



## Eurocode3 and F.E.M. 1.001 Fatigue

10 Dec 2020  
version 2020.0.2

- ▶ This step-by-step tutorial demonstrates how to implement the fatigue check according F.E.M. 1.001 and Eurocode 3 in SDC Verifier.
- ▶ FEM 1.001 Fatigue and Eurocode 3 detailed review;
- ▶ Implementation in SDC Verifier;
- ▶ Weld Finder Tool overview;
- ▶ Fatigue tables and plots;
- ▶ Report preparation and results.

## Allowable Stress Design method

The following formulae give for all values of  $\kappa$  the permissible stresses for fatigue

a)  $\kappa \leq 0$

- for tension :  $\sigma_t = 5 \cdot \sigma_w / (3 - 2 \cdot \kappa)$  (1)

- for compression :  $\sigma_c = 2 \cdot \sigma_w / (1 - \kappa)$  (2)

$\sigma_w$  is given in table above.

b)  $\kappa > 0$

- for tension  $\sigma_t = \sigma_0 / [1 - \kappa \cdot (1 - \sigma_0 / \sigma_{+1})]$  (3)

- for compression  $\sigma_c = 1,2 \cdot \sigma_t$  (4)

where  $\sigma_0$  = tensile stress for  $\kappa = 0$  is given by the formula (1) that is :

$$\sigma_0 = 1,66 \cdot \sigma_w$$

$\sigma_{+1}$  = tensile stress for  $\kappa = +1$  that is the ultimate strength  $\sigma_R$  divided by the coefficient of safety 4/3 :

$$\sigma_{+1} = 0,75 \cdot \sigma_R$$

$\sigma_t$  is limited in every case to  $0,75 \cdot \sigma_R$ .

By way of illustration, fig. A.3.6.1. shows curves giving the permissible stress as a function of the ratio  $\kappa$  for the following cases :

- steel A.52 ;
- predominant tensile stress ;
- group E6 ;
- construction cases  $W_0, W_1, W_2$  for unwelded components and cases of construction for joints  $K_0$  to  $K_4$ .

The permissible stresses have been limited to  $240 \text{ N/mm}^2$ , i.e. to the permissible stress adopted for checking for ultimate strength.

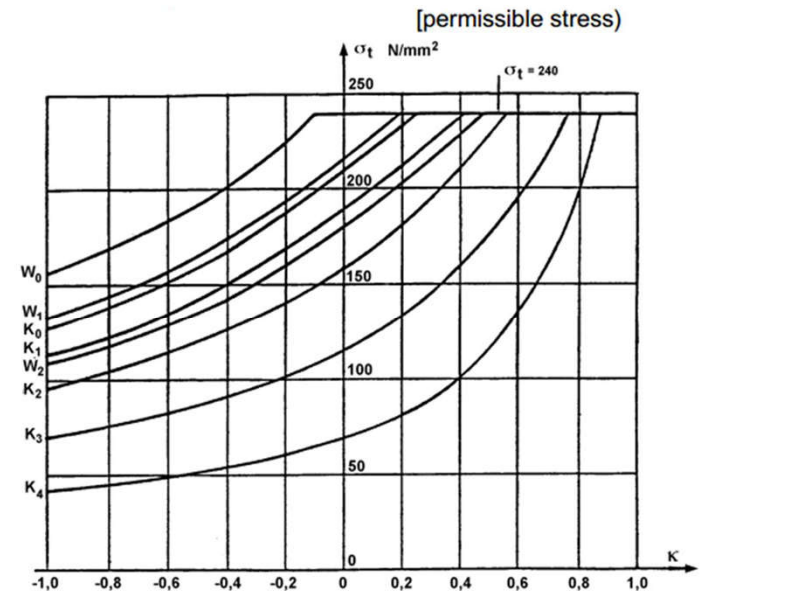


Figure A.3.6.1. - (A 52; tension; group E6)

# Fatigue in SDC Verifier

## Kappa Factor

$$\begin{aligned} K_x &= \sigma_{x \min} / \sigma_{x \max} \\ K_y &= \sigma_{y \min} / \sigma_{y \max} \\ K_{xy} &= \tau_{xy \min} / \tau_{xy \max} \end{aligned}$$

## Allowable Stress

- a)  $\kappa \leq 0$
- for tension :  $\sigma_t = 5 \cdot \sigma_w / (3 - 2 \cdot \kappa)$  (1)
  - for compression :  $\sigma_c = 2 \cdot \sigma_w \cdot (1 - \kappa)$  (2)
- $\sigma_w$  is given in table above.
- b)  $\kappa > 0$
- for tension  $\sigma_t = \sigma_0 / [1 - \kappa \cdot (1 - \sigma_0 / \sigma_{t1})]$  (3)
  - for compression  $\sigma_c = 1,2 \cdot \sigma_t$  (4)

## Utilization Factor Combined

$$\begin{aligned} &(\sigma_{x \max} / \sigma_{xa})^2 + (\sigma_{y \max} / \sigma_{ya})^2 - \\ &\sigma_{x \max} \cdot \sigma_{y \max} / (|\sigma_{xa}| \cdot |\sigma_{ya}|) + \\ &(\tau_{xy \max} / \tau_{xya})^2 \leq 1 \end{aligned}$$

Add Custom Check

ID: 2 Title: Fatigue Check

Alias: Fatigue\_Check

Description:

☒ Show Parameter Description

Options

☒ Calculate Results over Directions

☒ Calculate Results over Points

Load Calculation: Load Group Only

Selection: All Entities

Parameters (4) / Replacements (0)

Parameter = Kappa (Kappa Factor)

All: `if(SweldAbs > 0, SweldMin / SweldMax, SweldMax / SweldMin)`

Parameter = Sf (Stress Fatigue)

All: `Min(units.FromPaToCurrent(Switch(MaterialType, Fe360, Sf_Fe360(ElementGroup, WeldType), Fe510, Sf_Fe510(ElementGroup, WeldType))), Static_Check.Sallow)`

Parameter = Sallow\_fatigue (Allowable Stress Fatigue)

All: `if (Kappa > 0, if(SweldAbs > 0, (5 / 3 * Sf) / (1 - (1 - (5 / 3 * Sf) / (0.75 * tensile)) * Kappa), (2 * Sf) / (1 - (1 - (2 * Sf) / (0.9 * tensile)) * Kappa)), if(SweldAbs > 0, (5 * Sf) / (3 - 2 * Kappa), (2 * Sf) / (1 - Kappa)))`

Eqv.: 0

Parameter = Uf (Utilization Factor)

All: `Abs(SweldAbs) / Min(Static_Check.Sallow, Sallow_Fatigue)`

XY: `Abs(SweldAbs) / (Min(Static_Check.Sallow, Sallow_Fatigue / if(WeldType <= Weld_K4, SQRT(2), SQRT(3))))`

YZ: `Abs(SweldAbs) / (Min(Static_Check.Sallow, Sallow_Fatigue / if(WeldType <= Weld_K4, SQRT(2), SQRT(3))))`

ZX: `Abs(SweldAbs) / (Min(Static_Check.Sallow, Sallow_Fatigue / if(WeldType <= Weld_K4, SQRT(2), SQRT(3))))`

Eqv.: `pow(me.x, 2) + pow(me.y, 2) + pow(me.z, 2) + pow(me.xy, 2) + pow(me.yz, 2) + pow(me.zx, 2) - sign(SweldAbs.X) * me.x * sign(SweldAbs.Y) * me.y - sign(SweldAbs.Y) * me.y * sign(SweldAbs.Z) * me.z - sign(SweldAbs.Z) * me.z * sign(SweldAbs.X) * me.x`

Overall: `Max(me.x, me.y, me.z, me.xy, me.yz, me.zx, sqrt(me.eqv / 1.1))`

Clear results

OK Cancel

where the stress values  $\sigma_{xa}$ ,  $\sigma_{ya}$  and  $\tau_{xya}$  are those resulting from the application of formulae (1), (2), (3) and (4) limited to  $0,75 \cdot \sigma_R$ .

# Stress Fatigue

Stress Fatigue is used in Fatigue Allowable Stress calculations.

$\kappa \leq 0$

- for tension :  $\sigma_t = 5 \cdot \sigma_w / (3 - 2 \cdot \kappa)$  (1)

- for compression :  $\sigma_c = 2 \cdot \sigma_w / (1 - \kappa)$  (2)

Stress Fatigue depends on:

- Weld Type (W0-W2, K0-K4);
- Element Group / Loading Group (B1-B6);
- Material Type ( St360/St37, St510/St52).

Table T.A.3.6.1.  
Values of  $\sigma_w$  depending on the component group and construction case (N/mm<sup>2</sup>)

Component group	Unwelded components Construction cases						Welded components Construction cases (Steels St 37 to St 52, Fe 360 to Fe 510)				
	W <sub>0</sub>		W <sub>1</sub>		W <sub>2</sub>		K <sub>0</sub>	K <sub>1</sub>	K <sub>2</sub>	K <sub>3</sub>	K <sub>4</sub>
	Fe 360 St 37 St 44	St 52 Fe 510 St 44	Fe 360 St 37 St 44	St 52 Fe 510 St 44	Fe 360 St 37 St 44	St 52 Fe 510 St 44					
E1	249,1	298,0	211,7	253,3	174,4	208,6	(361,9)	(323,1)	(271,4)	193,9	116,3
E2	224,4	261,7	190,7	222,4	157,1	183,2	(293,8)	262,3	220,3	157,4	94,4
E3	202,2	229,8	171,8	195,3	141,5	160,8	238,4	212,9	178,8	127,7	76,6
E4	182,1	201,8	154,8	171,5	127,5	141,2	193,5	172,8	145,1	103,7	62,2
E5	164,1	177,2	139,5	150,6	114,9	124,0	157,1	140,3	117,8	84,2	50,5
E6	147,8	155,6	125,7	132,3	103,5	108,9	127,5	113,8	95,6	68,3	41,0
E7	133,2	136,6	113,2	116,2	93,2	95,7	103,5	92,4	77,6	55,4	33,3
E8	120,0	120,0	102,0	102,0	84,0	84,0	84,0	75,0	63,0	45,0	27,0

Corresponding values of Stress fatigue in SDC Verifier:

Extreme Table

ID 1 Title Utilization Factor (LG1, All Entries)

Description

Options

Check 2. Fatigue Check

Load Group 1. Load Group 1

Table Type Parameter over Directions

Parameter Stress Fatigue

Selection

+ All welds

Elements 12400

Fill Table

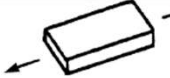
Extreme	X	Y	Z	XY	YZ	ZX	Eqv.	Overall
Minimum								
Value	95.60e+6	113.80e+6	127.50e+6				147.80e+6	0.00e+6
Element ID	1	326	326				1	1
Maximum								
Value	95.60e+6	113.80e+6	127.50e+6				147.80e+6	0.00e+6
Element ID	1	326	326				1	1
Absolute								
Value	95.60e+6	113.80e+6	127.50e+6				147.80e+6	0.00e+6
Element ID	1	326	326				1	1

OK Cancel



# Weld Type

Weld Type – also called Notch Case, defines which elements belong to what weld type (K0-K4 – joints affected by welding, W0-W2 – elements and joints, not affected by welding). Weld Type depends on shape, structural design, whole pattern or type and quality of welds.


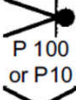
Case W<sub>0</sub>

Reference	Description	Figure	Symbol
W <sub>0</sub>	Parent metal, homogeneous surface. Part without joints or breaks in continuity (solid bars) and without notch effects unless the latter can be calculated.		

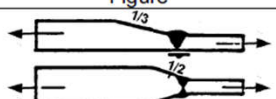


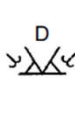
Case K<sub>0</sub> - Slight stress concentration

Reference	Description	Figure	Symbol
0,1	Parts butt-welded (S.Q.) at right angles to direction of forces		




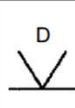
Case K<sub>1</sub> - Moderate stress concentration

Reference	Description	Figure	Symbol
1,1	Parts joined by butt welding (O.Q.) at right angles to the direction of the forces		

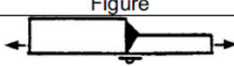



Case K<sub>2</sub> - Medium stress concentration

Reference	Description	Figure	Symbol
2,1	Parts of different thickness butt welded (O.Q.) at right angles to the direction of the forces. Asymmetrical slope : 1 in 3 (or symmetrical slopes : 1 in 2)		
2,4	Cruciform joint made with K-welds (S.Q.) perpendicular to the direction of the forces		

Case K<sub>3</sub> - Severe stress concentration

Reference	Description	Figure	Symbol
3,11	Butt weld with backing strip and no backing run. Backing strip secured by intermittent tack welds		
3,4	Cruciform joint made with K-weld (O.Q.) at right angles to the direction of the forces		

Case K<sub>4</sub> - Very severe stress concentration

Reference	Description	Figure	Symbol
4,1	Parts of different thickness butt welded (O.Q.) at right angles to the direction of the forces. Asymmetrical position without blend slope		
4,4	Cruciform joint made with fillet weld (O.Q.) at right angles to the direction of the forces		



# Element Group

Element Group also called Loading Group depends on: Class of Utilization, Load Spectrum.

