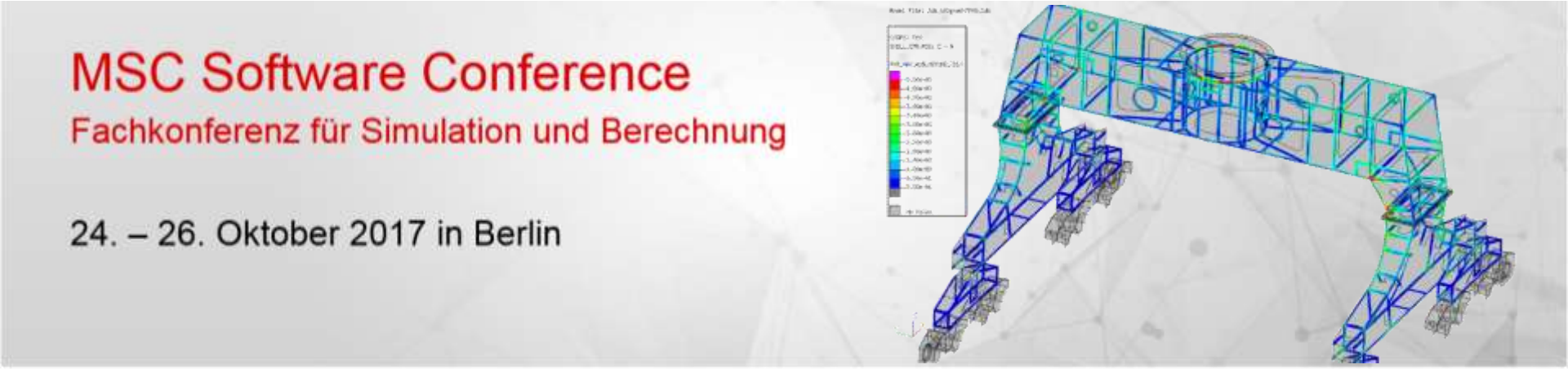
# Effiziente Schweißnahtbewertung anhand eines 120t-Baggerportals

**CAE Simulation & Solutions** Maschinenbau Ingenieurdienstleistungen GmbH
*Krach W., Wimmer W.*
**Albatros** Engineering GmbH
*Ströbitzer, W.*

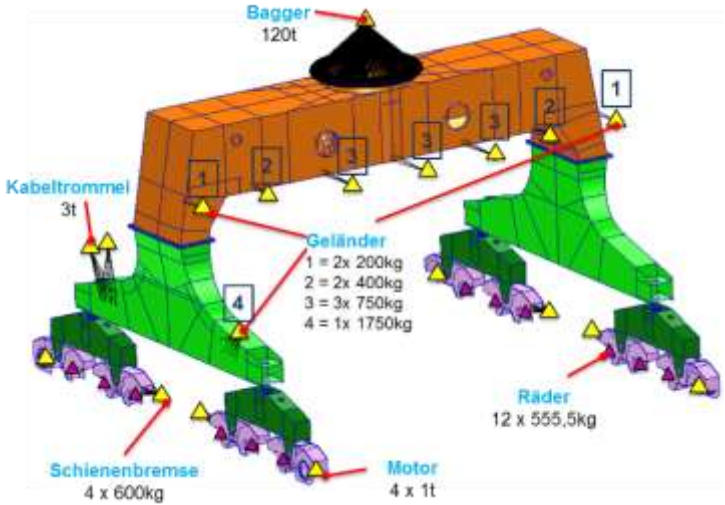


## Aufgabenstellung

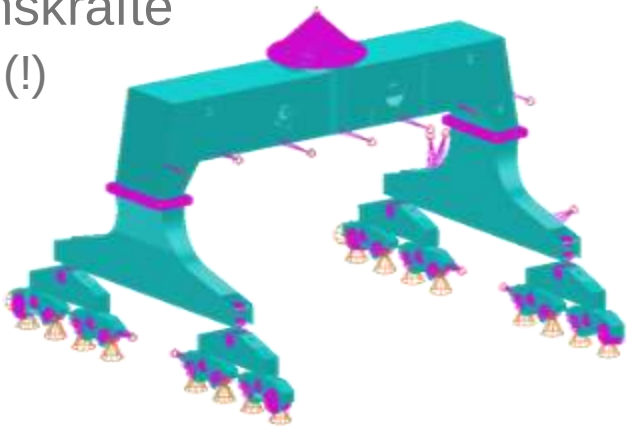
- Auslegung Baggerportal
- Schnittstelle = Vorgabe Baggerhersteller
- Bestimmung ‚Balkenquerschnitte‘
- Bestimmung Blechdicken
- Festlegung Schweißnahtart und Schweißnahtquerschnitt

## Modellierung

- Schalenmittelflächen
- Massenpunkte
  - Masse ca. 80t
  - Baggermasse 120t

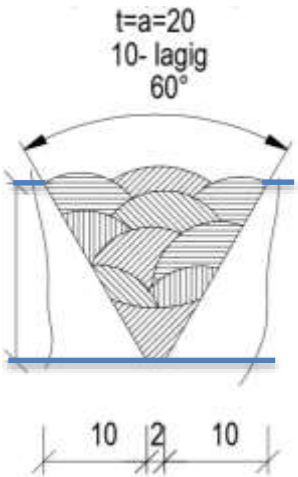


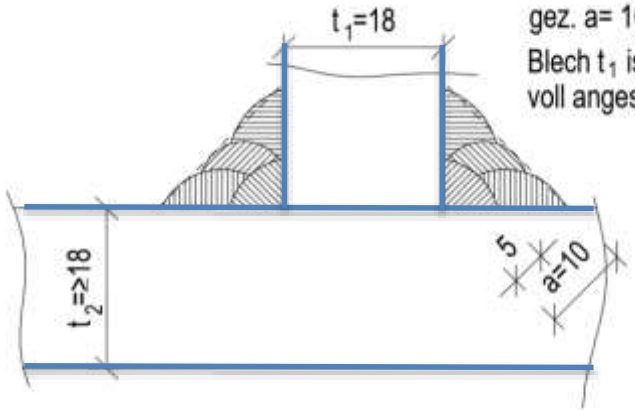
- Reaktionskräfte
  - Kippen (!)



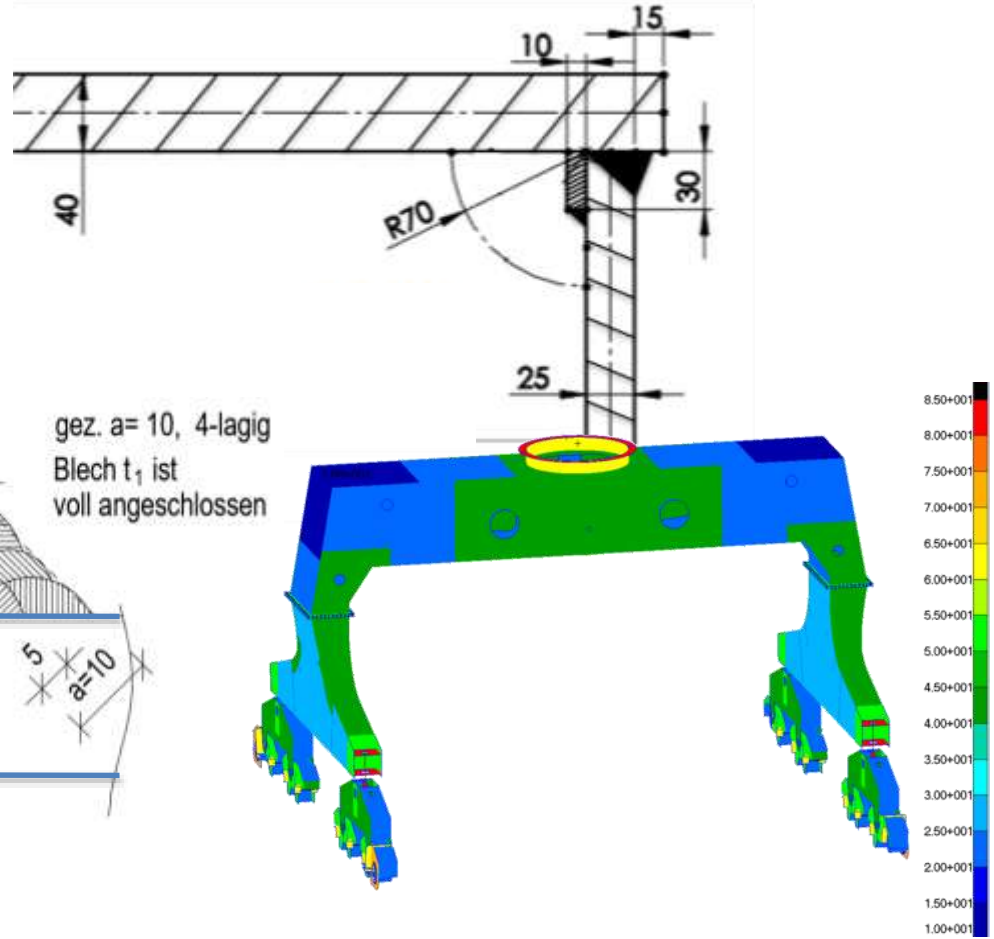
## Modellierung

- Schweißnähte
  - a = t
  - Nahtart undefiniert
  - Annahme = V-Naht (!)
  - Beispiele:



