1.0833E+00	9.40209E-01	OK	78	1	e1	6.006E+00	4326195	SF493	1.0213E+00	4.81648E-01	OK
105	2	e2p	7.594E+00	4326495	SF493	2.1013E+00	9.67417E-01	OK	115	1	e1	4.495E+00	5444279	SF493	1.0199E+00	4.81014E-01	OK
107	1	e1	1.075E+02	5411220	SF493	2.0281E+00	9.56813E-01	OK	47	3	e1	4.776E+00	5611440	SF493	1.0102E+00	4.76427E-01	OK
82	2	e1	2.484E+01	5516102	SF493	1.9425E+00	9.26812E-01	OK	82	2	e1	5.011E+00	5612095	SF493	1.0100E+00	4.72209E-01	OK
76	2	e1	1.112E+02	5516487	SF493	1.9648E+00	9.29977E-01	OK	65	1	e1	5.370E+00	5621020	SF493	9.9924E-01	4.71202E-01	OK
17	2	e1	2.767E+01	5615409	SF493	1.9395E+00	9.12000E-01	OK	81	1	e1	5.900E+00	5633006	SF493	9.7421E-01	4.60392E-01	OK
114	1	e1	1.161E+02	5623367	SF493	1.9702E+00	9.15134E-01	OK	60	2	e1	6.472E+00	5641973	SF493	9.7068E-01	4.57088E-01	OK
67	1	e1	4.195E+01	5641240	SF493	1.7901E+00	8.99518E-01	OK	15	1	e2p	2.702E+00	5620979	SF493	9.7020E-01	4.67918E-01	OK
59	1	e1	2.516E+02	5649129	SF493	1.7617E+00	8.92068E-01	OK	67	2	e1	3.975E+00	5641989	SF493	9.6820E-01	4.58482E-01	OK
106	1	e1	1.665E+01	5649750	SF493	1.7633E+00	8.90918E-01	OK	87	2	e1	4.401E+00	5647462	SF493	9.6207E-01	4.52379E-01	OK
82	1	e1	1.245E+01	4366163	SF493	1.7513E+00	8.26017E-01	OK	20	1	e1	4.934E+00	4324710	SF493	9.5765E-01	4.51628E-01	OK
111	1	e1	7.720E+02	4326249	SF493	1.6941E+00	7.80497E-01	OK	27	1	e1	4.334E+00	5433379	SF493	9.5018E-01	4.46204E-01	OK
114	1	e1	1.180E+01	5649749	SF493	1.4902E+00	7.52094E-01	OK	84	2	e1	4.877E+00	4325494	SF493	9.4024E-01	4.31200E-01	OK
82	2	e1	4.773E+00	4323559	SF493	1.4394E+00	7.1132E-01	OK	117	2	e1	1.430E+01	4326489	SF493	1.4890E-01	4.47900E-01	OK
83	1	e1	2.484E+00	4470426	SF493	1.5095E+00	7.53922E-01	OK	62	1	e1	4.522E+00	5501091	SF493	1.47977E-01	4.46007E-01	OK
86	1	e1	4.775E+00	4346202	SF493	1.5955E+00	7.52400E-01	OK	108	1	e1	4.670E+00	4209343	SF493	1.36991E-01	4.41020E-01	OK
19	1	e1	2.945E+00	5612026	SF493	1.5028E+00	7.46938E-01	OK	13	1	e1	4.697E+00	5572267	SF493	1.3626E-01	4.36928E-01	OK
16	1	e1	1.310E+02	4244410	SF493	1.5079E+00	7.11160E-01	OK	24	1	e1	4.412E+00	5501027	SF493	1.31687E-01	4.34668E-01	OK
10	1	e1	3.190E+01	5570234	SF493	1.4522E+00	6.89399E-01	OK	66	1	e1	4.578E+00	4304046	SF493	1.20518E-01	4.24418E-01	OK
45	1	e1	1.400E+01	5649480	SF493	1.4102E+00	6.69018E-01	OK	92	1	e1	4.108E+00	5591958	SF493	1.15071E-01	4.11874E-01	OK
116	1	e1	5.914E+00	5484288	SF493	1.2883E+00	6.26002E-01	OK	84	2	e1	4.346E+00	4457849	SF493	1.1206E-01	4.01829E-01	OK
124	1	e1	7.506E+00	4339120	SF493	1.3024E+00	6.14214E-01	OK	122	1	e1	3.611E+00	4237130	SF493	1.1122E-01	4.29731E-01	OK