Example of Load Cycles:

Load Cycles	Number	Total
Moves per hour	30	
Hours per day	10	300
Days per year	300	90000
Number of Years	20	1800000
Total	Million:	1.8

Load Spectrum

Table T.2.1.4.3. - Spectrum classes

Symbol	Spectrum factor $k_{sp}$			
P1		$k_{sp}$	$\leq$	0,125
P2	0,125	$<$	$k_{sp}$	$\leq$ 0,250
P3	0,250	$<$	$k_{sp}$	$\leq$ 0,500
P4	0,500	$<$	$k_{sp}$	$\leq$ 1,000

$$k_{sp} = (\sigma_1 / \sigma_{max})^c (n_1 / n) + (\sigma_2 / \sigma_{max})^c (n_2 / n) + \dots + (\sigma_r / \sigma_{max})^c (n_r / n) = \sum_{i=1}^r [(\sigma_i / \sigma_{max})^c (n_i / n)]$$

$$n_1 + n_2 + \dots + n_r = \sum_{i=1}^r n_i = n$$

Class of Utilization **B7** (1.8 million  $< 2 \times 10^6$ )

Table T.2.1.4.2. - Classes of utilization

Symbol	Total duration of use (number n of stress cycles)			
B0		$n$	$\leq$	16 000
B1	16 000	$<$	$n$	$\leq$ 32 000
B2	32 000	$<$	$n$	$\leq$ 63 000
B3	63 000	$<$	$n$	$\leq$ 125 000
B4	125 000	$<$	$n$	$\leq$ 250 000
B5	250 000	$<$	$n$	$\leq$ 500 000
B6	500 000	$<$	$n$	$\leq$ 1 000 000
B7	1 000 000	$<$	$n$	$\leq$ 2 000 000
B8	2 000 000	$<$	$n$	$\leq$ 4 000 000
B9	4 000 000	$<$	$n$	$\leq$ 8 000 000
B10	8 000 000	$<$	$n$	

Element Group

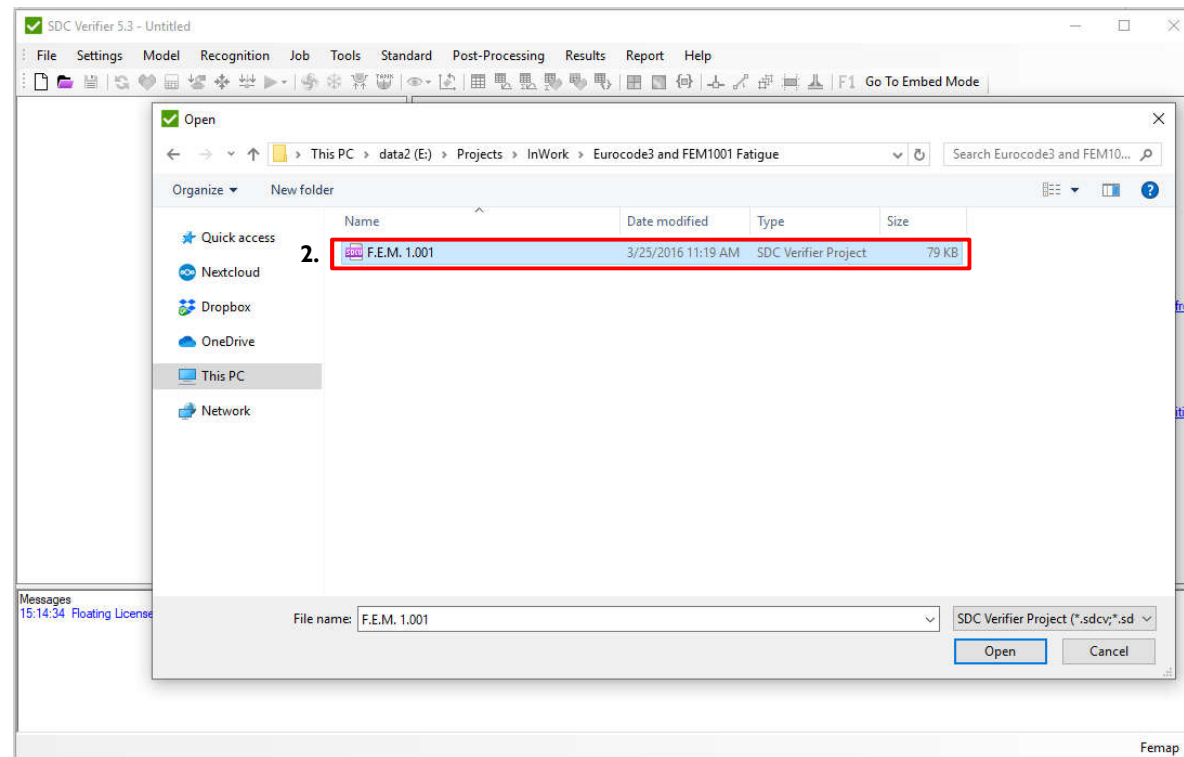
Table T.2.1.4.4. - Component groups

Stress Spectrum class	Class of utilization										
	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
P1	E1	E1	E1	E1	E2	E3	E4	E5	E6	E7	E8
P2	E1	E1	E1	E2	E3	E4	E5	E6	E7	E8	E8
P3	E1	E1	E2	E3	E4	E5	E6	E7	E8	E8	E8
P4	E1	E2	E2	E4	E5	E6	E7	E8	E8	E8	E8

# Open the starter model

1 Launch **SDC Verifier** 

2 Open project **F.E.M. 1.001**

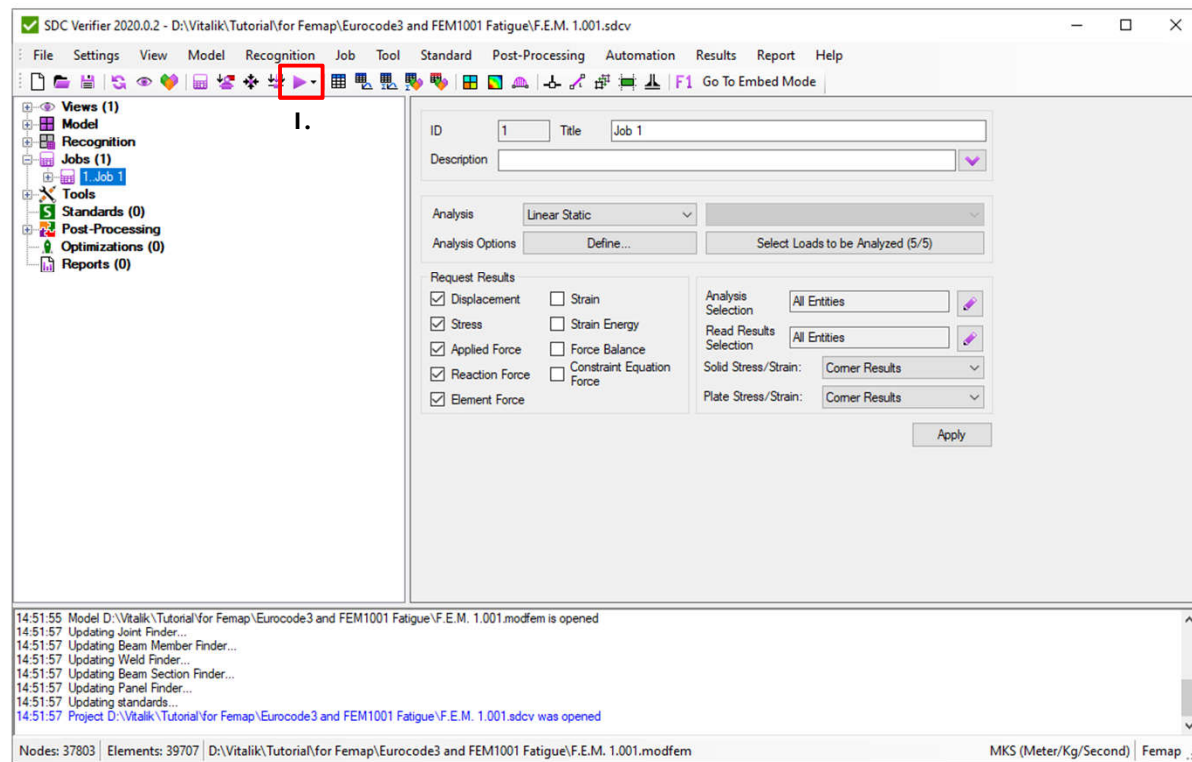




# Run Analysis

1

Press  to start Analysis in Femap



# Weld Finder

1

Execute Recognition => **Weld Finder** => **Edit...**


2

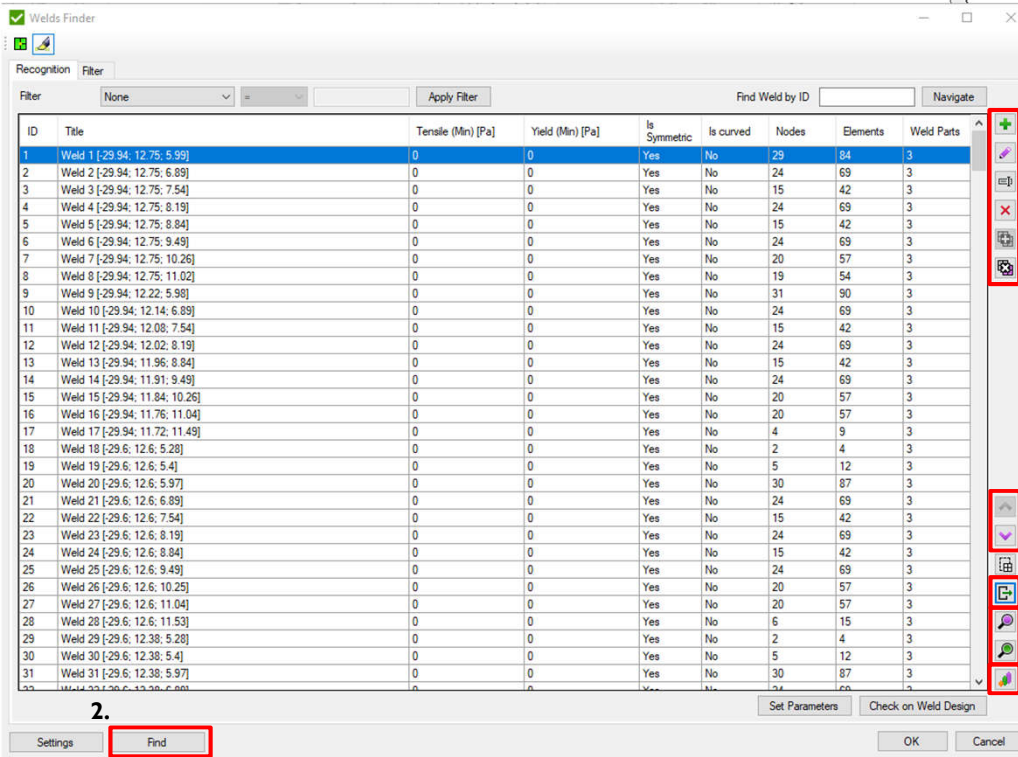
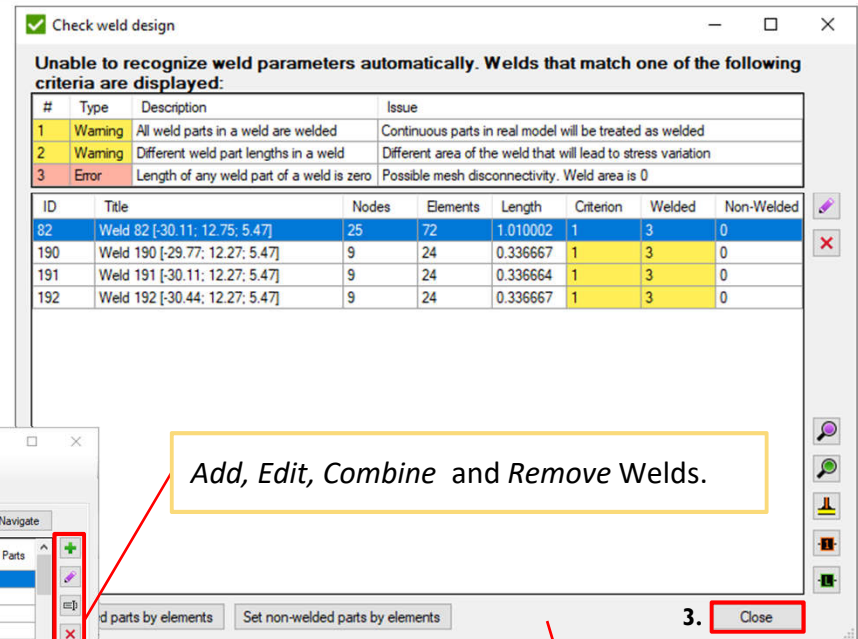
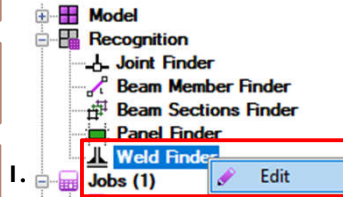
Press *Find*.

3

Press *Close*.

4

Press  to Export selected sections to components



Add, Edit, Combine and Remove Welds.

3.

There were found some Welds with all welded Parts; click to close this message

Move Welds. Order is important when one element belongs to 2 welds.