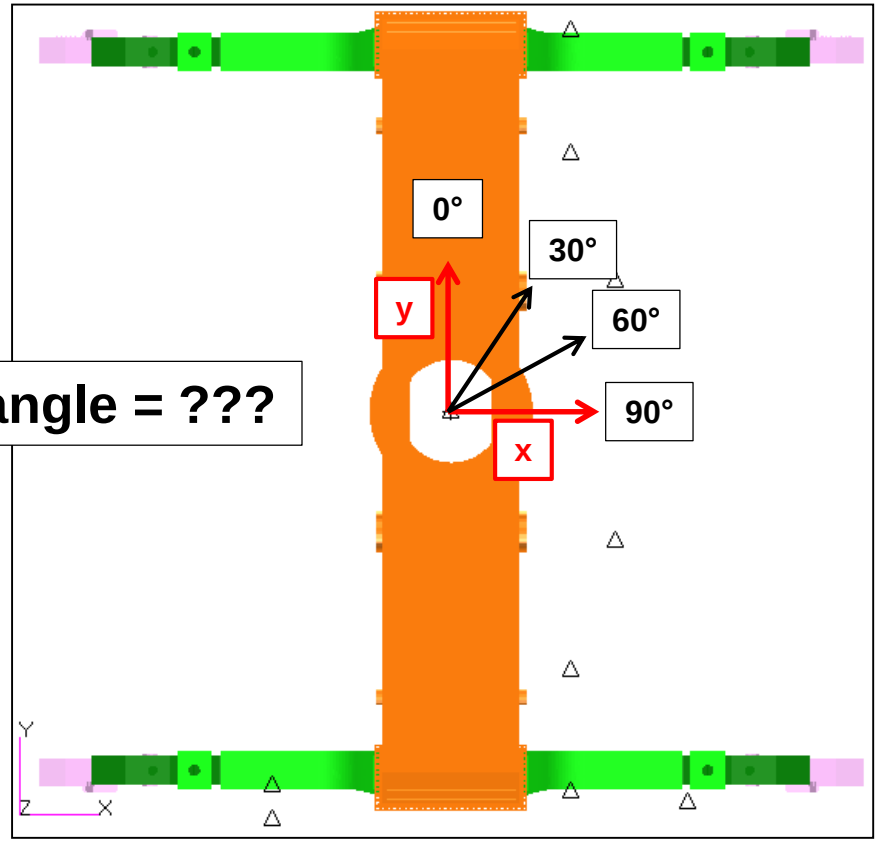




gez. a= 10, 4-lagig
Blech $t_1$ ist
voll angeschlossen



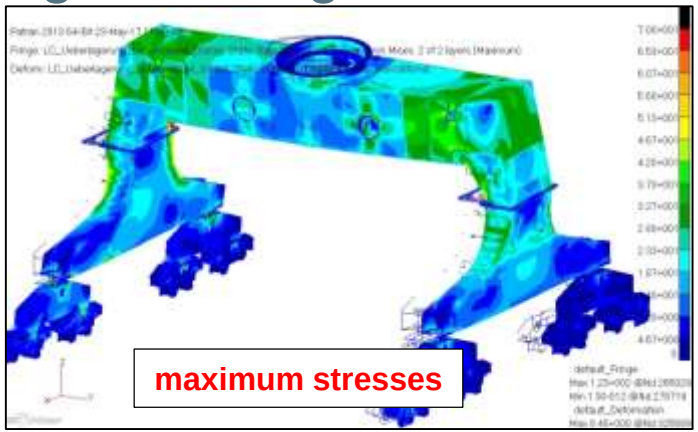
# Fatigue Load - Lebensdauer

- Überlagerung_Leben – 0°
  - Fx_175kN
    - » x = 0 kN
    - » y = 175 kN
    - » ∑ = 175 kN
  - My_4043 kNm
    - » x = 0 kNm
    - » y = 4.043 kNm
    - » ∑ = 4.043 kNm
  - Mz_420 kNm
    - » z = 420 kNm
    - » ∑ = 420 kNm