29	1	e1	1.445E+01	4324206	SF493	1.2790E+00	6.12409E-01	OK	67	1	e1	4.072E+00	4474890	SF493	1.0702E-01	4.24881E-01	OK
63	1	e1	2.071E+01	4497471	SF493	1.2071E+00	5.92848E-01	OK	94	1	e1	4.075E+00	4275884	SF493	1.0621E-01	4.21712E-01	OK
82	1	e1	1.892E+02	5510006	SF493	1.2312E+00	5.60973E-01	OK	119	2	e1	3.207E+00	4213497	SF493	1.02761E-01	4.21028E-01	OK
106	2	e1	1.120E+01	5639540	SF493	1.2001E+00	5.59741E-01	OK	14	1	e1	4.002E+00	5612227	SF493	1.0204E-01	4.19038E-01	OK
29	1	e1	1.870E+01	4326242	SF493	1.24051E+00	5.59583E-01	OK	70	1	e1	2.685E+00	4203930	SF493	8.8713E-01	4.04243E-01	OK
49	1	e1	3.568E+00	5642582	SF493	1.2461E+00	5.47698E-01	OK	96	2	e1	2.261E+00	4046228	SF493	8.4480E-01	3.96178E-01	OK
122	2	e1	7.020E+01	4474569	SF493	1.2093E+00	5.50661E-01	OK	80	1	e1	2.942E+00	4261129	SF493	1.0387E-01	3.81688E-01	OK
54	1	e1	5.875E+01	5624596	SF493	1.2043E+00	5.32446E-01	OK	1004	1	e1	2.588E+00	5659592	SF493	8.1104E-01	3.12694E-01	OK
1	1	e1	1.652E+01	5577052	SF493	1.2191E+00	5.74448E-01	OK	114	1	e1	2.105E+00	4221202	SF493	7.9600E-01	3.07379E-01	OK
103	1	e1	1.027E+02	4445127	SF493	1.2143E+00	5.70217E-01	OK	23	1	e1	2.722E+00	4453823	SF493	7.9277E-01	3.01364E-01	OK
104	1	e1	1.545E+02	5658236	SF493	1.2117E+00	5.71377E-01	OK	40	2	e1	1.995E+00	5642838	SF493	7.9779E-01	3.10778E-01	OK
101	1	e1	5.602E+01	4479702	SF493	1.2004E+00	5.60002E-01	OK	102	1	e1	2.500E+00	4401012	SF493	6.7668E-01	3.10008E-01	OK
90	1	e1	2.800E+02	SF493	1.2699E+00	5.49914E-01	OK	28	1	e1	2.205E+00	4262900	SF493	6.5147E-01	3.07204E-01	OK	
20	1	e1	6.600E+00	4377943	SF493	1.15991E+00	5.69779E-01	OK	70	1	e1	2.185E+00	4003211	SF493	6.4449E-01	3.03984E-01	OK
61	1	e1	1.041E+02	5503954	SF493	1.1697E+00	5.69977E-01	OK	111	1	e1	1.920E+00	5642640	SF493	6.2122E-01	3.02002E-01	OK
1004	1	e1	5.211E+01	5646789	SF493	1.1950E+00	5.6932E-01	OK	106	1	e1	5.372E+00	4247051	SF493	6.1995E-01	2.9958E-01	OK
124	2	e1	1.280E+01	4339219	SF493	1.1929E+00	5.6088E-01	OK	11	1	e1	2.076E+00	5640681	SF493	6.1487E-01	2.91938E-01	OK
72	1	e1	1.000E+01	4323146	SF493	1.1864E+00	5.61931E-01	OK	82	1	e1	2.016E+00	5542226	SF493	5.9660E-01	2.81873E-01	OK
17	1	e1	4.802E+02	5481002	SF493	1.1851E+00	5.58991E-01	OK	17	2	e1	2.004E+00	5451012	SF493	5.8560E-01	2.81027E-01	OK
7	1	e1	1.780E+01	4448239	SF493	1.1817E+00	5.57028E-01	OK	90	1	e1	1.912E+00	4290497	SF493	5.8246E-01	2.78821E-01	OK
1	1	e1	1.450E+02	5481426	SF493	1.1782E+00	5.56611E-01	OK	2001	1	e1	1.910E+00	4451823	SF493	5.8246E-01	2.78821E-01	OK