Preview selected welds

Plot of selected welds in colors and with labels of IDs

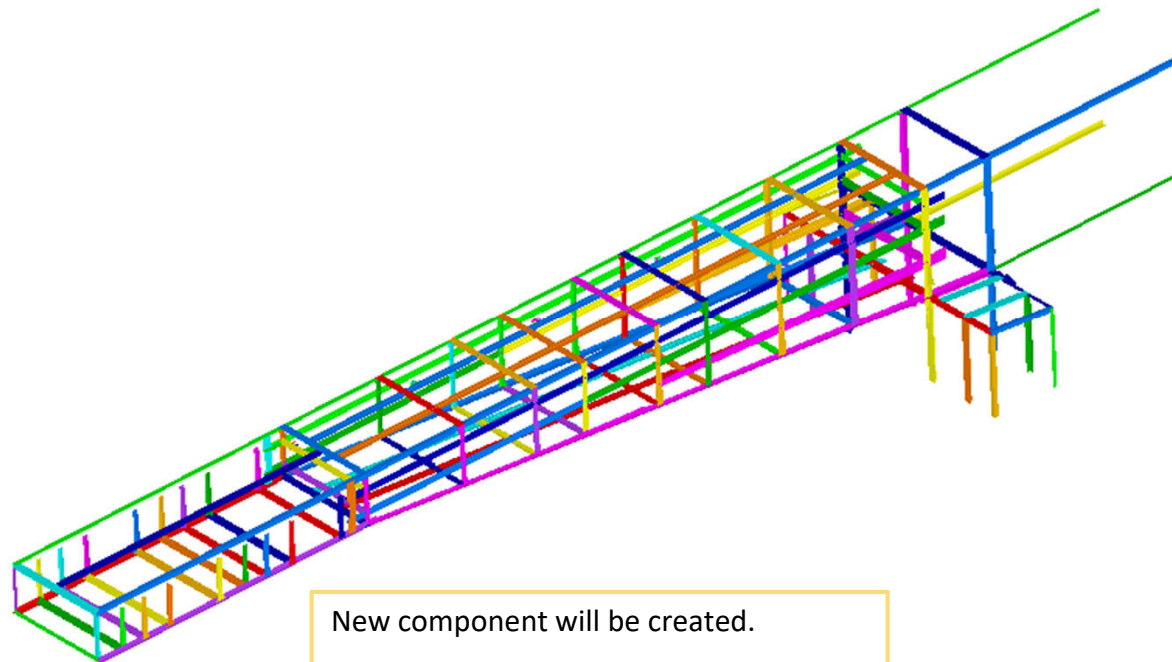
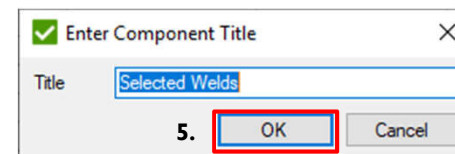
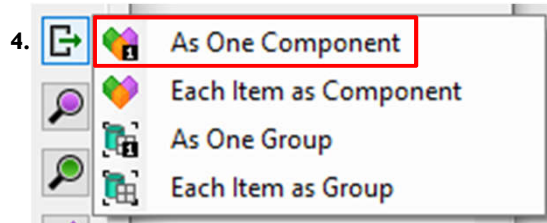
# Weld Finder. Export

4

Click *As One Component*

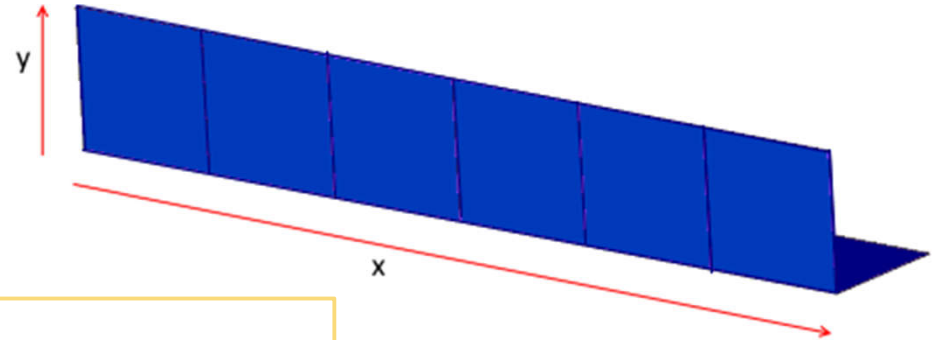
5

Press *OK*.



# Stress Transformation

Stresses for weld elements are automatically transformed in the direction of the corresponding weld from Weld Finder Tool using the wedge method. Stresses are transformed only for plate type elements.



$$\sigma_{nn} = \frac{(\sigma_{xx} + \sigma_{yy})}{2} + \frac{(\sigma_{xx} - \sigma_{yy})}{2} * \cos 2\theta + \tau_{xy} * \sin 2\theta$$

$$\tau_{nt} = -\frac{(\sigma_{xx} - \sigma_{yy})}{2} * \sin 2\theta + \tau_{xy} * \cos 2\theta$$

$$\sigma_{tt} = \frac{(\sigma_{xx} + \sigma_{yy})}{2} - \frac{(\sigma_{xx} - \sigma_{yy})}{2} * \cos 2\theta - \tau_{xy} * \sin 2\theta$$

$\sigma_{xx}, \sigma_{yy}, \tau_{xy}$  – original x,y and shear stress in local element x,y and shear directions

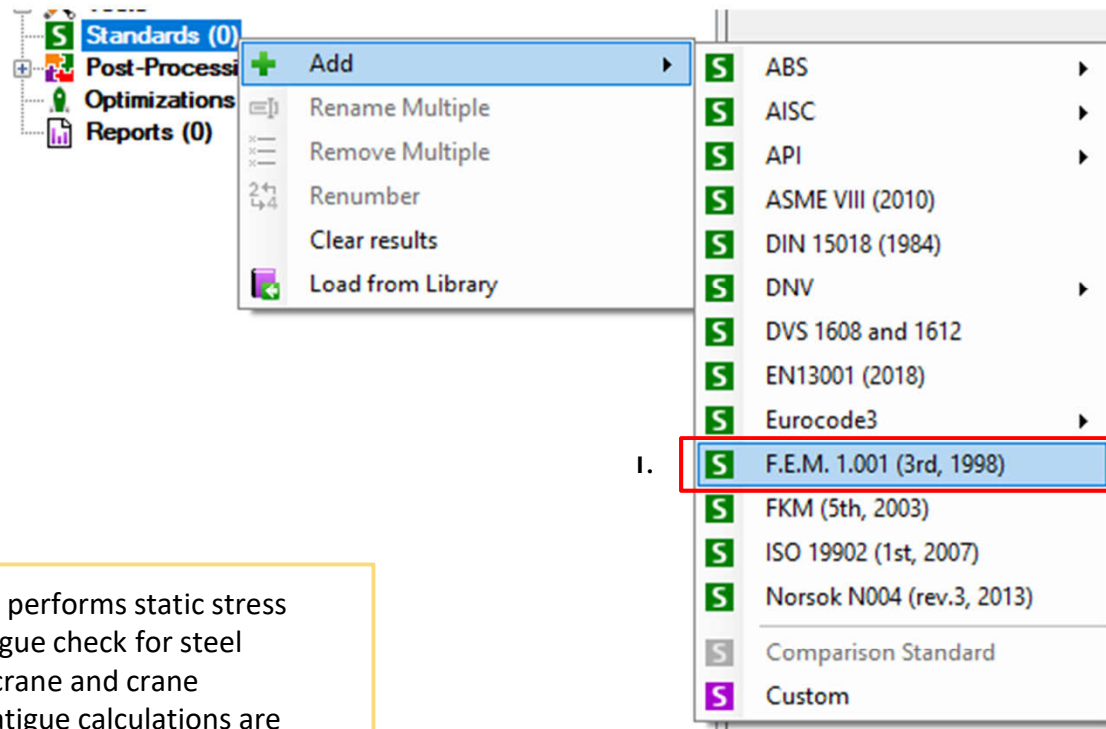
$\sigma_{tt}, \sigma_{nn}, \tau_{nt}$  – transformed x,y and shear stress in weld x,y and shear directions

$\theta$  – angle between the element and weld x directions.

# Add FEM 1.001 standard

1

Execute *Add* => **F.E.M. 1.001** in Standards context menu.



**F.E.M. 1.001** - performs static stress check and fatigue check for steel structures of crane and crane equipment. Fatigue calculations are performed according to Allowable Stress Design method (ASD).

# F.E.M. 1.001 Standard

1 Selection: **All Entities**

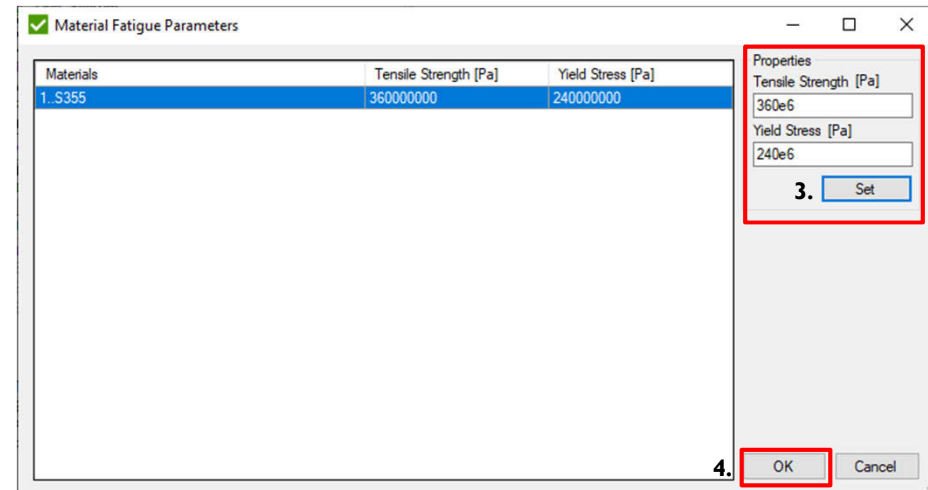
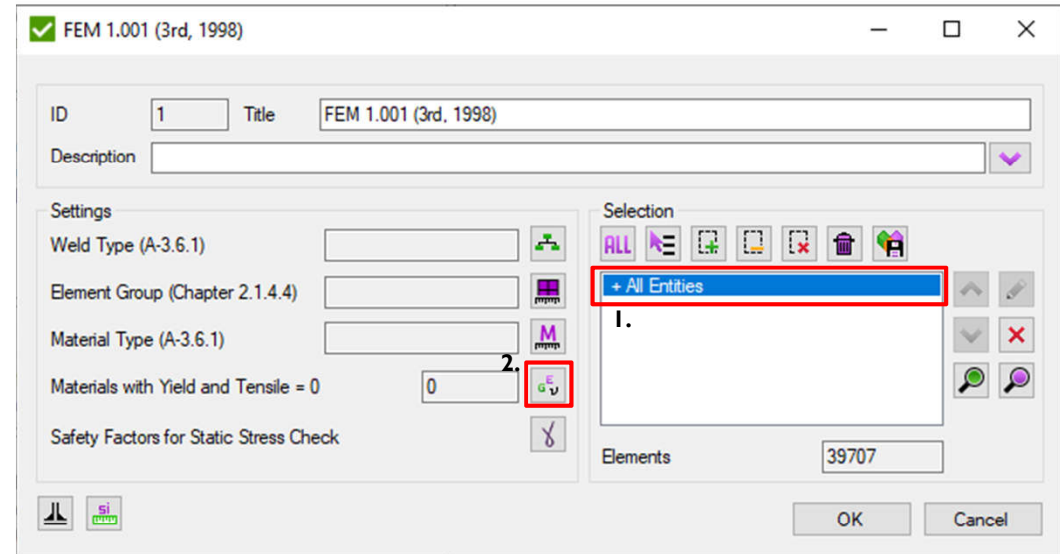
2 Press  to edit material properties.

Amount of materials with not defined Tensile or Yield are displayed in the field

3 Tensile Strength: **360e6**  
Yield Stress: **240e6** and Press *Set*.

4 Press *OK*.

*Unit System.* Stress Fatigue values are constant for specified material and are measured in Pa. Changing unit system enables to convert Pa into Mpa, for example.






# Definition of weld categories




- ▶ Weld/notch category determines fatigue resistance
- ▶ Division in welds / non welds for FEM 1.001:
  - ▶ W category is for non welded parts
  - ▶ K category is for welded parts
- ▶ Fatigue resistance is further specified by adding classes
  - ▶ W0-W2 for non-welded parts
  - ▶ K0-K4 for welded parts
- ▶ Better fatigue resistance results in lower class number

# Weld Classes depends on Weld Type


## Non-weld group W0

nr.	description of the main types	symbol
W01	Part without hole and without joint, with a normal state of the surface, without notch behaviour.	