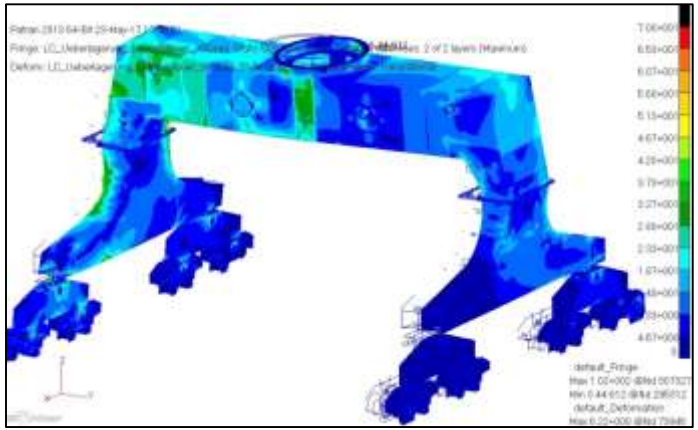


## Fatigue loading – Lebensdauer – Front view (70MPa, D-Scale 100)

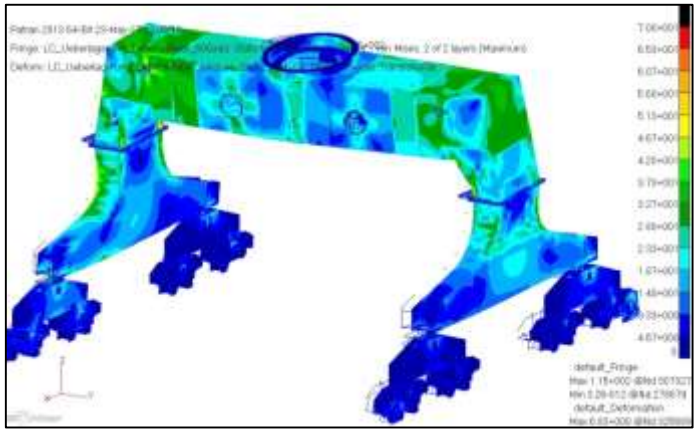
0°



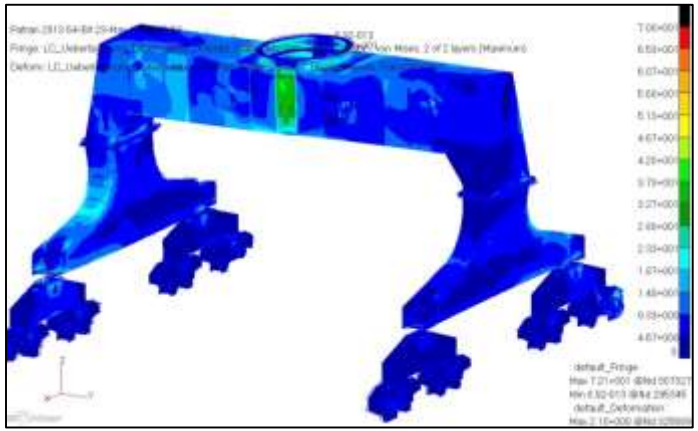

30°



60°

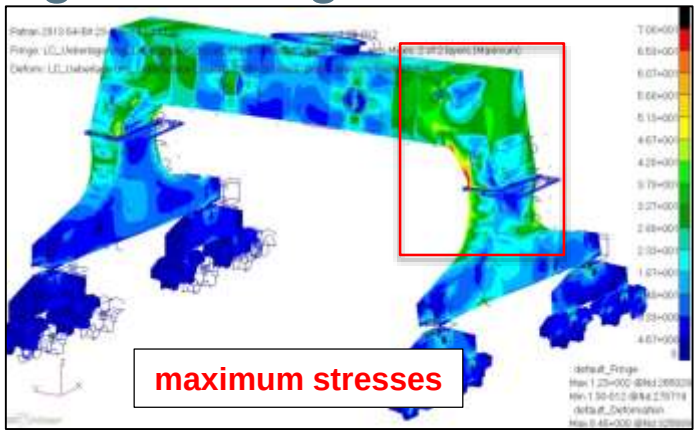


90°

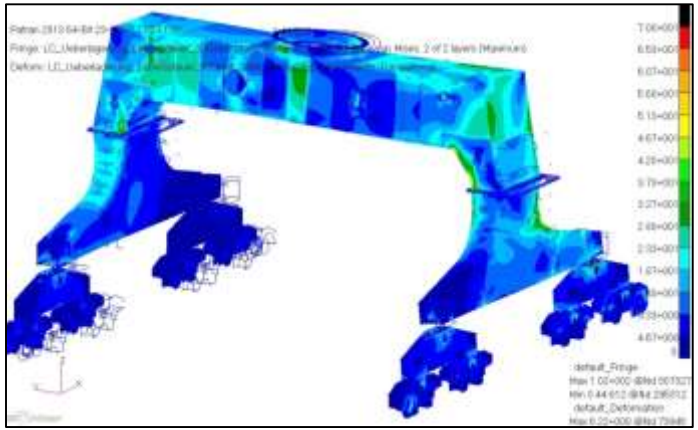


# Fatigue loading – Lebensdauer – Back view (70MPa, D-Scale 100)

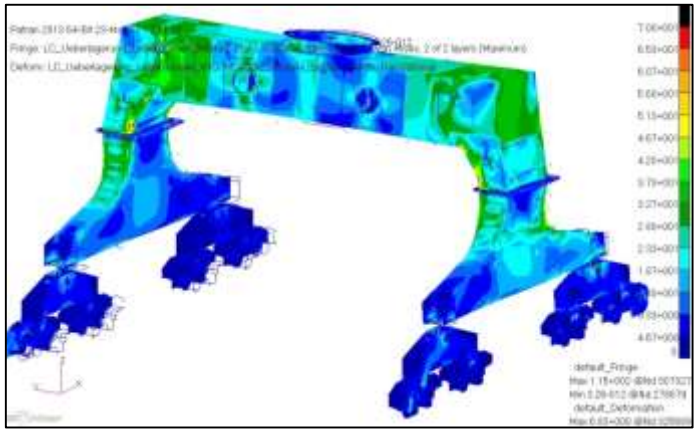
0°



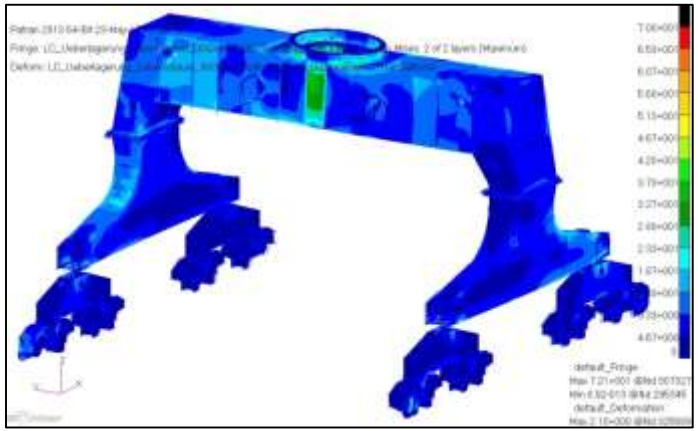

30°



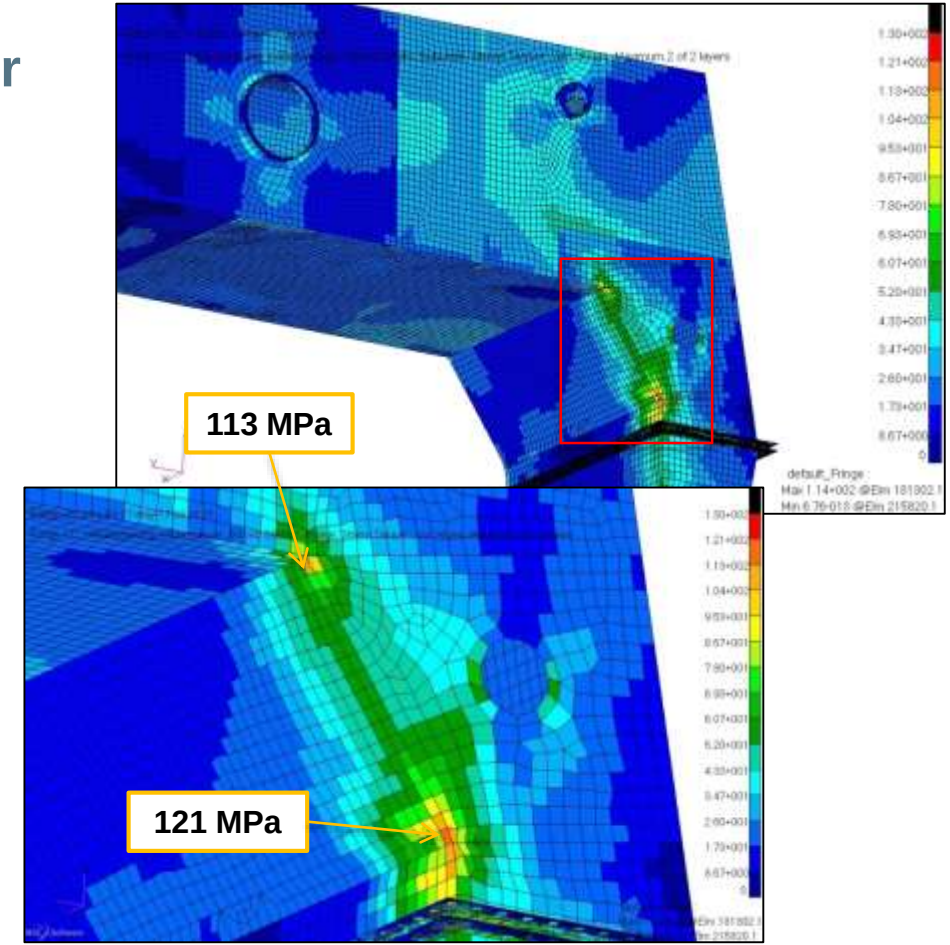
60°



90°



- Fatigue loading – Lebensdauer
- 10 Jahre haltbar ???
- Spannungsschwingbreiten?
- Normbewertung nach EC3
- FKM-Richtlinie
- …



# Fatigue evaluation – LIMIT Load case Overview

Loads

| Name | Load Group | FE Result | Factor/Channel |
|---|---|---|---|
| LOAD_LC_Ueberlagerung_Lebensdauer_0Grad | Default | LC_Ueberlagerung_Lebensdauer_0Grad | 1.0 |
| LOAD_LC_Ueberlagerung_Lebensdauer_120Grad | Default | LC_Ueberlagerung_Lebensdauer_0Grad | -0.5 |
| | | LC_Ueberlagerung_Lebensdauer_90Grad | 0.866 |
| LOAD_LC_Ueberlagerung_Lebensdauer_150Grad | Default | LC_Ueberlagerung_Lebensdauer_0Grad | -0.866 |
| | | LC_Ueberlagerung_Lebensdauer_90Grad | 0.5 |
| LOAD_LC_Ueberlagerung_Lebensdauer_300Grad | Default | LC_Ueberlagerung_Lebensdauer_0Grad | 0.5 |
| | | LC_Ueberlagerung_Lebensdauer_90Grad | -0.866 |
| LOAD_LC_Ueberlagerung_Lebensdauer_330Grad | Default | LC_Ueberlagerung_Lebensdauer_0Grad | 0.866 |
| | | LC_Ueberlagerung_Lebensdauer_90Grad | -0.5 |
| LOAD_LC_Ueberlagerung_Lebensdauer_null | Default | LC_Ueberlagerung_Lebensdauer_0Grad | 0.0 |
| LOAD_LC_Ueberlagerung_Lebensdauer_180Grad | Default | LC_Ueberlagerung_Lebensdauer_0Grad | -1.0 |
| LOAD_LC_Ueberlagerung_Lebensdauer_30Grad | Default | LC_Ueberlagerung_Lebensdauer_30Grad | 1.0 |
| LOAD_LC_Ueberlagerung_Lebensdauer_210Grad | Default | LC_Ueberlagerung_Lebensdauer_30Grad | -1.0 |
| LOAD_LC_Ueberlagerung_Lebensdauer_60Grad | Default | LC_Ueberlagerung_Lebensdauer_60Grad | 1.0 |
| LOAD_LC_Ueberlagerung_Lebensdauer_240Grad | Default | LC_Ueberlagerung_Lebensdauer_60Grad | -1.0 |
| LOAD_LC_Ueberlagerung_Lebensdauer_90Grad | Default | LC_Ueberlagerung_Lebensdauer_90Grad | 1.0 |
| LOAD_LC_Ueberlagerung_Lebensdauer_270Grad | Default | LC_Ueberlagerung_Lebensdauer_90Grad | -1.0 |

**Lastfall-kombinationen**

Selected:

LOAD_LC_Ueberlagerung_Lebensdauer_0Grad
LOAD_LC_Ueberlagerung_Lebensdauer_120Grad
LOAD_LC_Ueberlagerung_Lebensdauer_150Grad
LOAD_LC_Ueberlagerung_Lebensdauer_180Grad
LOAD_LC_Ueberlagerung_Lebensdauer_210Grad
LOAD_LC_Ueberlagerung_Lebensdauer_240Grad
LOAD_LC_Ueberlagerung_Lebensdauer_270Grad
LOAD_LC_Ueberlagerung_Lebensdauer_300Grad
LOAD_LC_Ueberlagerung_Lebensdauer_30Grad
LOAD_LC_Ueberlagerung_Lebensdauer_330Grad
LOAD_LC_Ueberlagerung_Lebensdauer_60Grad
LOAD_LC_Ueberlagerung_Lebensdauer_90Grad
LOAD_LC_Ueberlagerung_Lebensdauer_null

**← 360 Grad**

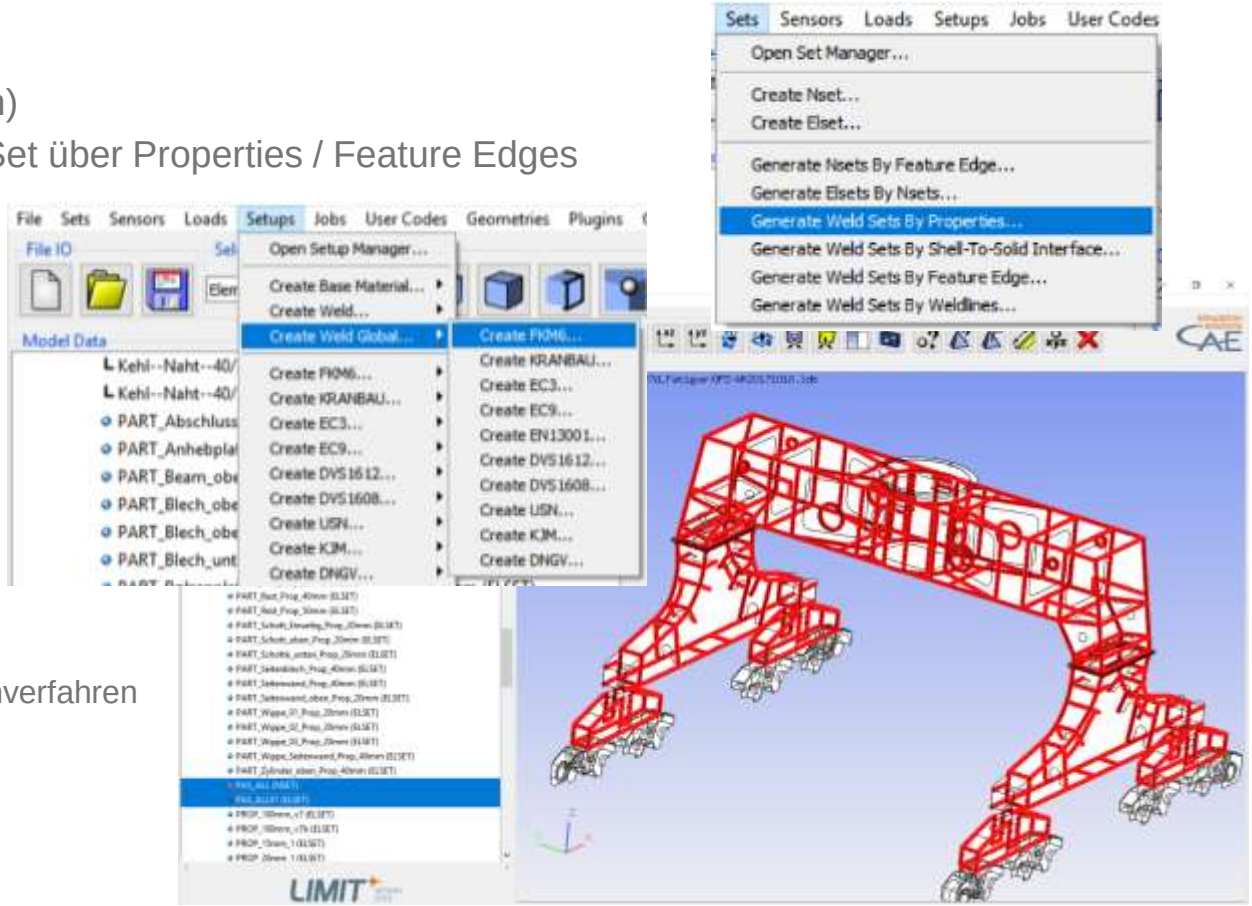
**180 Grad →**

Selected:

LOAD_LC_Ueberlagerung_Lebensdauer_0Grad
LOAD_LC_Ueberlagerung_Lebensdauer_120Grad
LOAD_LC_Ueberlagerung_Lebensdauer_150Grad
LOAD_LC_Ueberlagerung_Lebensdauer_180Grad
LOAD_LC_Ueberlagerung_Lebensdauer_30Grad
LOAD_LC_Ueberlagerung_Lebensdauer_60Grad
LOAD_LC_Ueberlagerung_Lebensdauer_90Grad
LOAD_LC_Ueberlagerung_Lebensdauer_null