28	1	e1	3.014E+02	5623736	SF493	1.1761E+00	5.54948E-01	OK	5	1	e1	1.824E+00	4413399	SF493	5.8246E-01	2.78821E-01	OK
100	1	e1	1.772E+02	4304963	SF493	1.1700E+00	5.51719E-01	OK	89	1	e1	1.811E+00	4413399	SF493	5.8246E-01	2.78821E-01	OK
21	1	e1	4.460E+01	4300059	SF493	1.1404E+00	5.31601E-01	OK	71	1	e1	1.874E+00	4401854	SF493	5.7604E-01	2.71877E-01	OK
112	2	e1	1.022E+02	5577699	SF493	1.1499E+00	5.31310E-01	OK	4	1	e1	1.922E+00	4443470	SF493	5.6624E-01	2.67041E-01	OK
88	1	e1	1.397E+01	4323978	SF493	1.1407E+00	5.31120E-01	OK	119	1	e1	1.765E+00	4451854	SF493	5.6022E-01	2.67318E-01	OK
117	1	e1	1.424E+01	4304650	SF493	1.1404E+00	5.31020E-01	OK	55	1	e1	1.874E+00	4457489	SF493	5.5183E-01	2.62059E-01	OK
74	1	e1	2.378E+01	5444044	SF493	1.1441E+00	5.49011E-01	OK	90	1	e1	1.796E+00	5477015	SF493	5.2847E-01	2.46222E-01	OK
1	1	e1	1.640E+02	4364823	SF493	1.1424E+00	5.47818E-01	OK	122	1	e1	1.738E+00	4471648	SF493	5.1872E-01	2.47474E-01	OK
91	1	e1	2.276E+01	4327119	SF493	1.1587E+00	5.46441E-01	OK	120	1	e1	1.435E+00	5489768	SF493	3.72711E-01	1.79774E-01	OK
104	1	e1	4.196E+01	4315221	SF493	1.1554E+00	5.44499E-01	OK	88	1	e1	1.344E+00	4200770	SF493	3.9767E-01	1.61724E-01	OK
76	1	e1	1.240E+02	4312858	SF493	1.1203E+00	5.44218E-01	OK	41	1	e1	1.432E+00	5612162	SF493	3.7184E-01	1.61224E-01	OK
83	1	e1	3.284E+00	5643826	SF493	1.1314E+00	5.43938E-01	OK	52	2	e1	1.416E+00	5515959	SF493	3.8161E-01	1.46664E-01	OK
80	1	e1	4.010E+01	5494200	SF493	1.1000E+00	5.42073E-01	OK	68	1	e1	1.405E+00	4412169	SF493	2.1603E-01	1.41114E-01	OK
10	1	e1	1.551E+01	4314400	SF493	1.1004E+00	5.43931E-01	OK	126	1	e1	1.395E+00	4205866	SF493	3.4444E-01	1.37722E-01	OK
89	2	e1	1.265E+01	4310203	SF493	1.1493E+00	5.14641E-01	OK	113	1	e1	1.386E+00	4009310	SF493	2.1139E-01	1.44022E-01	OK
82	1	e1	1.200E+01	4312150	SF493	1.1075E+00	5.40122E-01	OK	18	1	e1	1.500E+00	5614212	SF493	2.5699E-01	1.44112E-01	OK
84	1	e1	1.240E+01	4317234	SF493	1.1052E+00	5.40058E-01	OK	39	1	e1	1.285E+00	4207101	SF493	2.2687E-01	1.11709E-01	OK
89	2	e1	9.508E+00	4322649	SF493	1.1493E+00	5.39068E-01	OK	79	1	e1	1.372E+00	5640444	SF493	1.8524E-01	9.20778E-01	OK
46	1	e1	1.268E+01	5642640	SF493	1.1291E+00	5.37228E-01	OK	59	1	e1	1.182E+00	4452467	SF493	1.6824E-01	8.68888E-01	OK
9	2	e1	1.121E+01	5642490	SF493	1.1143E+00	5.32687E-01	OK	102	1	e1	1.181E+00	4472634	SF493	1.1209E-01	8.62696E-01	OK
56	1	e1	2.039E+01	5493200	SF493	1.1294E+00	5.30741E-01	OK	98	1	e1	1.197E+00	4461298	SF493	1.4816E-01	7.97778E-01	OK
106	1	e1	1.481E+01	4316438	SF493	1.1163E+00	5.29758E-01	OK	8	2	e1	1.118E+00	4456973	SF493	1.1629E-01	7.62697E-01	OK