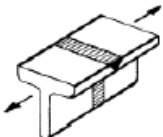
## Slight notch behavior group K0

nr.	description of the main types	symbol
011	Parts, joined by a butt weld of special quality, perpendicular to the direction of force.	 $\nabla$ P 100 $\nabla$ P 100


## Moderate notch behavior group K1

nr.	description of the main types	symbol
111	Parts, joined by a butt weld of ordinary quality, perpendicular to the direction of force.	 $\nabla$ P or P 100 $\times$ P or P 100

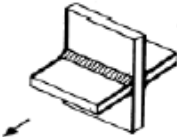
## Medium notch behavior group K2

nr.	description of the main types	symbol
211	Profiles, joined by butt welds of special quality, perpendicular to the direction of force.	 $\nabla$ P 100 $\nabla$ P 100


## Great notch behavior group K3

311	Parts joined by a butt weld with a backing strap, without sealing run and perpendicular to the direction of force. Backing strap fixed by tack welding.		$\nabla$
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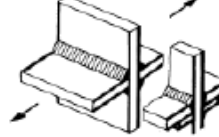
## and a different connection type 351

nr.	description of the main types	symbol
351	Double bevel weld of ordinary quality, perpendicular to the direction of force, between crossing parts.	 $\nabla$ D

## Very great notch behavior group K4

nr.	description of the main types	symbol
412	Parts of different thickness, joined by a butt weld of ordinary quality, perpendicular to the direction of force. Asymmetrical joint without slope.	 $\nabla$ P $\times$ P

## and a different connection type 451

451	Fillet welds of normal quality or single bevel weld (included fillet weld) with backing, perpendicular to the direction of force, between crossing parts.	 $\nabla$ D $\nabla$ D
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# Weld Type – stress direction

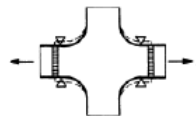


	Perpendicular to weld	Parallel with weld	Shear
Weld	<b>K1</b>	<b>K2</b>	<b>K0</b>
No weld	<b>W0</b>		$\tau_D(-1) = \sigma_D(-1) / \text{sqrt}(3)$

Steel Grade	$\sigma_D(-1)$ for $\kappa=-1$ element group 5 St 52-3							
Notch group	<b>W0</b>	<b>W1</b>	<b>W2</b>	<b>K0</b>	<b>K1</b>	<b>K2</b>	<b>K3</b>	<b>K4</b>
Stress amplitude	163.8	130.3	104.2	118.8	106.1	89.1	63.6	38.2

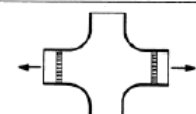


For beams SCF of connections can be included in the classification

Depends on Stress concentrations:

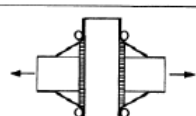


**Slight notch behavior group K0**

013	Gusset, jointed by butt welds of special quality, perpendicular to the direction of force.		 P 100  P 100
-----	--	---	--

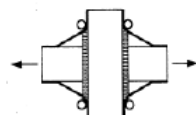


**Moderate notch behavior group K1**

113	Gusset, jointed by butt welds of ordinary quality, perpendicular to the direction of force.		 P or P 100  P or P 100
-----	---	---	--

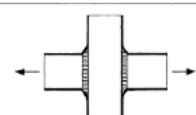


**Medium notch behavior group K2**

213	Butt weld of special quality and continuous part, both perpendicular to the direction of force, at a crossing of flanges with in-welded corner plates. The ends of the welds are ground to prevent them from notch behaviour.		 P 100  P 100
-----	---	---	--

**Great notch behavior group K3**

313	Butt weld of ordinary quality and continuous part both perpendicular to the direction of force, at a crossing of flanges with welded corner plates. The ends of the welds have been ground to prevent them from notch behaviour.		 P or P 100  P or P 100
-----	--	---	--

**Very great notch behavior group K4**

413	Butt weld of ordinary quality, perpendicular to the direction of force, at a crossing of flanges without corner plates.		 P  P
-----	---	---	--

(not included in this tutorial)

# Weld Type Classification

1 Press Ok-->Yes (*Define* for the Weld Type).

2 Press  to Add Condition.

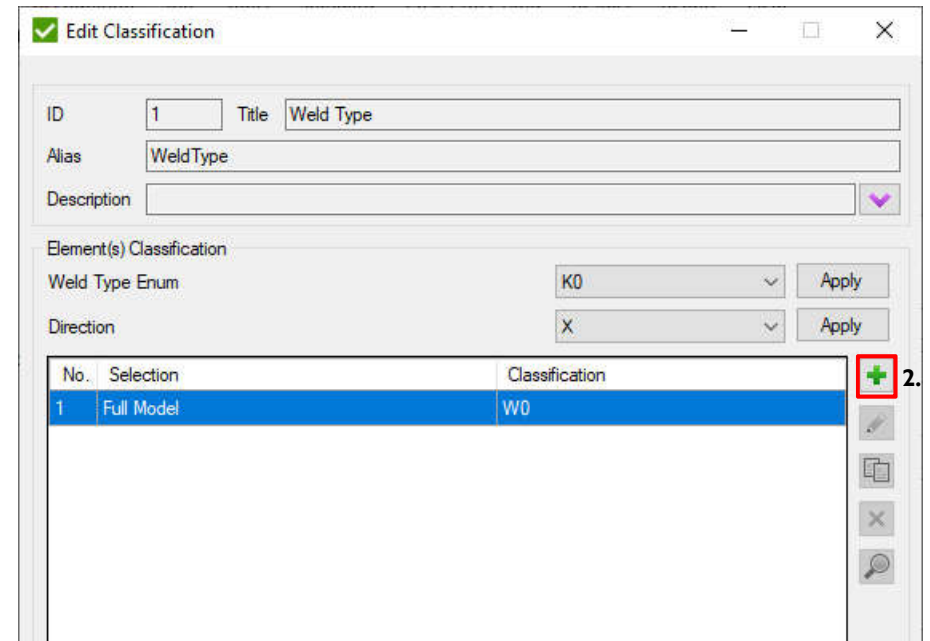
3 Press *Add all Welds*

4 Select *Multiple Conditions* options

5 Press X/Y/XY

6 X: K1 Y: K2 XY: K0

7 Press *OK*



**Edit Classification**

ID: 1 Title: Weld Type

Alias: WeldType


Description:

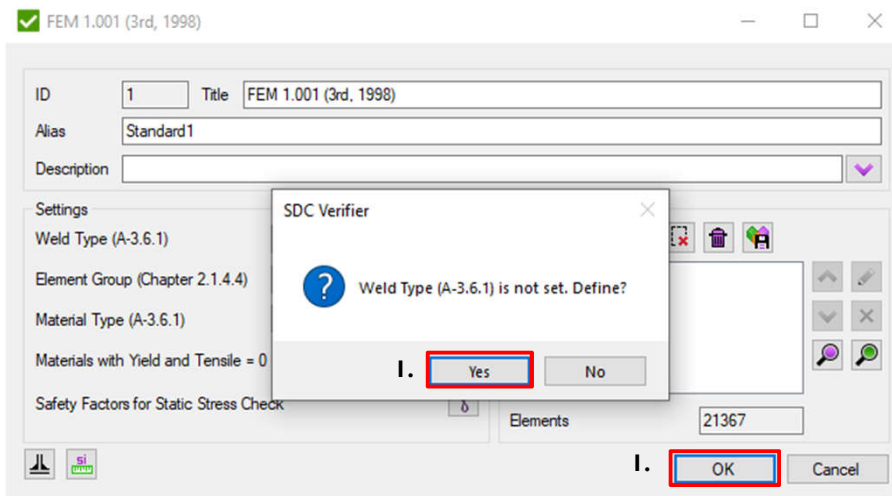
Element(s) Classification

Weld Type Enum: K0 Apply

Direction: X Apply

No.	Selection	Classification
1	Full Model	W0

2. 



**FEM 1.001 (3rd, 1998)**

ID: 1 Title: FEM 1.001 (3rd, 1998)

Alias: Standard1

Description:

Settings

Weld Type (A-3.6.1)

Element Group (Chapter 2.1.4.4)

Material Type (A-3.6.1)

Materials with Yield and Tensile = 0

Safety Factors for Static Stress Check

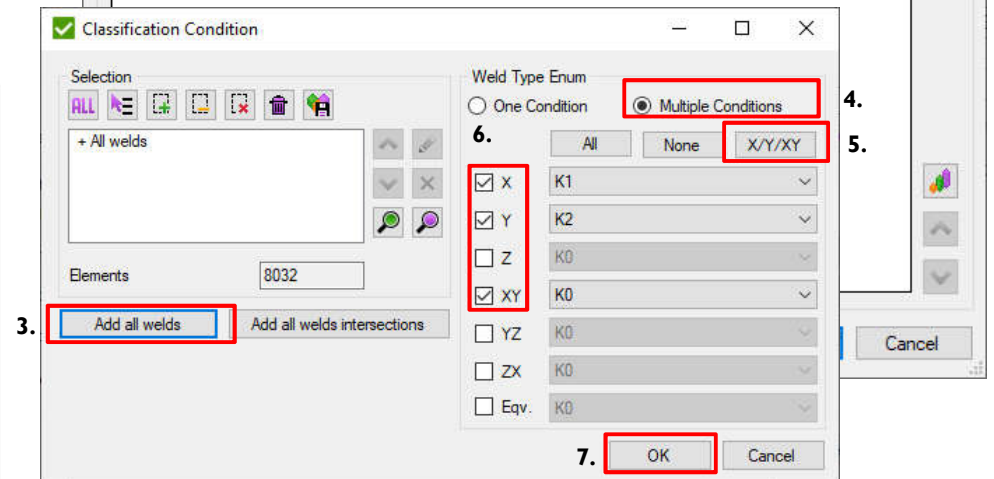
Elements: 21367

SDC Verifier

Weld Type (A-3.6.1) is not set. Define?

1. Yes

1. OK



**Classification Condition**

Selection

+ All welds

Elements: 8032

Weld Type Enum

☐ One Condition ☒ Multiple Conditions

6. X Y Z XY YZ ZX Eqv.

K1 K2 K0 K0 K0 K0 K0

7. OK

# Weld Type classification intersecting welds

1 Press  to Add Condition.

2 Click *All welds intersections*














































3 Value: **K2**

4 Directions: **X**

5 Press *OK*

**Classification Condition**

Selection

+ All welds intersections

Elements 718

Add all welds Add all welds intersections

Weld Type Enum

☒ One Condition ☐ Multiple Conditions

Value 3. **K2**

Directions All None X/Y/XY

4. ☒ **X**

☐ Y

☐ Z

☐ XY

☐ YZ

☐ ZX

☐ Equivalent

5. **OK** Cancel

**Edit Classification**

ID 1 Title Weld Type

Alias WeldType

Description

Element(s) Classification

Weld Type Enum K0 Apply

Direction X Apply

No.	Selection	Classification
1	Full Model	W0
2	All welds	K1 (X)
3	All welds	K2 (Y)
4	All welds	K0 (XY)

At intersecting welds all stresses are perpendicular to the weld direction. The last condition overwrites the previous ones and settings in condition 2 => K1 (X) are replaced with K2(X) for intersections

Import Welds OK Cancel



# Check classification

✓ Edit Classification

ID: 1 Title: Weld Type

Alias: WeldType

Description:

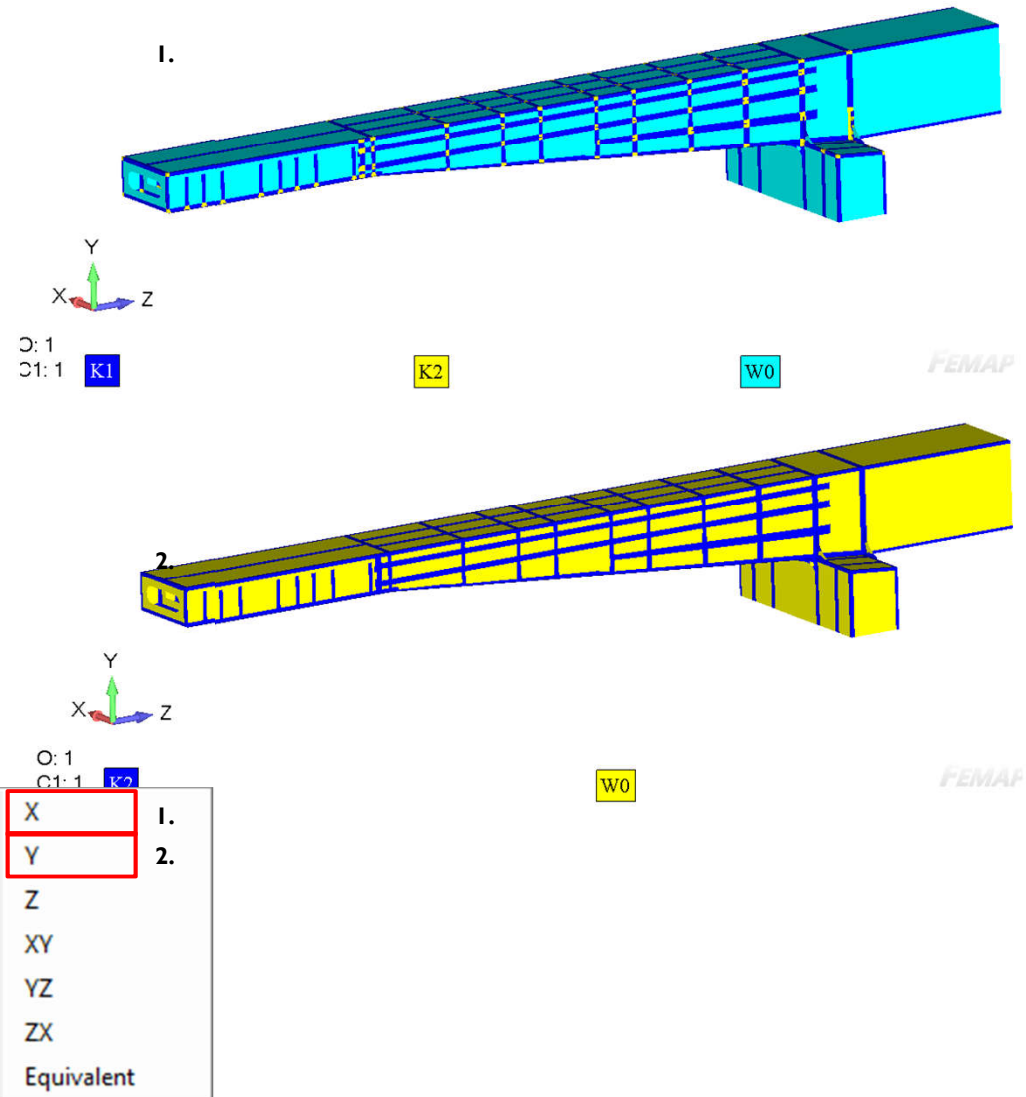
Element(s) Classification

Weld Type Enum: K0 Apply


Direction: X Apply

No.	Selection	Classification
1	Full Model	W0
2	All welds	K1 (X)
3	All welds	K2 (Y)
4	All welds	K0 (XY)
5	All welds intersections	K2 (X)