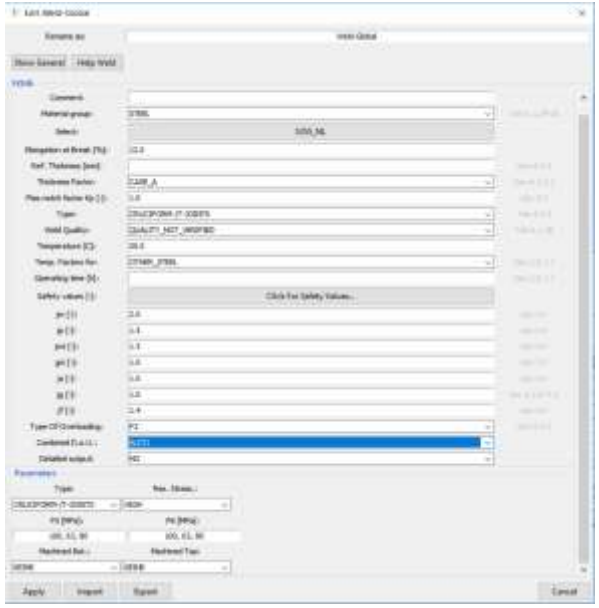
# LIMIT

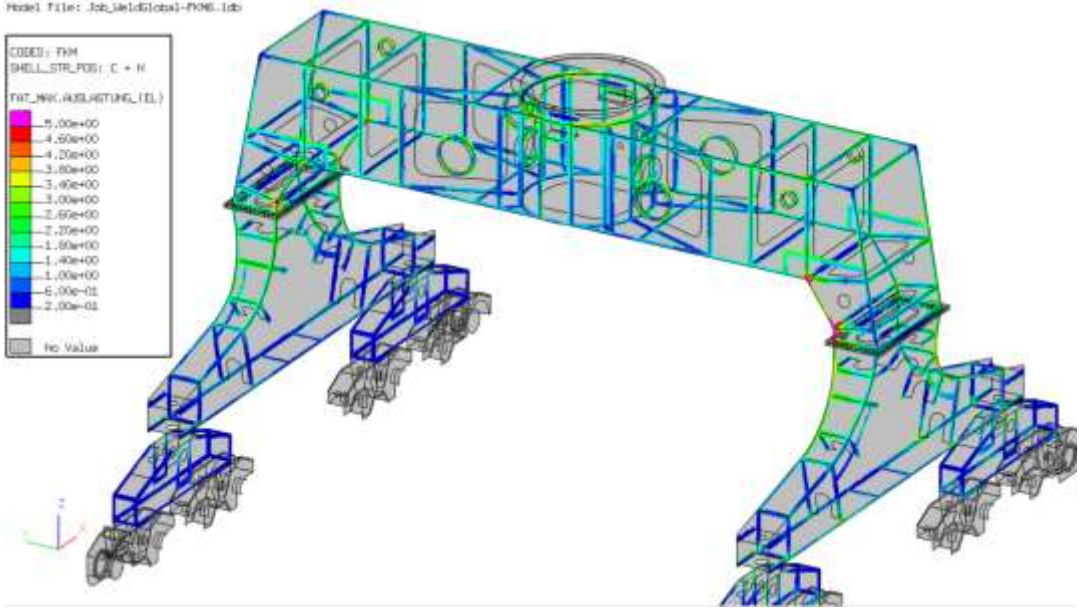
- Method: Weld global (1h)
  - Element Set / Knoten Set über Properties / Feature Edges
    - » PAS_ALL
  - Create Weld Global
    - » Normenauswahl FKM6
  - Vorteile
    - » Sehr schnell
    - » Globaler Überblick
  - Nachteile
    - » a=t
    - » Längs / Quer / Schub
    - » kritisches Schnittebenenverfahren crit. Planes



# LIMIT

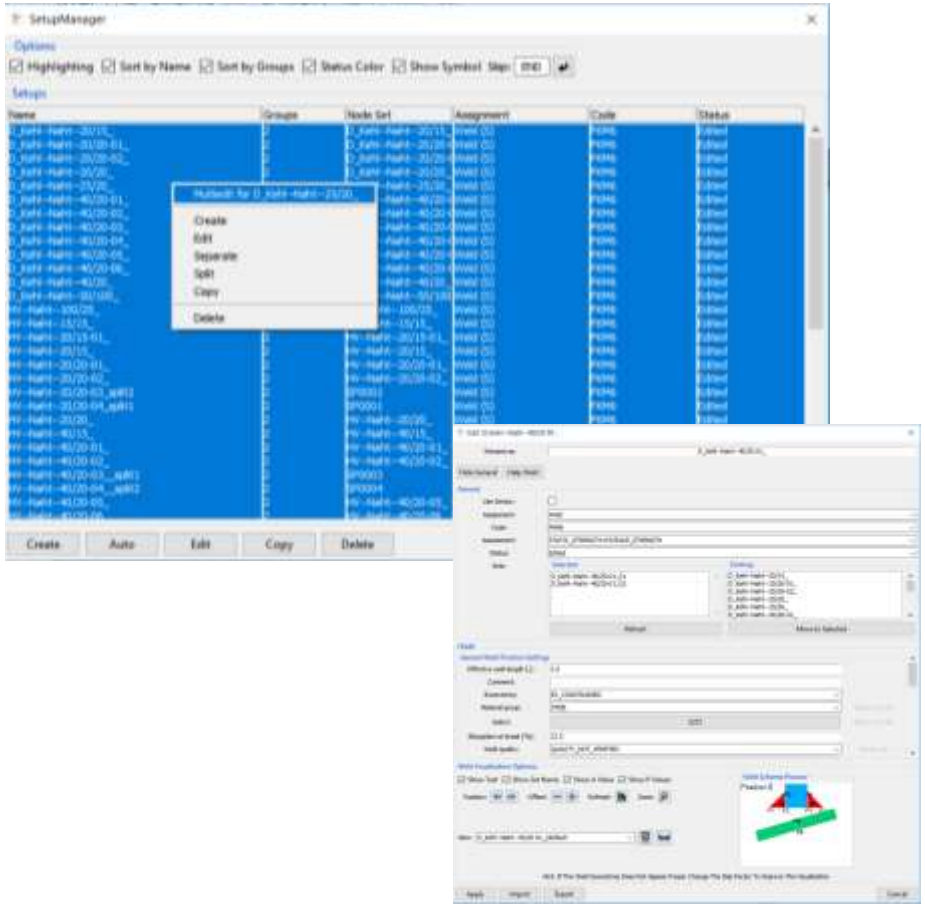
- Method: Weld global (1h)
  - » critical Plane – kritisches Schnittebenenverfahren
  - » Daher SEHR konservativ, weil Schnittebenenverfahren höchste Spannung in Richtung der geringsten zulässigen Spannung legt!
  - » Längs / quer / Schub trotzdem sinnvoll (Interaktion)





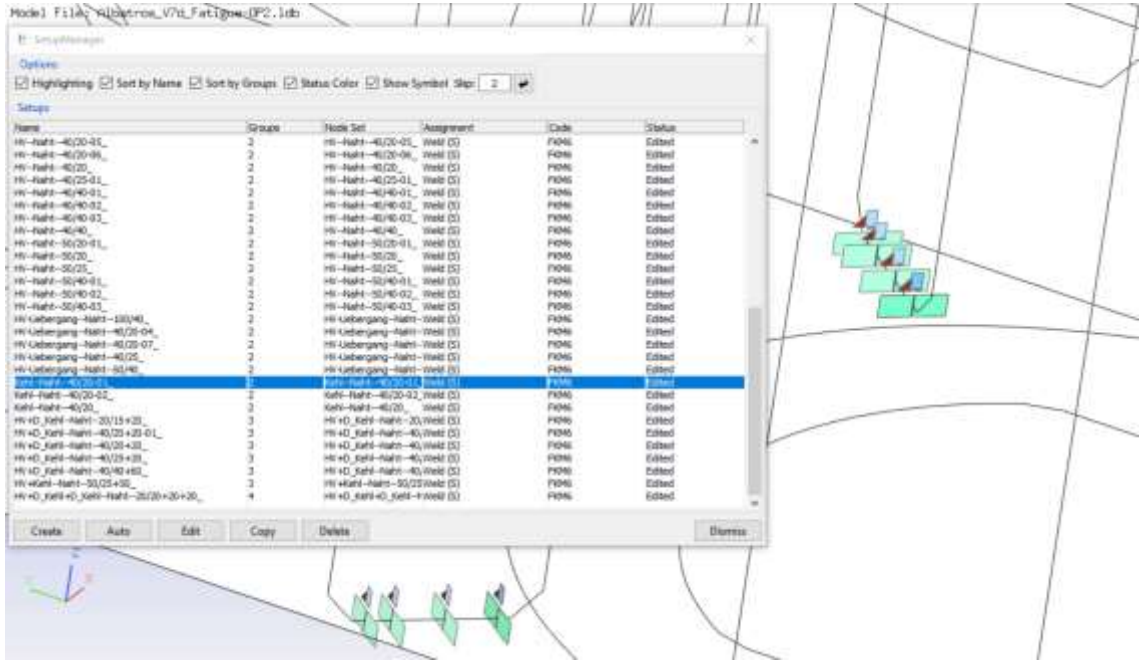
# LIMIT

- Method: Multiedit (3h)
  - Bestimmung der relevanten Schweißnähte
  - Normenauswahl
    - » Nahttypen teilen
    - » a= 0.8*t
    - » Längs / Quer / Schub
    - » 2 Durchläufe wegen einseitiger Kehlnähte
  - Vorteile
    - » schnell
    - » Guter Überblick
    - » Berücksichtigung der Nahtrichtung!
  - Nachteile
    - » Nahtgruppenbewertung



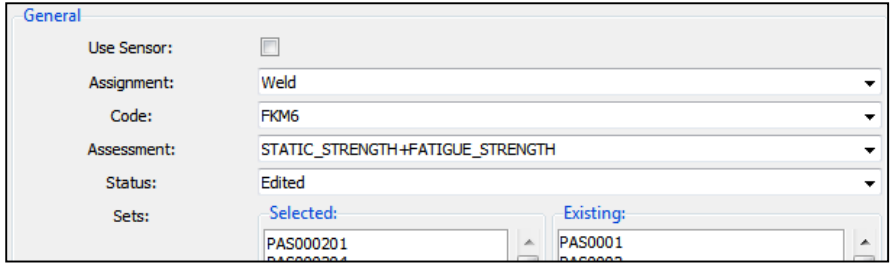
# LIMIT

- Method: Schweißnahtdefinitionen (3 Tage)
  - Bewertung der relevanten Schweißnähte
  - Normenauswahl
    - » a= 0.8*t
    - » Längs / Quer / Schub
    - » Bilder Nähte
    - » Kehlnaht
    - » V-Naht
    - » 100% Prüfung



# LIMIT - Weld line evaluation – Lebensdauer

- Weld line assessment using LIMIT
- FKM 6th edition
- STATIC assessment
- Fatigue assessment




- static safety factor

Static Safety Factor: jp, jm, jpt, jmt (Tab. 3.5.1)

| | HIGH Consequ. Of Failure | MEAN Consequ. Of Failure | MODERATE Consequ. Of Failure |
|---|---|---|---|
| HIGH Prob. Of Stress Comb. Occur. | jm=2.0<br>jp=1.5<br>jmt=1.5<br>jpt=1.0 | jm=1.85<br>jp=1.4<br>jmt=1.4<br>jpt=1.0 | jm=1.75<br>jp=1.3<br>jmt=1.3<br>jpt=1.0 |
| LOW Prob. Of Stress Comb. Occur. | jm=1.8<br>jp=1.35<br>jmt=1.35<br>jpt=1.0 | jm=1.7<br>jp=1.25<br>jmt=1.25<br>jpt=1.0 | jm=1.6<br>jp=1.2<br>jmt=1.2<br>jpt=1.0 |