Detailed Investigation

ClARP – Visualization:

FE Entities Fatigue Results Fracture Analysis Test Data

Scope Damage Assessment Visualization Output Report

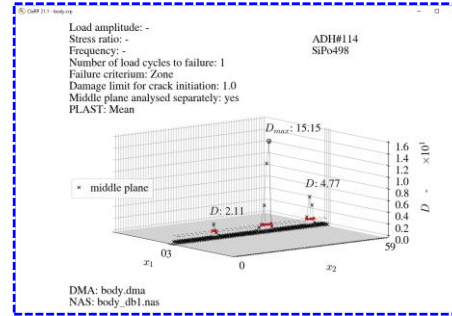
Adhesive Layers

Scope Damage Assessment Visualization Output Report

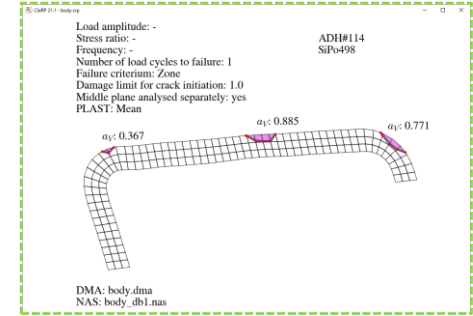
Unit Grid Plot

Geometry Plot

Unit Grid Plot:



Geometry Plot:



ClARP – Output:

FE Entities Fatigue Results Fracture Analysis Test Data

Scope Damage Assessment Visualization Output Report

Adhesive Layers

Scope Damage Assessment Visualization Output Report

Output-File

Output

HyperView:

Load model and results:

Load model

Load results

Extended Entity Selection

Visibility filter:

Select set:

- ADH#114_SiPo498_2L3S_o (12123) (SETS_ID_POOL)
- ADH#115_SiPo498_2L3S_o (12124) (SETS_ID_POOL)
- ADH#116_SiPo498_2L3S_o (12125) (SETS_ID_POOL)
- ADH#117_SiPo498_2L3S_o (12126) (SETS_ID_POOL)



Conclusion

- The new method for the assessment of adhesives calibrated by test results
 - provides with the Degree of Utilization a_V a further result in addition to Damage D
 - consider nodes with damage maxima and their neighboring nodes
 - enables a clear comparison of highly damaged areas
 - limits the number of critical cracked zones significantly
- The assessment of adhesives by the new Standalone Tool *ClaRP*
 - is applied to damage results in a post-processing step
 - is directly applicable to complex structures
 - requires low computational effort
 - enables the visualization for detailed investigation
 - be executed in Batch Mode and thus automated
 - can be used to locate critical adhesive layers for sub-model analyses
 - uses an open Universal format for the input of node-based results
 - uses an open database, that can be extended
- The focus is now on gaining experience & the improvement of usability



DRIVING **EXCELLENCE.**
INSPIRING **INNOVATION.**

Acknowledgment



With many thanks to FOSTA (Forschungsvereinigung Stahlanwendung e.V.), which has cooperated with MAGNA for many years in IGF research projects.

The funding of the IGF projects was provided by the AiF (Arbeitsgemeinschaft industrieller Forschungsvereinigungen e.V.) as part of the Program for the Promotion of the IGF (Industrielle Gemeinschaftsforschung) by the Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Government.

Special thanks go to the universities, institutes and people involved in the IGF projects for the great research. Same to all MAGNA development partners from industry who continuously support the ECS (Engineering Center Steyr) in method development.

- [1] IFAM in Bremen, IfM an der Universität Kassel und SzM an der TU Darmstadt. Schwingfestigkeitsauslegung von geklebten Stahlbauteilen des Fahrzeugbaus unter Belastung mit variablen Amplituden. Vorläufiger Abschlussbericht zum IGF-Vorhaben ZN307, Forschungsvorhaben P796, 12 2011.
- [2] IFAM in Bremen, SAM an der TU Darmstadt, LWF an der Universität Paderborn und IfM an der Universität Kassel. Analyse der Schwingfestigkeit geklebter Stahlverbindungen unter mehrkanaliger Belastung. Abschlussbericht Forschungsvorhaben P1028 mit dem Förderkennzeichen 18107N.
- [3] LWF an der Universität Paderborn, IFAM in Bremen und IfW an der Universität Kassel. Methodenentwicklung zur Berechnung und Auslegung geklebter Stahlbauteile im Fahrzeugbau bei schwingender Beanspruchung. Vorläufiger Abschlussbericht zum AiF-ZUTECH Forschungsprojekt ZN141, Forschungsvorhaben P653, 1 2007.
- [4] LBF in Darmstadt, LWF an der Universität Paderborn und IFAM in Bremen. Auslegung von geklebten Stahlblechstrukturen im Automobilbau für schwingende Last bei wechselnden Temperaturen unter Berücksichtigung des Versagensverhaltens. Abschlussbericht zum IGF-Vorhaben ZN428.