Import Welds OK Cancel

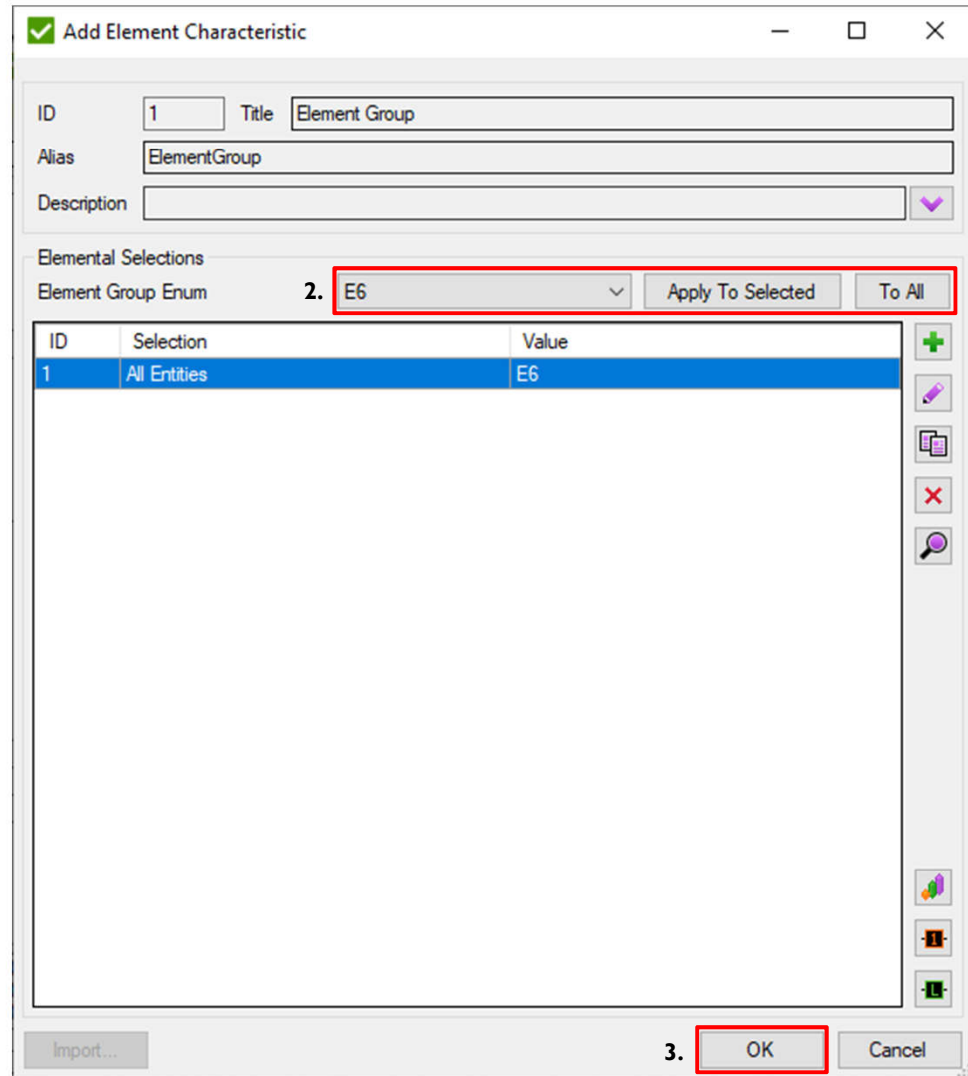


# Element Group classification

1 Press  for the Element Group.

2 Select Element Group: **E6**. Press *To All*.


3 Press *OK*.




✓ Add Element Characteristic

ID: 1 Title: Element Group

Alias: ElementGroup

Description: 


Elemental Selections

Element Group Enum: 2. E6  Apply To Selected To All

ID	Selection	Value
1	All Entities	E6

Import... 3. OK Cancel

# Material Type classification

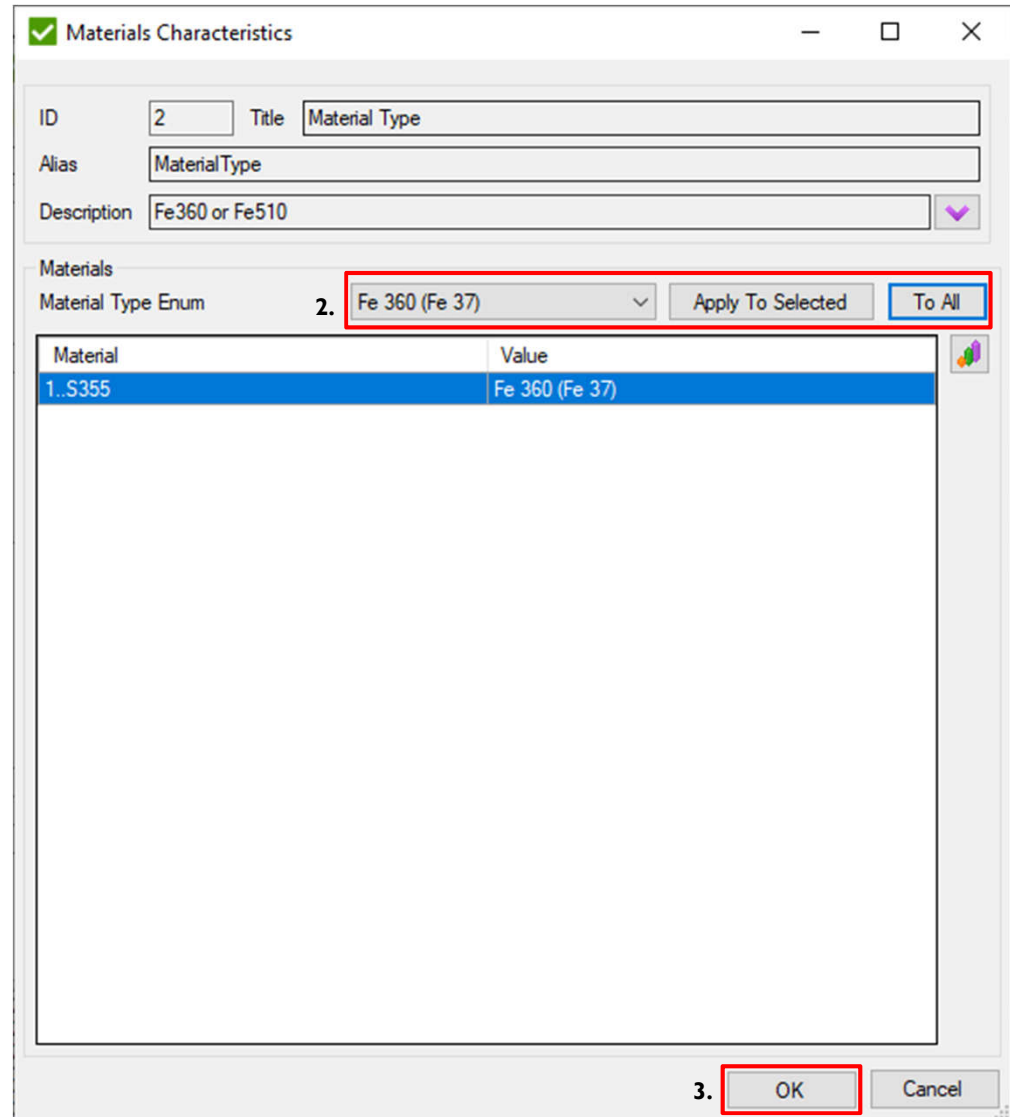
1 Press  for the Material Type.

2 Select Material Type: **Fe360 (Fe 37)**.  
Press *To All*.

3 Press *OK*.

4 Press *OK* to create Standard.

**Material Type** defines which steel is used: St37 or St52. Stress Fatigue values are different for different materials.




The dialog box titled "Materials Characteristics" contains the following fields and controls:

- ID: 2
- Title: Material Type
- Alias: Material Type
- Description: Fe360 or Fe510
- Materials section:
  - Material Type Enum: 2. Fe 360 (Fe 37) (highlighted with a red box)
  - Buttons: Apply To Selected, To All (highlighted with a red box)
- Table:

Material	Value
1..S355	Fe 360 (Fe 37)
- Buttons at the bottom: OK (highlighted with a red box), Cancel

# Create extreme table

1 Execute  **Table (expand/extreme)** in **Fatigue Check** context menu.

2 Load: **1..Load Group1**.

Fatigue check supports only Load Groups. If only one load group exist in the project it will be selected automatically.

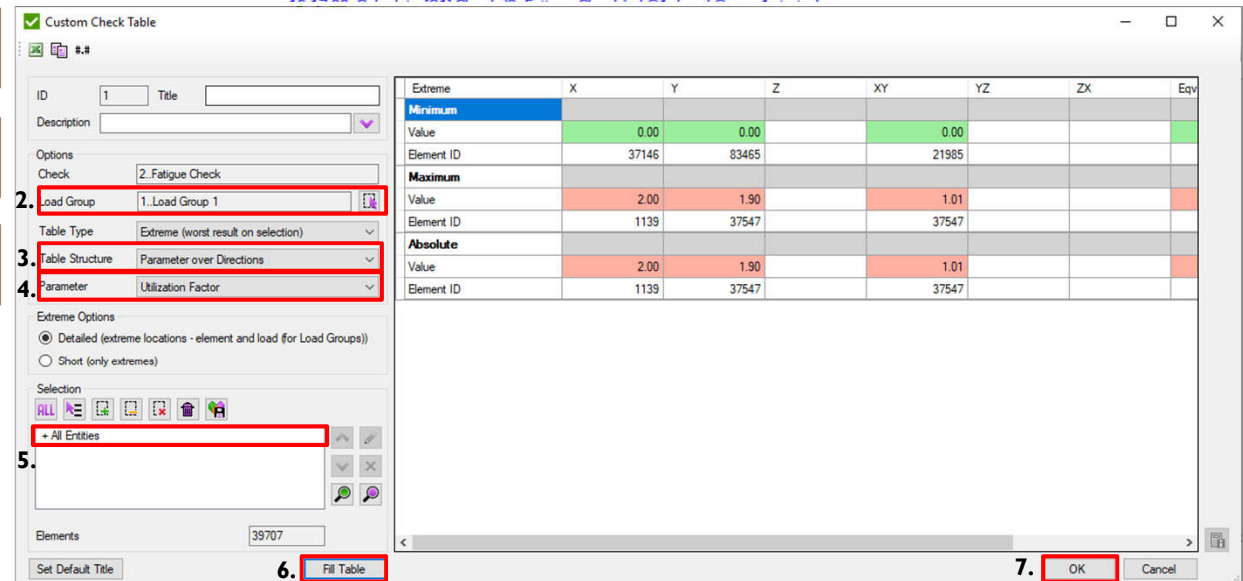
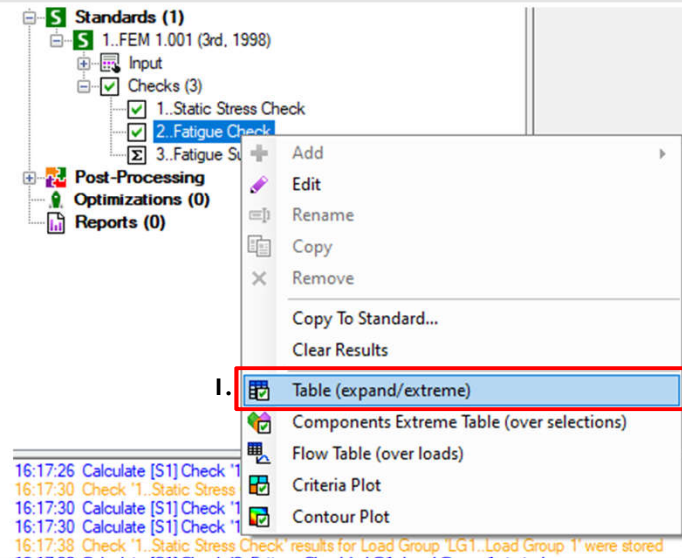
3 Table Type: **Parameter over Directions**.