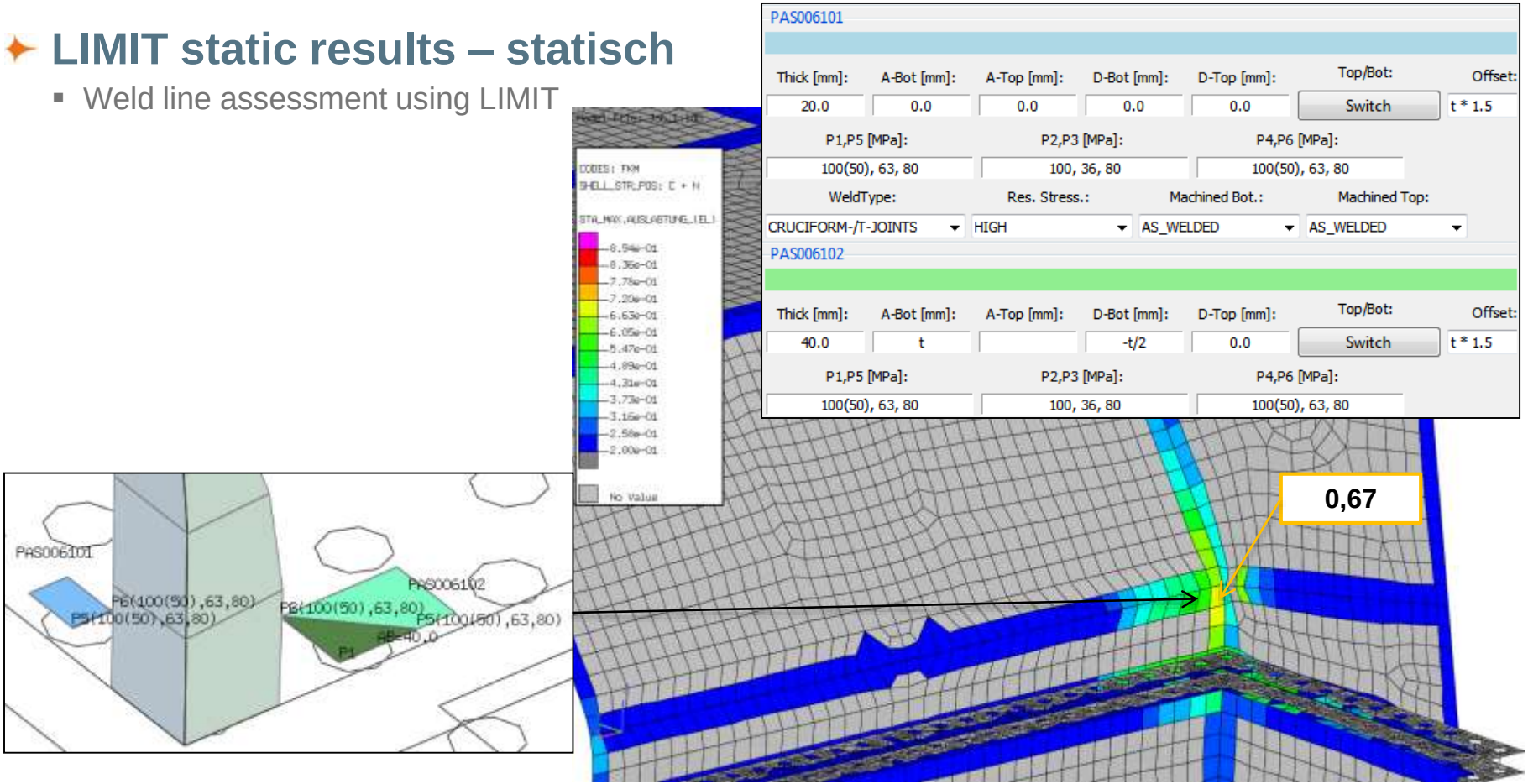
- Material safety factor Fatigue assessment

Material Safety Factors For Welded Components: jf (Tab 4.5.3)

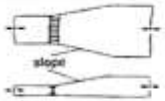
| | HIGH Consequ. Of Failure | MEAN Consequ. Of Failure | MODERATE Consequ. Of Failure |
|---|---|---|---|
| NO Regular Inspection | jf=1.4 | jf=1.25 | jf=1.15 |
| YES Regular Inspection | jf=1.2 | jf=1.1 | jf=1.0 |

# LIMIT static results – statisch

- Weld line assessment using LIMIT



## HV weld, transition in thickness

| No. | Structural detail | Description | FAT Steel | FAT Al |
|---|---|---|---|---|
| 300 | Longitudinally loaded welds | | | |
| 313 | | Longitudinally loaded butt weld, without stop/start positions, NDT, with stop/start positions. | 100<br>90 | 40<br>36 |
| 200 | Butt welds, transversely loaded | | | |
| 222 |   | Transversely loaded butt weld made in shop, welded in flat position, weld profile controlled, NDT, with transition in thickness and width, *1<br>slope 1:5<br>slope 1:3<br>slope 1:2<br>Some misalignment is already allowed for by the fatigue class. | 90<br>80<br>72 | 32<br>28<br>25 |
| 215 | | Transversely loaded butt weld on permanent backing bar, root crack. *1 | 71 | 25 |

**P1 – P6**

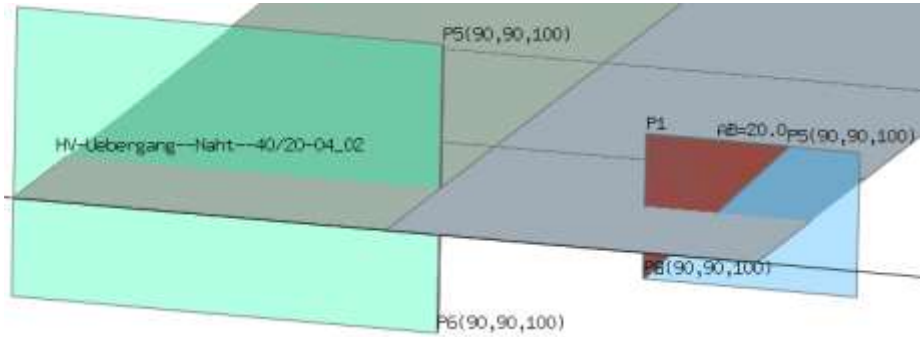
**P1, P5, P4, P6**

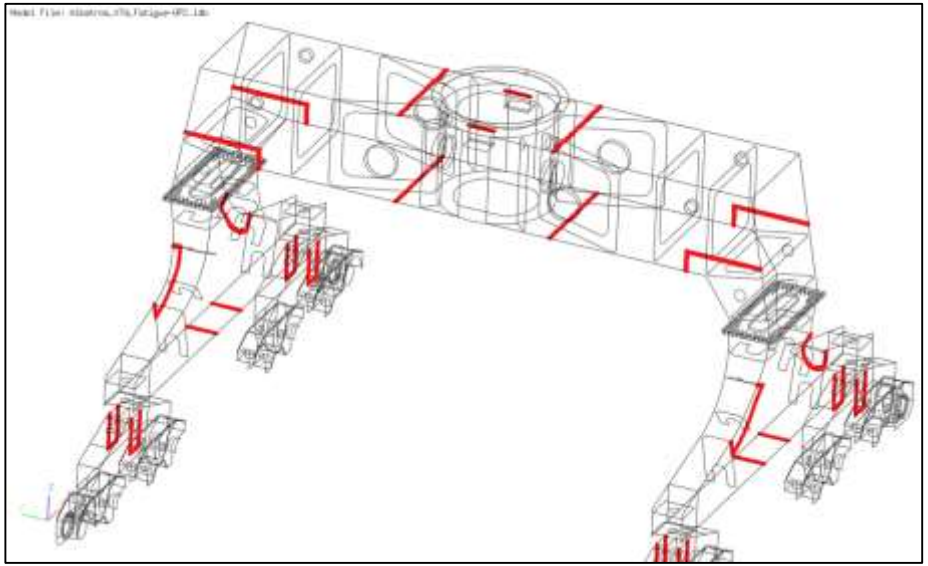
**P3**

Table 5.4.2 Fatigue classes for nominal stress (shear stress), according to *Hobbacher* /13/

| No. | Structural detail | Description | FAT Steel | FAT Al |
|---|---|---|---|---|
| 1 | | Full penetration butt welds. | 100 | 36 |

**P1 – P6**



## double fillet weld

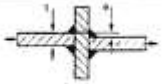
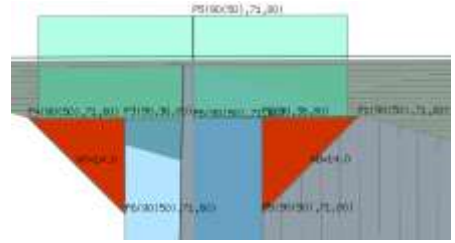
| No. | Structural detail | Description | FAT Steel | FAT Al |
|---|---|---|---|---|
| 300 | Longitudinally loaded welds | | | |
| 323 | | Continuous manual longitudinal fillet or butt weld (based on stress range in flange). | 90 | 36 |
| 500 | Non-load carrying attachments | | | |
| 521 | | Longitudinal fillet welded gusset at length l<br>L ≤ 50 mm<br>50 mm < L ≤ 150 mm<br>150 mm < L ≤ 300 mm<br>300 mm < Ll<br>gusset near edge: see 525 "flat side gusset". | <br><br>80<br>71<br>63<br>50 | <br><br>28<br>25<br>20<br>18 |
| 400 | Cruciform joints and/or T-joints | | | |
| 413 |  | Cruciform joint or T-joint, fillet welds or partial penetration K-butt welds, no lamellar tearing, toe crack.<br>Misalignment e < 0.15 · t,<br>No misalignment. | <br><br>63<br>71 | <br><br>22<br>25 |
| 414 | | Cruciform joint or T-joint, fillet welds or partial penetration K-butt welds including toe ground joints, root crack.<br>Analysis based on stress in weld<br>σ = F/Σ(a · l) l length of the weld joint<br>for a/t ≤ 1/3 t sheet metal thickness | <br><br><br><br>36<br>40 | <br><br><br><br>12<br>14 |

Table 5.4.2 Fatigue classes for nominal stress (shear stress), according to *Hobbacher* /13/

| No. | Structural detail | Description | FAT Steel | FAT Al |
|---|---|---|---|---|
| 2 | | Fillet welds,<br>partial penetration butt welds. | 80 | 28 |