4 Parameter: **Utilization Factor**.


5 Selection: **All Entities**.

6 Press **Fill Table**.

7 Press **OK**.



# Create criteria plot

1 Execute  **Criteria Plot** in **Fatigue Check** context menu

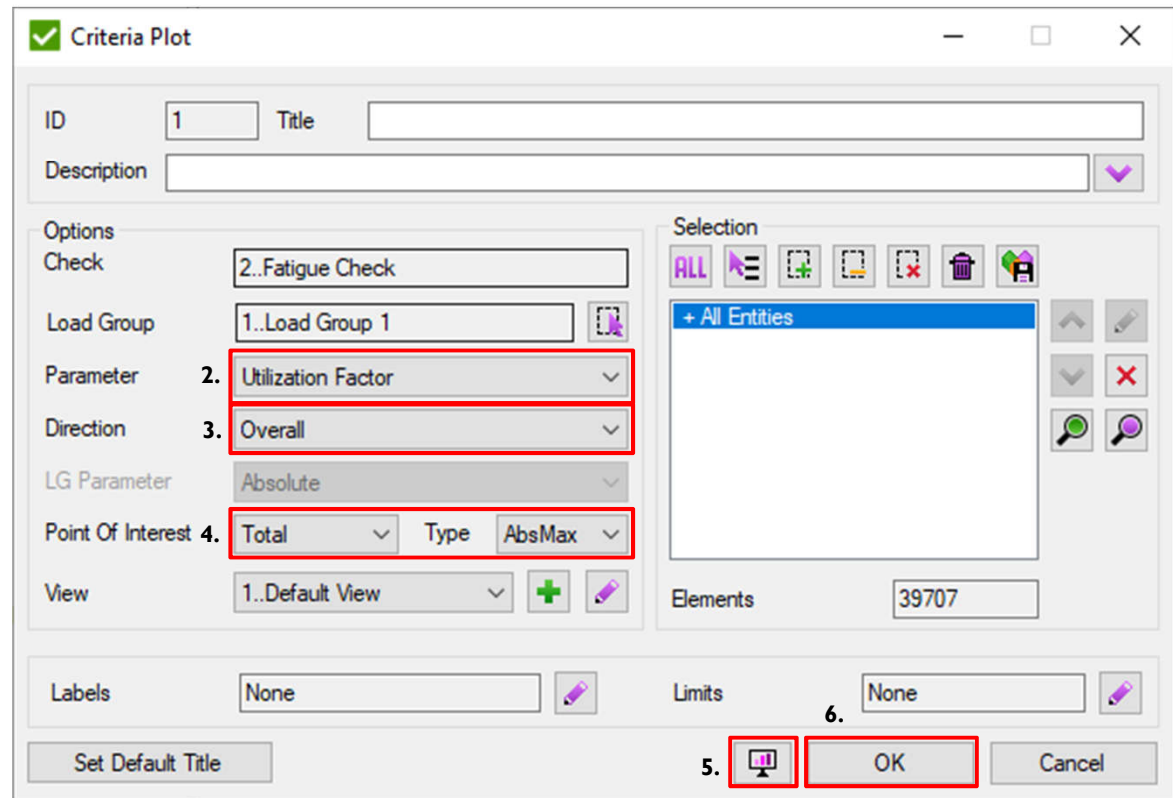
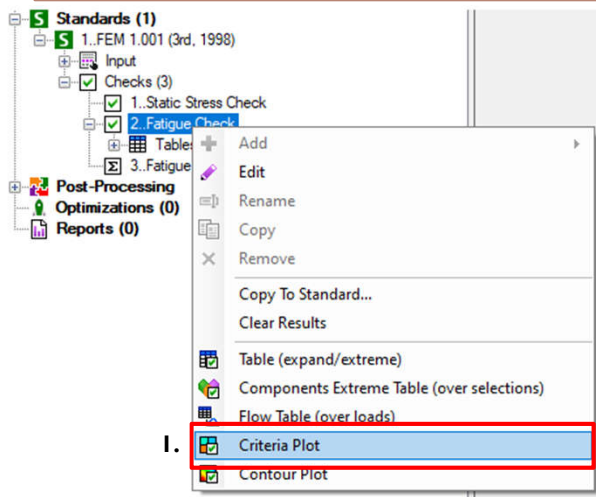
2 Parameter: **Utilization Factor**

3 Direction: **Overall**

4 Point of interest: **Total** Type: **AbsMax**


5 Press  **Preview**

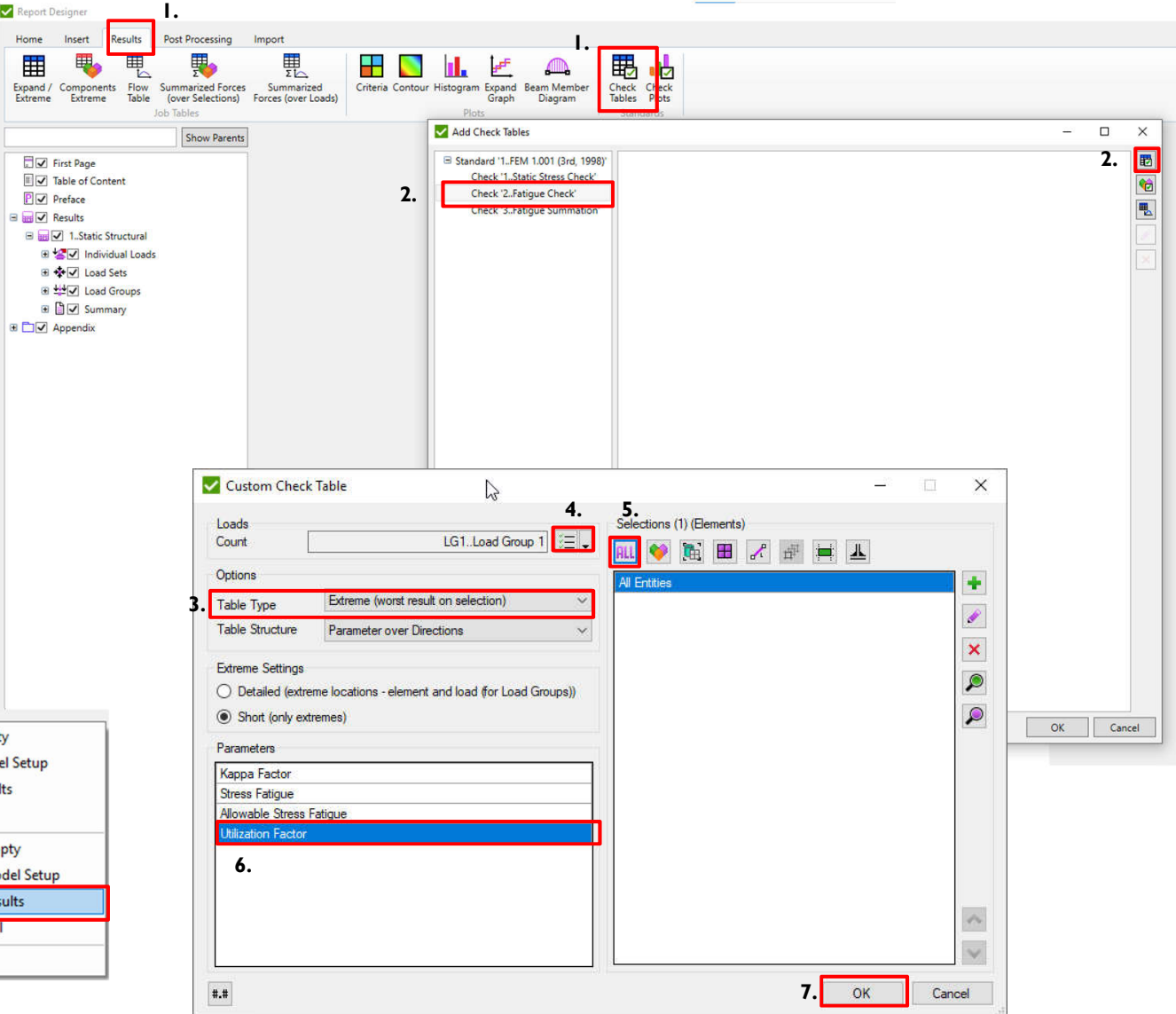
6 Press **OK**



Point of interest = AbsMax Total is absolute maximum utilization factors among all point of interest.

# Report. Tables and plots

- 1 Results => *Check Tables*
- 2 Press => *Check '2..Fatigue Check'*  
=> 
- 3 Table Type: **Extreme.**
- 4 Load Group: **1..Load Group**
- 5 Selection: **All Entities.**
- 6 Parameter: **Utilization Factor.**
- 7 Press OK.




The screenshot shows the SDC Verifier software interface. The Report Designer window is open, showing a tree view of report sections. The 'Results' section is selected. The 'Add Check Tables' dialog is open, showing a list of check tables. The 'Custom Check Table' dialog is open, showing the configuration for a new check table. The 'Table Type' is set to 'Extreme (worst result on selection)'. The 'Table Structure' is set to 'Parameter over Directions'. The 'Extreme Settings' are set to 'Short (only extremes)'. The 'Parameters' list includes 'Kappa Factor', 'Stress Fatigue', 'Allowable Stress Fatigue', and 'Utilization Factor'. The 'Utilization Factor' parameter is selected. The 'Selections (1) (Elements)' list shows 'All Entities'. The 'OK' button is highlighted.



# Report. Tables and plots

1 Results => *Check Plots*

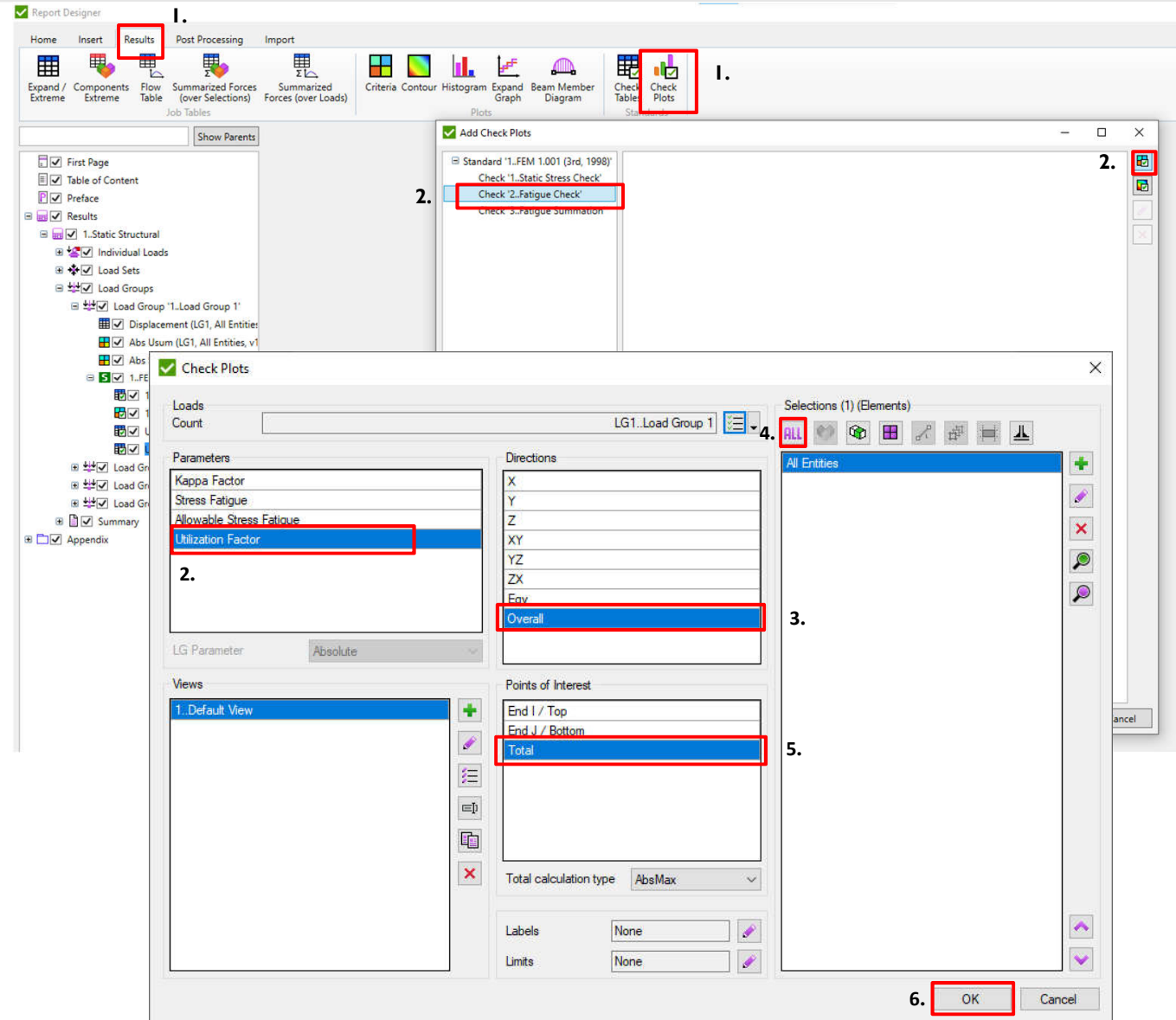
2 Press => *Check '2..Fatigue Check'* => 