P1 – P6

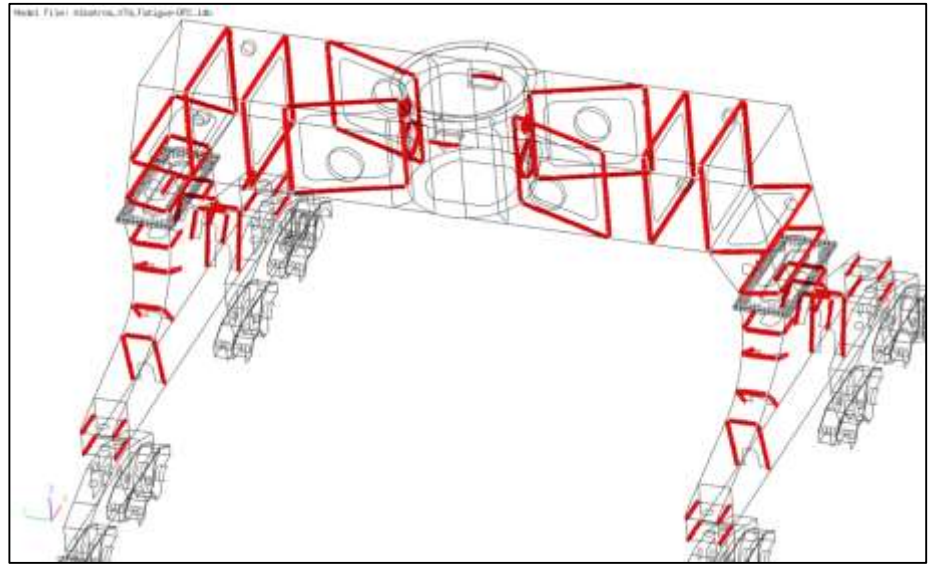


(P1 – P6)

P1, P5, P4, P6

P3

P1 – P6



## HV + double fillet weld + double fillet weld

| No. | Structural detail | Description | FAT Steel | FAT Al |
|---|---|---|---|---|
| 300 | Longitudinally loaded welds | | | |
| 323 | | Continuous manual longitudinal fillet or butt weld (based on stress range in flange). | 90 | 36 |
| 500 | Non-load carrying attachments | | | |
| 521 | | Longitudinal fillet welded gusset at length l<br>L ≤ 50 mm<br>50 mm < L ≤ 150 mm<br>150 mm < L ≤ 300 mm<br>300 mm < Ll<br>gusset near edge: see 525 "flat side gusset". | <br><br>80<br>71<br>63<br>50 | <br><br>28<br>25<br>20<br>18 |
| 400 | Cruciform joints and/or T-joints | | | |
| 413 | | Cruciform joint or T-joint, fillet welds or partial penetration K-butt welds, no lamellar tearing, toe crack.<br>Misalignment e < 0.15 · t,<br>No misalignment. | <br><br>63<br>71 | <br><br>22<br>25 |
| 414 | | Cruciform joint or T-joint, fillet welds or partial penetration K-butt welds including toe ground joints, root crack.<br>Analysis based on stress in weld<br>σ = F/Σ(a · l) l length of the weld joint<br>for a/t ≤ 1/3 t sheet metal thickness | <br><br><br>36<br>40 | <br><br><br>12<br>14 |

Table 5.4.2 Fatigue classes for nominal stress (shear stress), according to *Hobbacher* /13/

| No. | Structural detail | Description | FAT Steel | FAT Al |
|---|---|---|---|---|
| 2 | | Fillet welds,<br>partial penetration butt welds. | 80 | 28 |

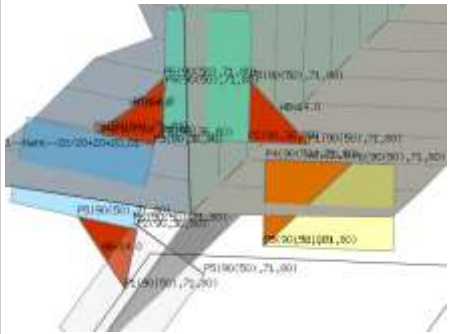
P1 – P6

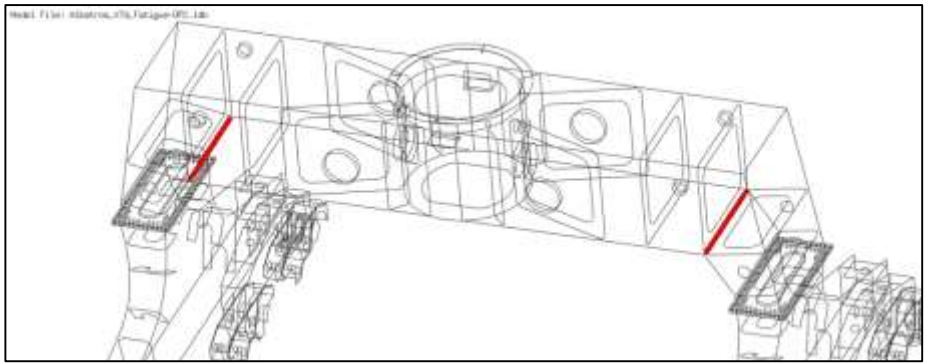
(P1 – P6)

P1, P5, P4, P6

P3

P1 – P6

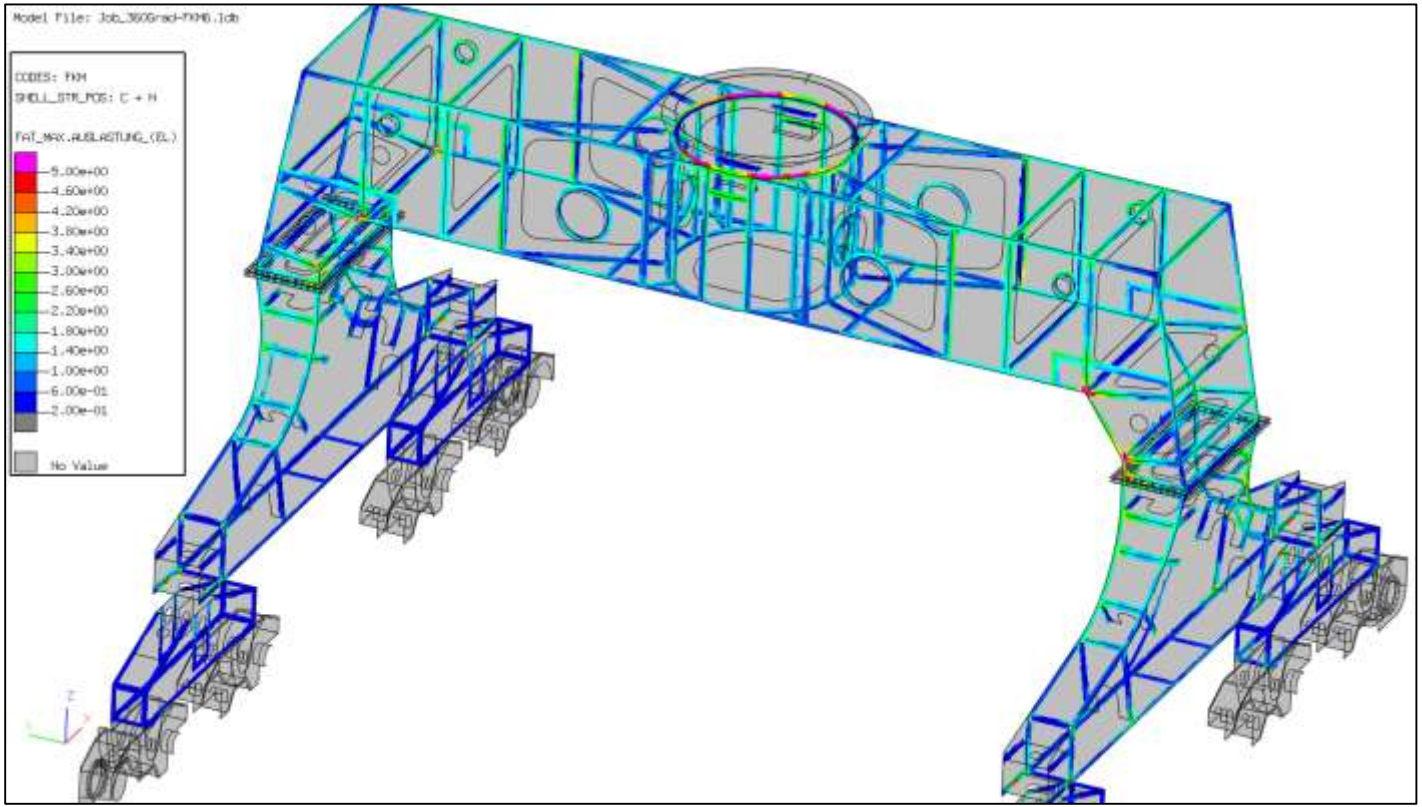




**double fillet weld defintion → worst case**

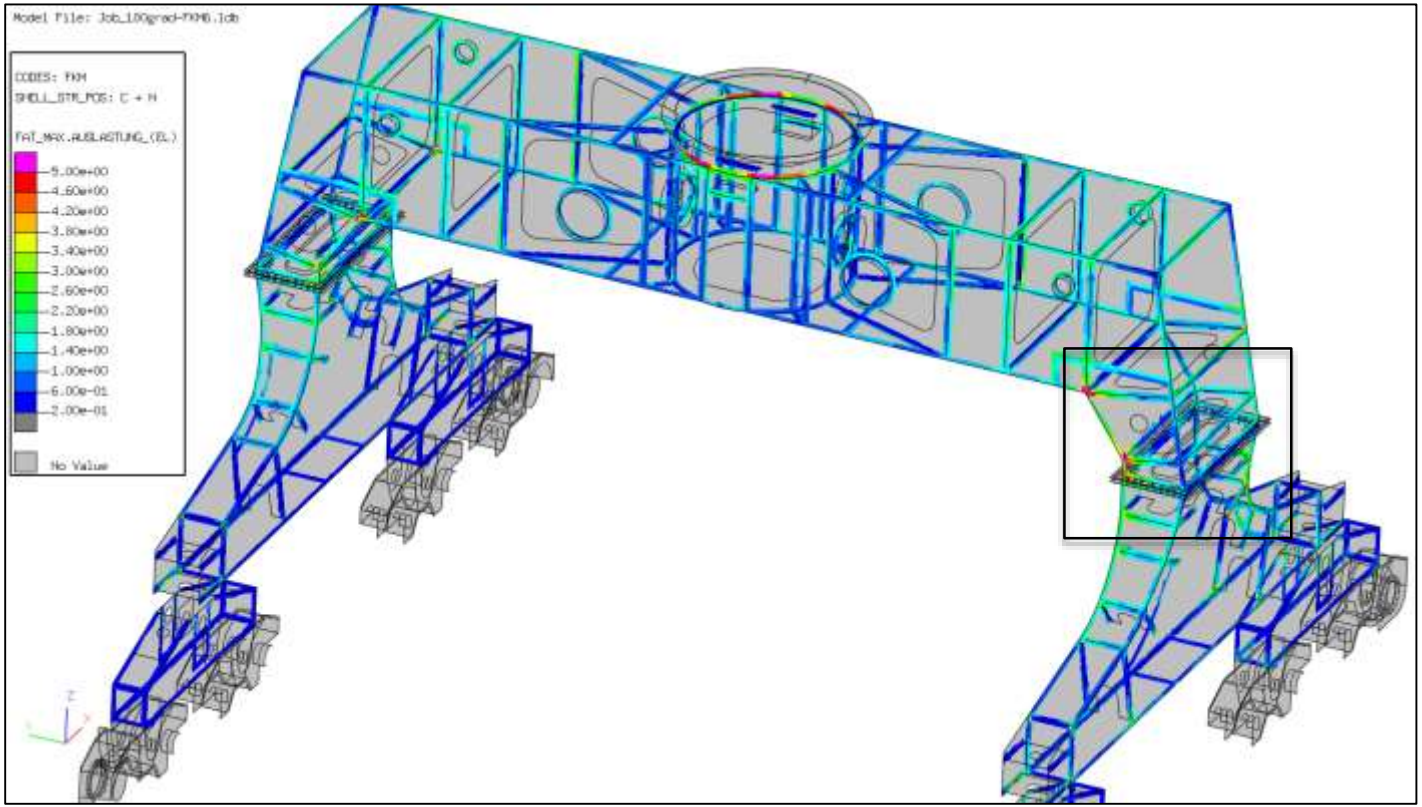
# Fatigue evaluation – Lebensdauer – 360 Grad – LIMIT