3 Direction: **Overall**

4 Point of Interest: **Total**.

5 Selection: **All Entities**.

6 Press *OK*.



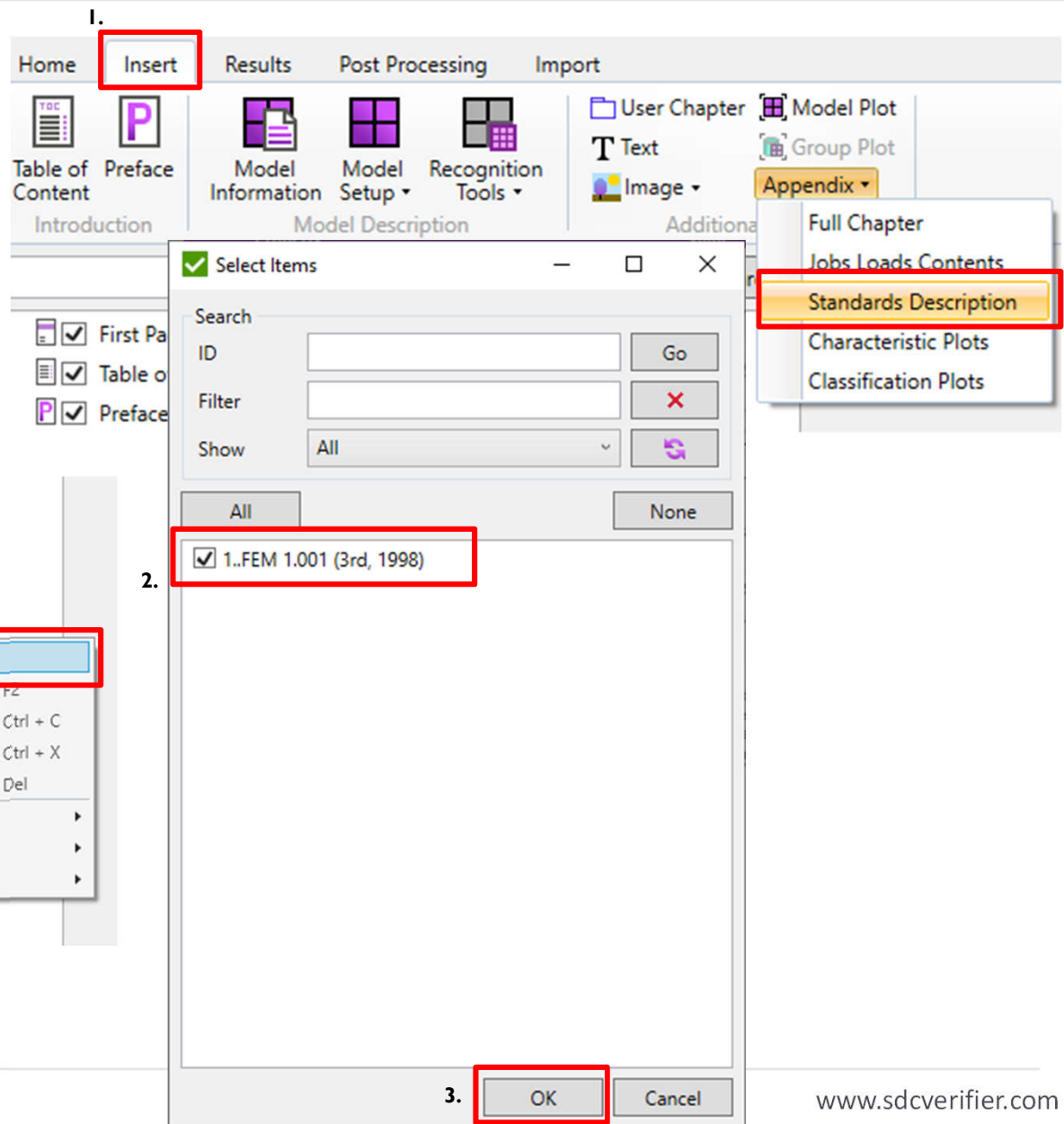
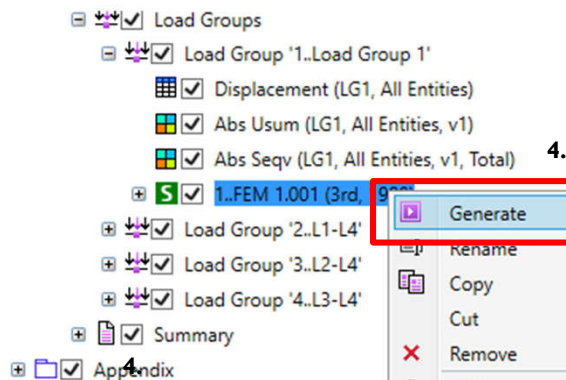
# Report. Fatigue Check

1 Insert => Appendix => Standards Description

2 Choose 1..FEM 1.001

3 Press OK.

4 Expand standard 1..FEM 1.001 => Generate .



# Report. Results

## 2..Fatigue Check

Property	Value
Category	Elemental Custom Check
Selection	All Entities
Parameters	4

### 1..Utilization Factor (LG1, All Entities)

Standard	1.FEM 1.001 (3rd, 1998)			Check	[S1] 2. Fatigue Check			
Load Group	LG1..Load Group 1			Parameter	Utilization Factor			
Selection	All Entities							
Extreme	X	Y	Z	XY	YZ	ZX	Eqv	Overall
Minimum								
Value	0.00	0.00		0.00			0.00	0.00
Element ID	37146	83465		21985			83624	22151
Maximum								
Value	2.00	1.90		1.01			4.04	2.01
Element ID	1139	37547		37547			37547	37547
Absolute								
Value	2.00	1.90		1.01			4.04	2.01
Element ID	1139	37547		37547			37547	37547

### 2..Utilization Factor (LG1, 9 Selections)

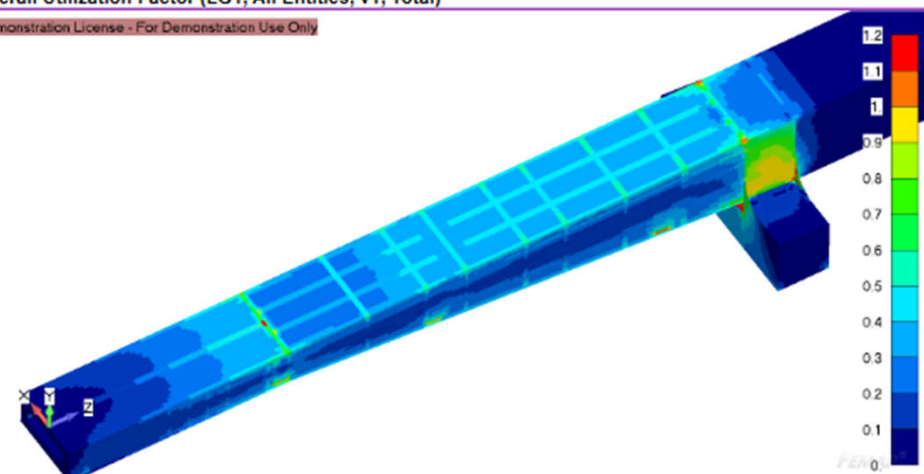
Check	[S1] 2..Fatigue Check			Load Group	LG1..Load Group 1			
Parameter	Utilization Factor			Selections	9			
Components	X	Y	Z	XY	YZ	ZX	Eqv	Overall
Plate '4..stl plt 10 mm thks'	0.73	1.11		0.24			1.09	1.11
Plate '5..stl plt 8 mm thks'	0.37	0.56		0.18			0.33	0.58
Plate '6..stl plt 15 mm thks'	2.00	1.62		0.99			3.72	2.00
Plate '10..stl plt 4 mm thks'	0.40	0.49		0.04			0.23	0.49
Plate '11..stl plt 12 mm thks'	1.39	1.90		1.01			4.04	2.01
Plate '12..stl plt 24 mm thks'								
Beam '13..stl L-bar 100x65x8 mm'	0.96						0.93	0.96
Beam '14..stl L-bar 100x65x8 mm (top)'	0.67						0.45	0.67
Beam '15..stl L-bar 100x65x8 mm (side)'	0.94						0.89	0.94

### Utilization Factor (LG1, All Entities)

Standard	1..FEM 1.001 (3rd, 1998)			Check	[S1] 2..Fatigue Check			
Load Group	LG1..Load Group 1			Parameter	Utilization Factor			
Selection	All Entities							
Extreme	X	Y	Z	XY	YZ	ZX	Eqv	Overall
Minimum		0.00	0.00		0.00			0.00
Maximum		2.00	1.90		1.01			4.04
Absolute		2.00	1.90		1.01			4.04

### Overall Utilization Factor (LG1, All Entities, v1, Total)

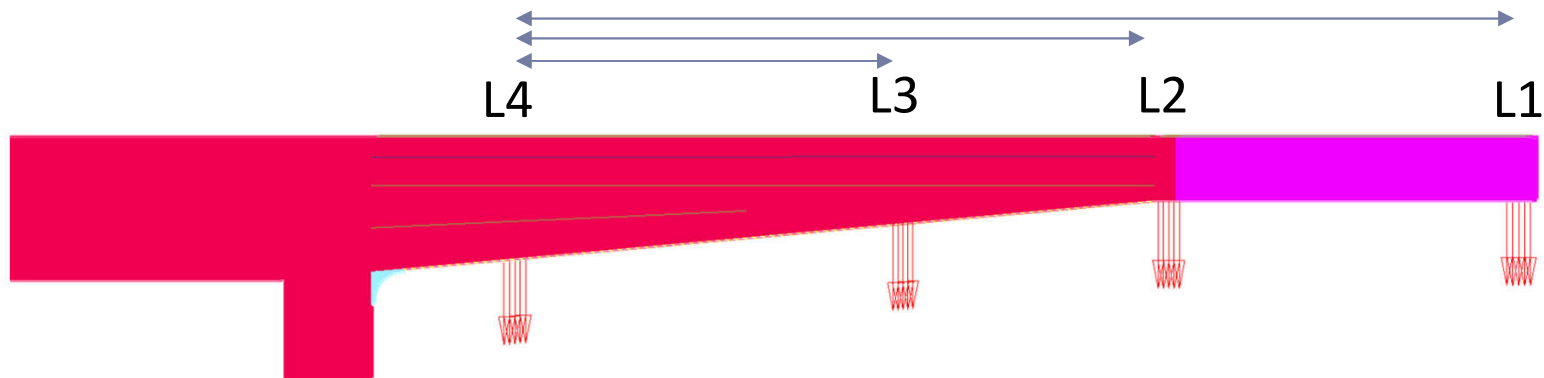
Demonstration License - For Demonstration Use Only



Check	[S1] 2..Fatigue Check	Point	Total
Load Group	LG1..Load Group 1	Parameter	Overall Utilization Factor
Selection	All Entities	View	1..Default View

- ▶ A better fatigue damage can be made if load cycles are specified more accurately.
- ▶ Instead of 2 million load cycles from start to end:

Load cycle	Number of cycles	Content
L4-L1	0,5 e6	LS4, LS3, LS2, LS1, IL1
L4-L2	1,0 e6	LS4, LS3, LS2, IL1
L4-L3	0,5 e6	LS4, LS3, IL1




NB gravity load is also included because the stress variation determines the fatigue damage

# Add Fatigue Group (stress history)

1 Select **Fatigue Groups** in Navigation tree

2 Title: **Detailed load cycles pattern**

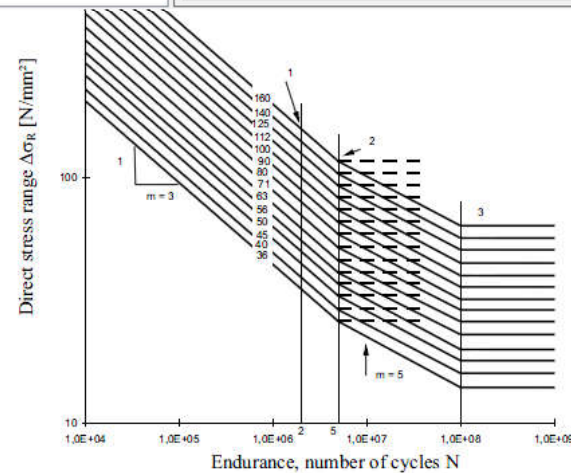
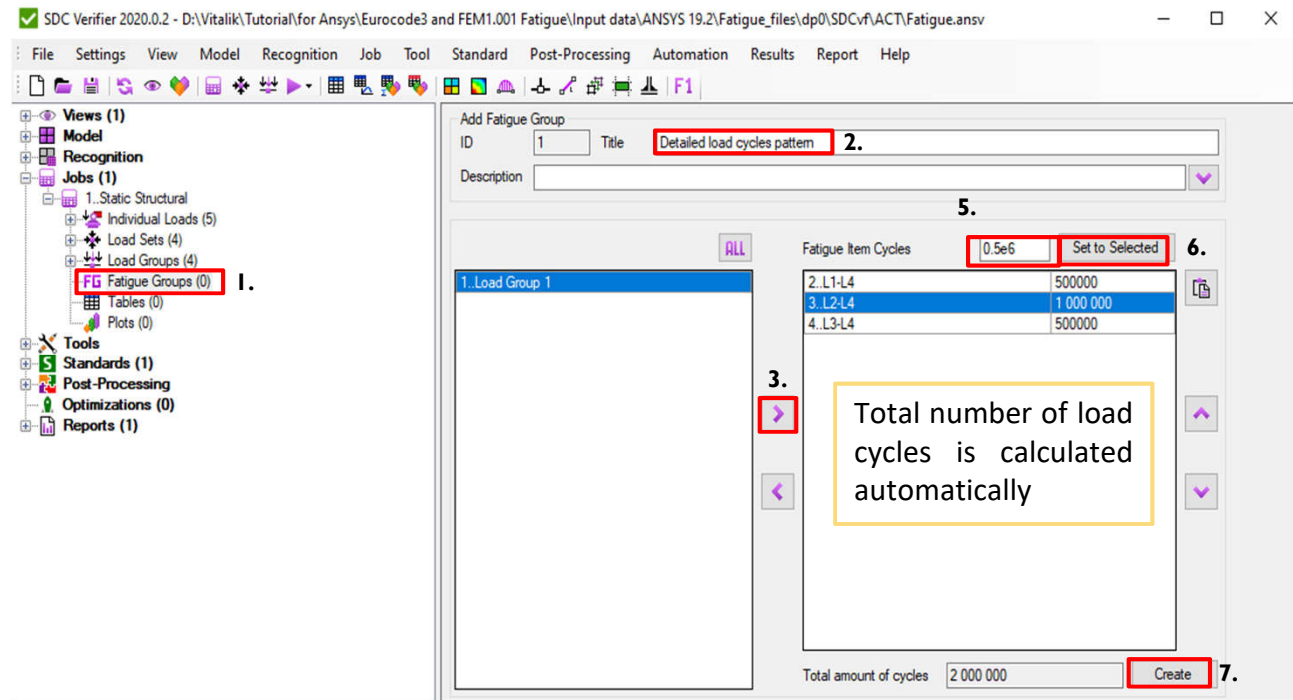
3 Select all groups and press 