**scale to 5.0 (max)**
**→ welds overloaded according to FKM 6th under current load assumptions**

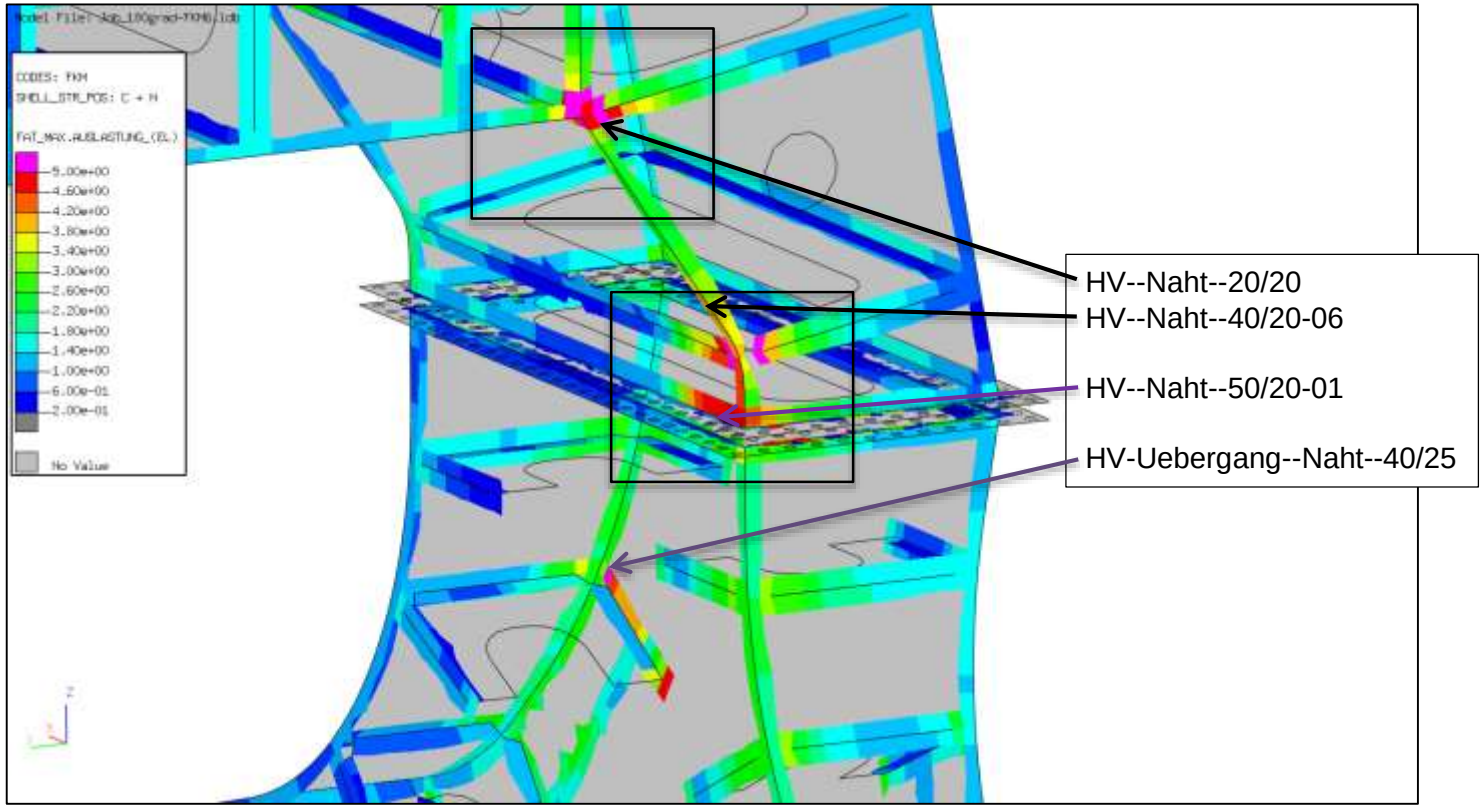


# Fatigue evaluation – Lebensdauer – 180 Grad – LIMIT

**scale to 5.0 (max)**
**→ welds overloaded according to FKM 6th under current load assumptions**



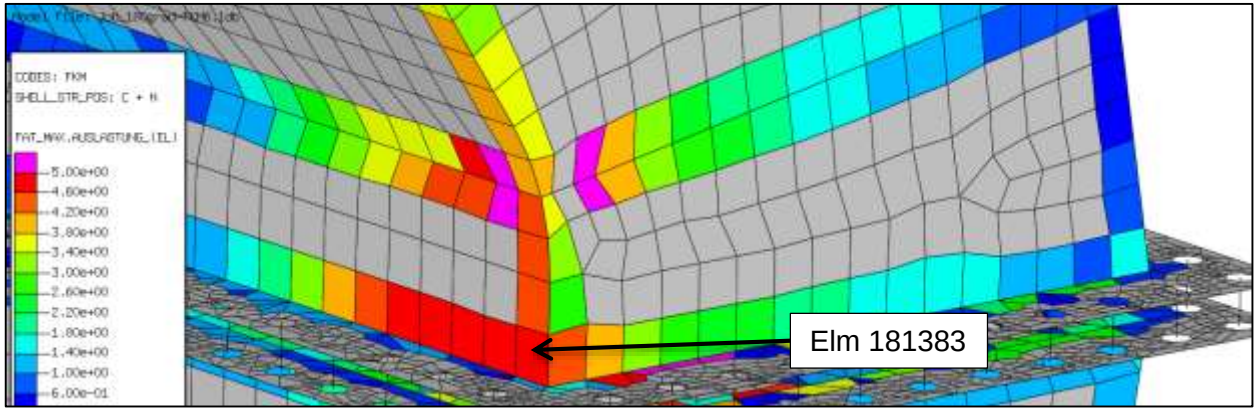
# Fatigue evaluation – Lebensdauer – 180 Grad – LIMIT



# Fatigue evaluation – 180 Grad – LIMIT

## Query function

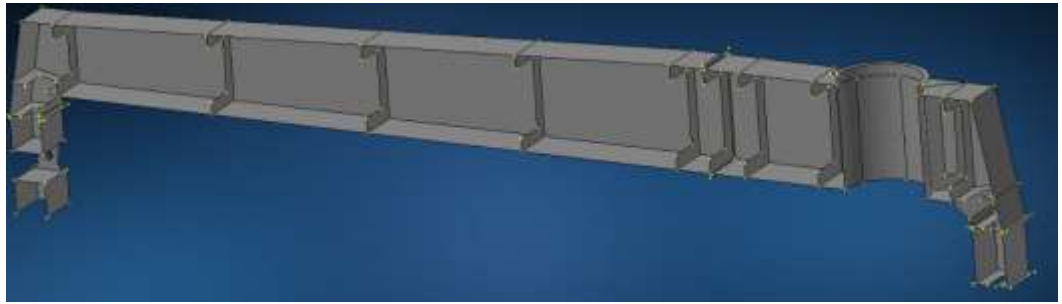
Node + Max.Auslastung
weld set name
between these Loadcases
which Point and FAT-number

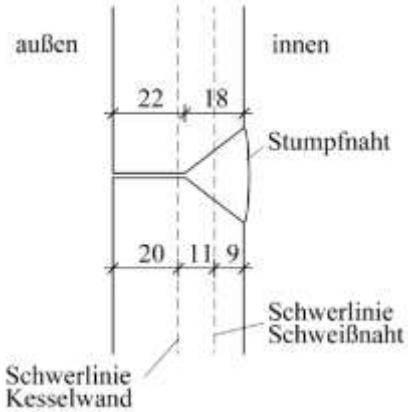


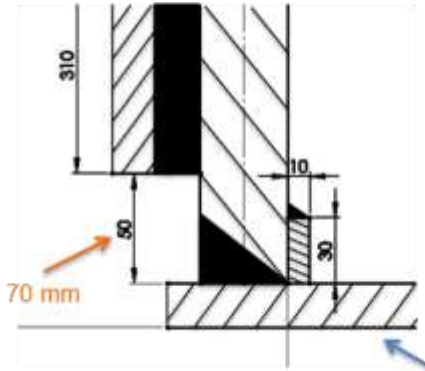

Element Id: 181383; Elset(s): HV--Naht--40/20-06_01, HV--Naht--50/20-01_01, _A_20.0__D_-10.0__ESN, _T_20.0__ESN_A_20.0__D_-10.0Results for FAT_MAX.AUSLASTUNG:
--
Node 259344: 3.6115 -> Set: HV--Naht--50/20-01_01_
LCs:(LOAD_LC_UEBERLAGERUNG_LEBENSDAUER_0GRAD)<>(LOAD_LC_UEBERLAGERUNG_LEBENSDAUER_180GRAD)
P1__1(FAT90/FAT80/FAT80)__2(FAT90/FAT71/FAT80)__5(FAT90/FAT80/FAT80)
Node 272523: 0.2 -> Set: not_analyzed
Node 269223: 3.9334 -> Set: HV--Naht--40/20-06_01_
Node 259328: 4.7475 -> Set: HV--Naht--50/20-01_01_
LCs:(LOAD_LC_UEBERLAGERUNG_LEBENSDAUER_0GRAD)<->(LOAD_LC_UEBERLAGERUNG_LEBENSDAUER_180GRAD)
P1__1(FAT90/FAT80/FAT80)__2(FAT90/FAT71/FAT80)__5(FAT90/FAT80/FAT80)

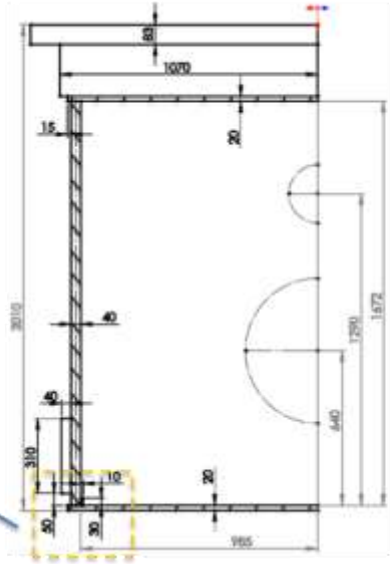
## Ergebnis

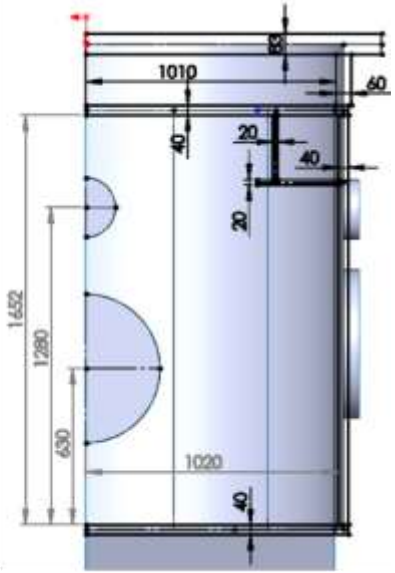
- Konstruktion
- Blechstärken
- Schweißnahtfestlegung
- Inspektionsplan
  - Wo kontrollieren?





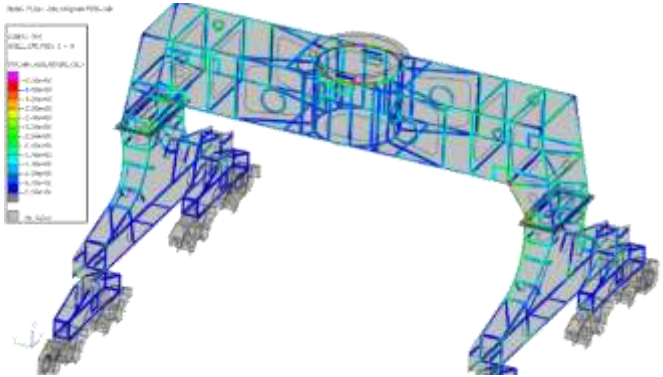





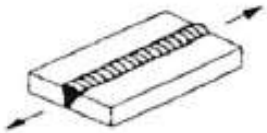
## Zusammenfassung

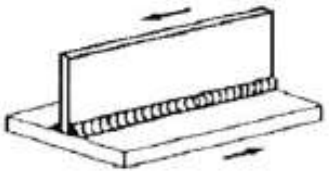
- FE Modellierung
  - Schalenmodell
- Lasten
  - Von Baggerlieferanten
  - 360° Rotation vs. 180° Rotation
- Lebensdauerbewertung in 3 Schritten
  - Weld Global = kritisches Schnittebenenverfahren
  - Multiedit von Nahtgruppen (Kehlnaht, V-Naht, …)
  - Einzelnahtbewertung (z.B. Röntgenprüfung)
- Schweißnahtfestlegung
  - Normbewertung (FKM) wegen Sicherheit
  - Kostenreduktion soweit möglich (Schweißzeiten)
  - Bewusstsein für Schweißnähte schaffen (!)

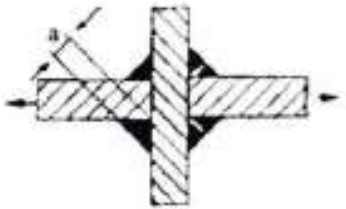


# LIMIT

- Method: Ausblick Smart Multiedit (3h)
  - Bestimmung der relevanten Schweißnähte
  - Automatisierte Erkennung der Nahttypen
    - » Stumpfnaht
    - » T-Stoß (Kehlnaht, V-Naht)
    - » Kreuzstoß
  - Normenauswahl
    - » a= 0.8*t
    - » Längs / Quer / Schub

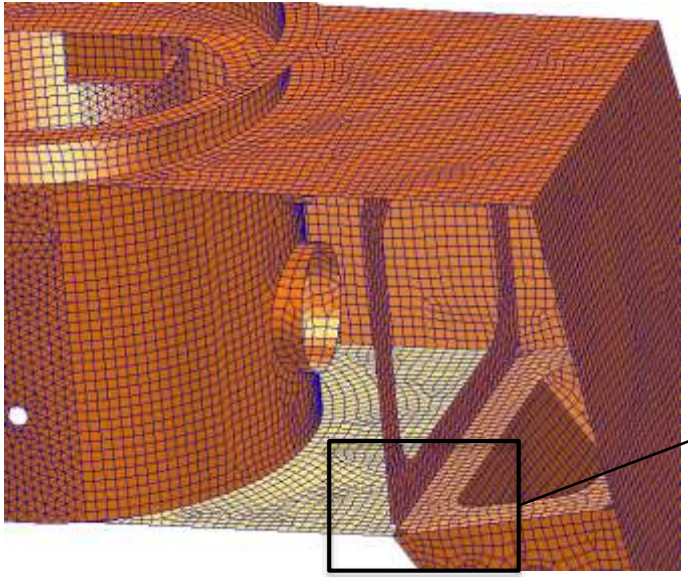


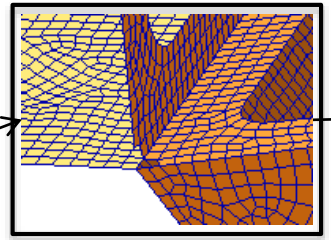


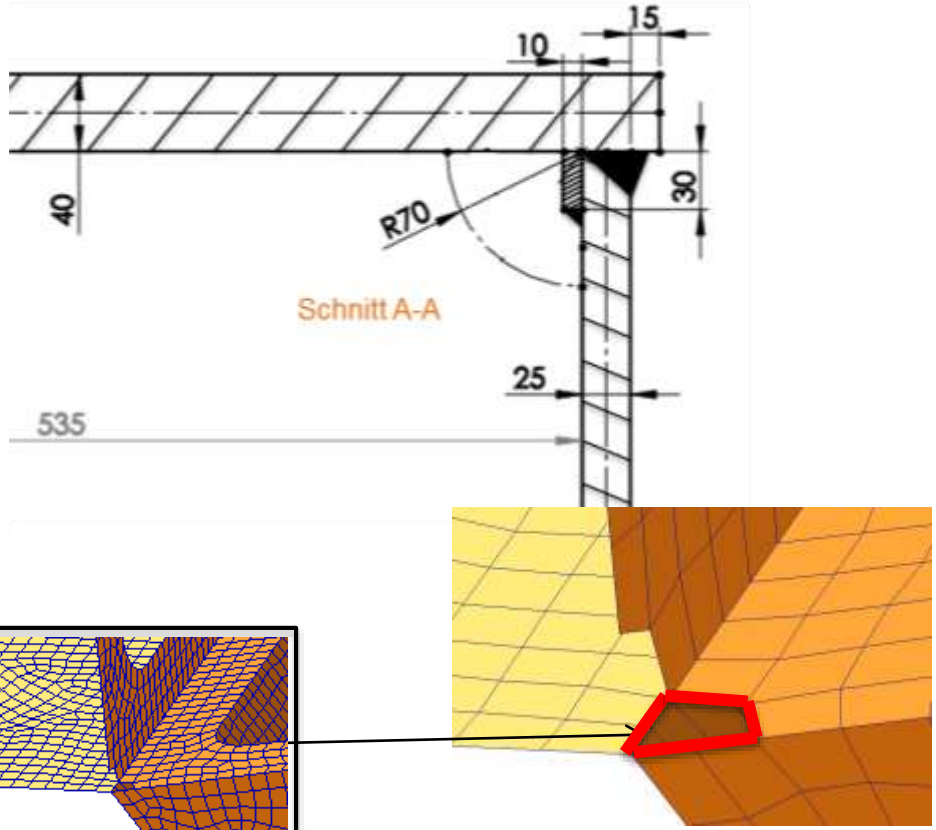


## NCSP V7d

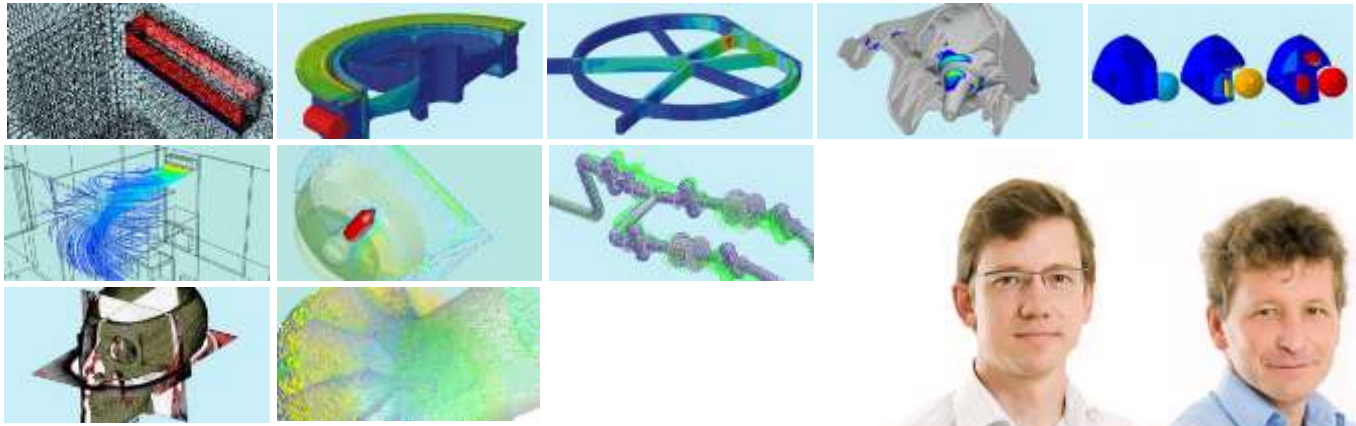
- Ecken ausschweißen ?!
  - Diskussion







# Herzlichen Dank für Ihre Aufmerksamkeit



Dr. Walter Vonach, Dr. Wolfgang Krach, Dr. Nikolaus Friedl

**CAE Simulation & Solutions**
Pitkagasse 2/1/16, A-1210 Wien
Tel.: +43 1 974 89 91 Fax: DW 99
E-mail:office@cae-sim-sol.at
www.cae-sim-sol.at