4 Select **1..L1-L4** and **3..L2-L4**

5 Fatigue Item Cycles: **0.5e+6** and **Set**.

6 Set **1e+6** cycles for 2..L3-L4

7 Press **Create**



# Fatigue calculation with Eurocode 3

1

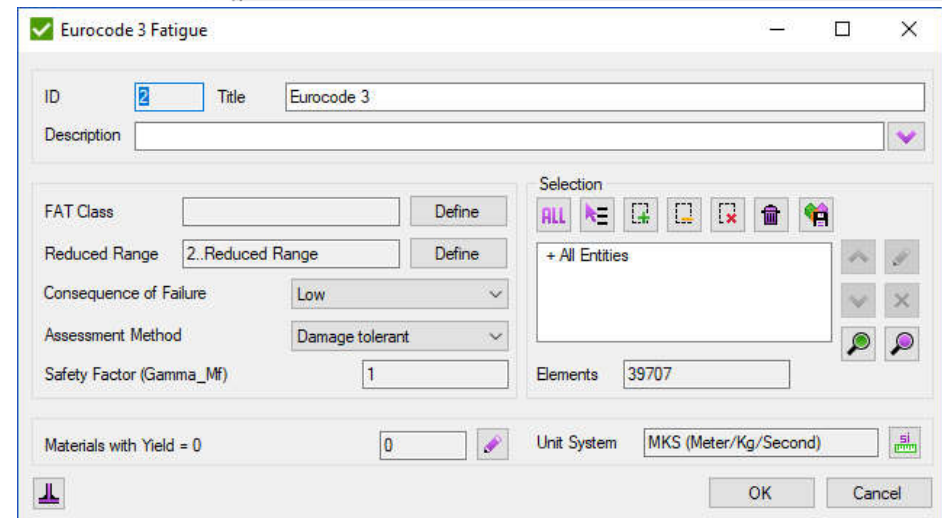
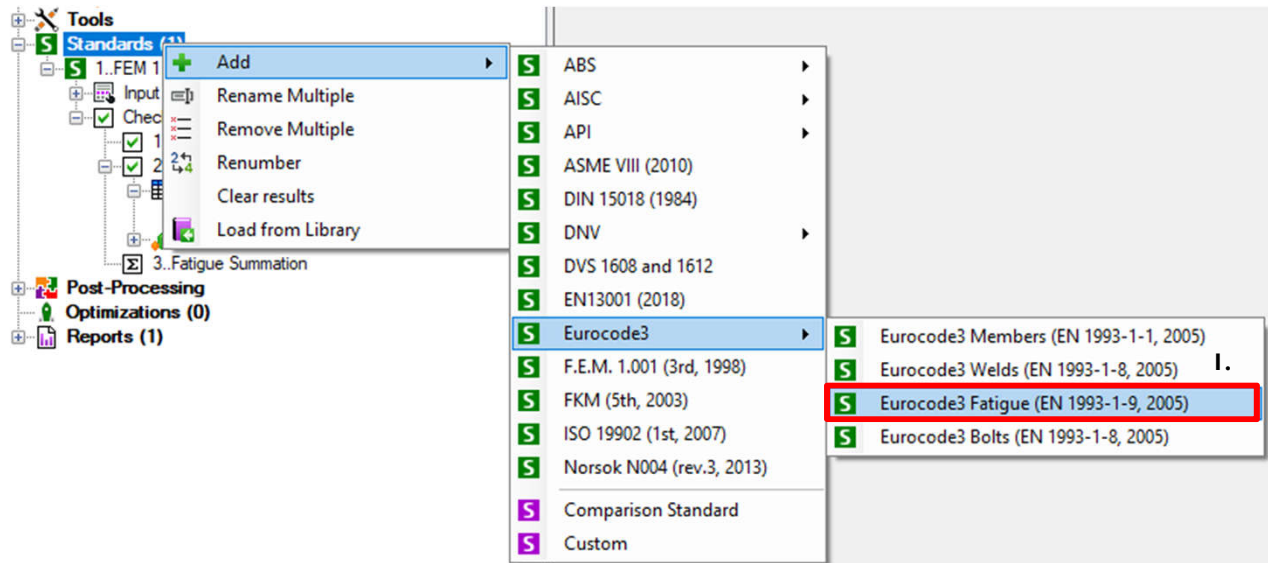
Execute *Add* => **Eurocode 3 Fatigue (EN 1993-1-9)** in Standards context menu.

2

Consequence of Failure: **Low**

3






Assessment Method: **Damage tolerant**





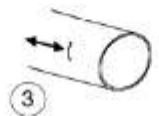
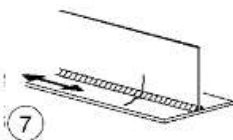
Safety Factor	Low consequence	High consequence
Damage tolerant	1.0	1.15
Safe life	1.15	1.35



# FAT classes Eurocode3

	Perpendicular to weld	Parallel with weld	Shear
Weld	80 	100 	80 
No weld	160 		100 

**Table 8.1: Plain members and mechanically fastened joints**

Detail category	Constructional detail	Description	Requirements
160	<p><b>NOTE</b> The fatigue strength curve associated with category 160 is the highest. No detail can reach a better fatigue strength at any number of cycles.</p>   	<p><u>Rolled and extruded products:</u></p> <p>1) Plates and flats; 2) Rolled sections; 3) Seamless hollow sections, either rectangular or circular.</p>	<p><u>Details 1) to 3):</u></p> <p>Sharp edges, surface and rolling flaws to be improved by grinding until removed and smooth transition achieved.</p>
100		<p>7) Repaired automatic or manual fillet or butt welds for categories 1) to 6).</p>	<p>7) Improvement by grinding performed by specialist to remove all visible signs and adequate verification can restore the original category.</p>

For determination of FAT classes check standard!  
In this tutorial only examples are given

- 5 ) For welds intersections: X: **80**

www.sdcverifier.com

# FAT classes plot

✓ Edit Classification

ID: 1 Title: FAT Class

Alias: FAT

Description:

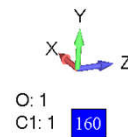
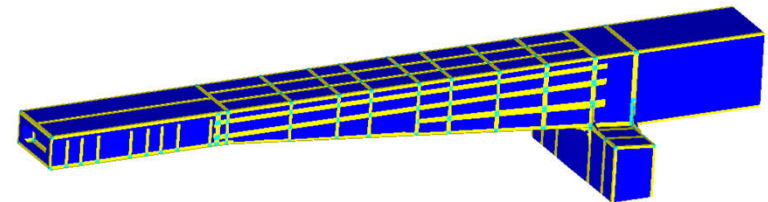
Element(s) Classification

FAT Stress: 160 Apply

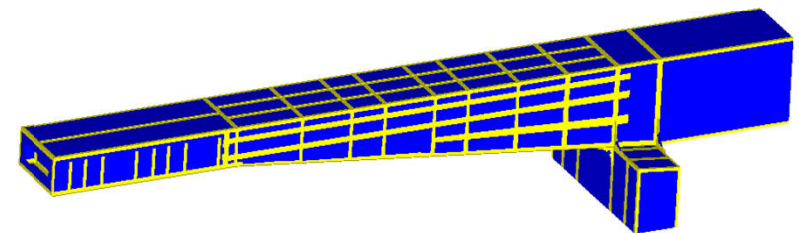
Direction: X Apply

No.	Selection	Classification
1	Full Model	160
4	All Entities	100 (XY, YZ, ZX)
2	All welds	100 (X)
3	All welds	80 (Y, XY)
5	All welds intersections	80 (X)

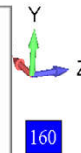
Import Welds OK Cancel



O: 1  
C1: 1



- X
- Y
- Z
- XY
- YZ
- ZX
- Equivalent



1.  
2.

160

80

# Fatigue Damage Plot

1 Execute *Criteria Plot* in **Fatigue Check** context menu

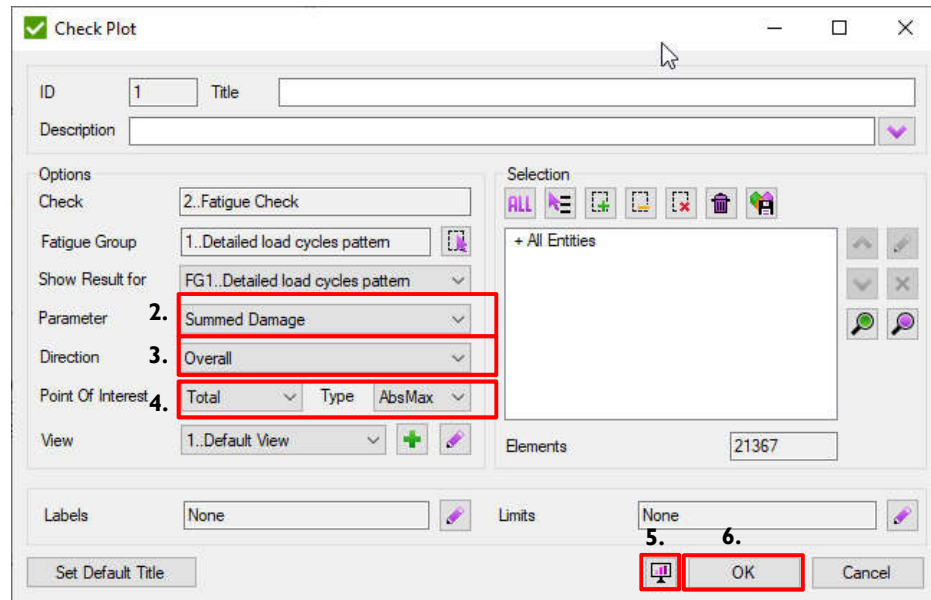
2 Parameter: **Summed Damage**

3 Direction: **Overall**

4 Point of interest: **Total** Type: **AbsMax**

5 Press  *Preview*

6 Press *OK*



Check Plot

ID 1 Title

Description

Options

Check 2..Fatigue Check

Fatigue Group 1..Detailed load cycles pattern

Show Result for FG1..Detailed load cycles pattern

Parameter 2. Summed Damage

Direction 3. Overall

Point Of Interest 4. Total Type AbsMax

View 1..Default View

Selection

ALL

+ All Entities

Elements 21367

Labels None

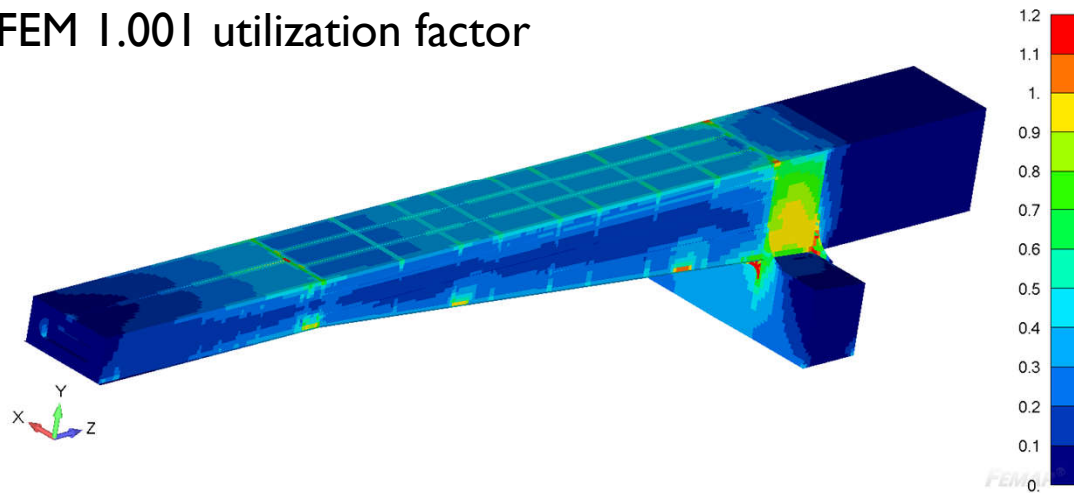
Limits None

Set Default Title

5. Preview 6. OK Cancel

# Comparison

FEM 1.001 utilization factor



Eurocode 3 utilization factor at 2 million cycles

