



Tutorial

# Eurocode3 and F.E.M. 1.001 Fatigue

Updated on: 20 June 2023

Tested with: 2023 R1.1

Version 2022.1

- ▶ 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.

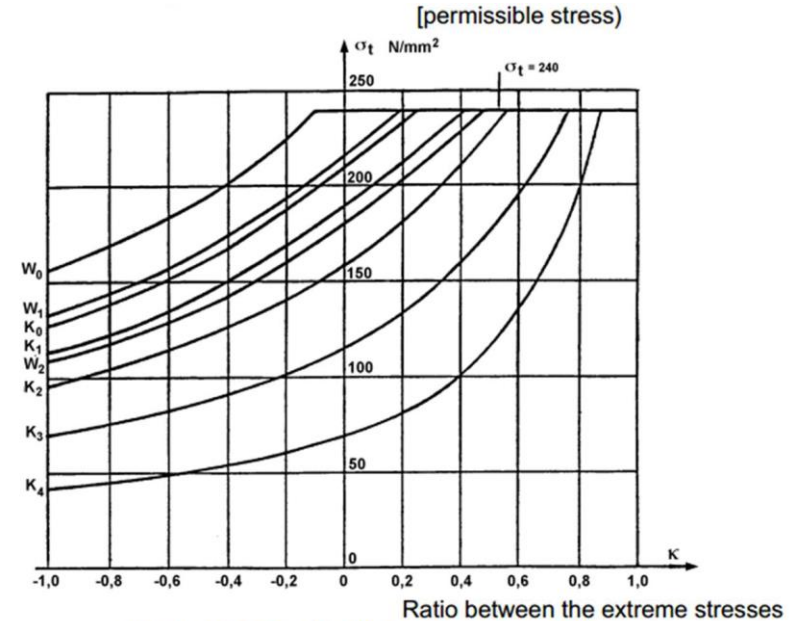


Figure A.3.6.1. - (A 52; tension; group E6)

## Kappa Factor

$$\kappa_x = \sigma_{x \min} / \sigma_{x \max}$$

$$\kappa_y = \sigma_{y \min} / \sigma_{y \max}$$

$$\kappa_{xy} = \tau_{xy \min} / \tau_{xy \max}$$

## 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

$$\left( \frac{\sigma_{x \max}}{\sigma_{xa}} \right)^2 + \left( \frac{\sigma_{y \max}}{\sigma_{ya}} \right)^2 - \frac{\sigma_{x \max} \cdot \sigma_{y \max}}{(\sigma_{xa} \cdot \sigma_{ya})} + \left( \frac{\tau_{xy \max}}{\tau_{xya}} \right)^2 \leq 1$$

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  $0,75 \cdot \sigma_R$ .

Custom Check (built-in, not editable)

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)  
Description: Ratio between the extreme stresses  
All: `if(SweldAbs > 0, SweldMin / SweldMax, SweldMax / SweldMin)`

Parameter = Sf (Stress Fatigue)  
Description: Permissible stress for fatigue depends on the element group (E1-E8) and weld type  
All: `Min(units.FromPaToCurrent(Switch(MaterialType, MaterialTypeEnum.Fe360Fe37, Sf_Fe360(ElementGroup, WeldType), MaterialTypeEnum.Fe510Fe52, Sf_Fe510(ElementGroup, WeldType))), 0.75 * Tensile)`

Parameter = Sallow fatigue (Allowable Stress Fatigue)  
Description: Appendix 3.6, formulas (1)-(4)  
All: `if(Kappa > 0, if(SweldAbs > 0, 1, 1.2) * (5 / 3 * Sf) / (1 - (1 - (5 / 3 * Sf) / (0.75 * tensile))) * Kappa, if(SweldAbs > 0, (5 * Sf) / (3 - 2 * Kappa), (2 * Sf) / (1 - Kappa)))`  
XY/YZ/ZX: `if(Kappa > 0, (5 / 3 * Sf) / (1 - (1 - (5 / 3 * Sf) / (0.75 * tensile))) * Kappa, (5 * Sf) / (3 - 2 * Kappa)) / if(WeldType <= WeldTypeEnum.K4, SQRT(2), SQRT(3))`  
Eqv: 0

Parameter = Uf (Utilization Factor)  
Description: Appendix 3.6, equivalent rule - (5)  
All: `Abs(SweldAbs) / Sallow_Fatigue`  
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))`

Clear results

OK Cancel

Stress Fatigue is used in Fatigue Allowable Stress calculations.

$$\kappa \leq 0$$

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

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

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	Fe 360 St 37 St 44	St 52 Fe 510	Fe 360 St 37 St 44	St 52 Fe 510					
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

Stress Fatigue depends on:

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

Corresponding values of Stress fatigue in SDC Verifier:

Custom Check Table

ID 1 Title Utilization Factor (LG1, All Entries)

Description

Options

Check 2. Fatigue Check

Load Group 1. Load Group 1

Table Structure Parameter over Directions

Parameter Stress Fatigue

Expand/Extreme Options

Table Type Extreme (worst result on selection)

☒ Detailed (extreme locations - element and load for Load Groups)

☐ Short (only extremes)

Filter by

Direction None

Value > 1

Sort by

Direction None

Order Ascending

Selection

ALL

+ All Entries

Elements 39707

Set Default Title

Fill Table

Extreme	X [Pa]	Y [Pa]	Z [Pa]	XY [Pa]	YZ [Pa]	ZX [Pa]	Eqv [Pa]	Overall
<b>Minimum</b>								
Value	113.80e+6	95.60e+6		127.50e+6			147.80e+6	
Element ID	1	326		326			1	
<b>Maximum</b>								
Value	147.80e+6	147.80e+6		147.80e+6			147.80e+6	
Element ID	1138	1138		1138			1	
<b>Absolute</b>								
Value	147.80e+6	147.80e+6		147.80e+6			147.80e+6	
Element ID	1138	1138		1138			1	

OK

Corresponding values of Stress fatigue in SDC Verifier for classification below

Edit Classification

ID 1 Title Weld Type

Alias WeldType

Description

Element(s) Classification

Weld Type Enum K0

Direction X

Selection	Classification
Full Model	W0
All welds	K1 (X)
All welds	K2 (Y)
All welds	K0 (XY)

Import Welds


Clear

OK



Cancel

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.		



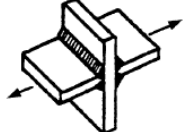

Case K<sub>0</sub> - Slight stress concentration

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




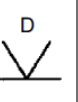
Case K<sub>1</sub> - Moderate stress concentration

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



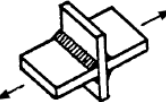
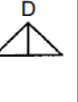
Case K<sub>2</sub> - Medium stress concentration

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

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 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

Class of Utilization **B7** (1.8 million < 2 x 10<sup>6</sup>)

Table T.2.1.4.2. - Classes of utilization

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

Load Spectrum

Table T.2.1.4.3. - Spectrum classes

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

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

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

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

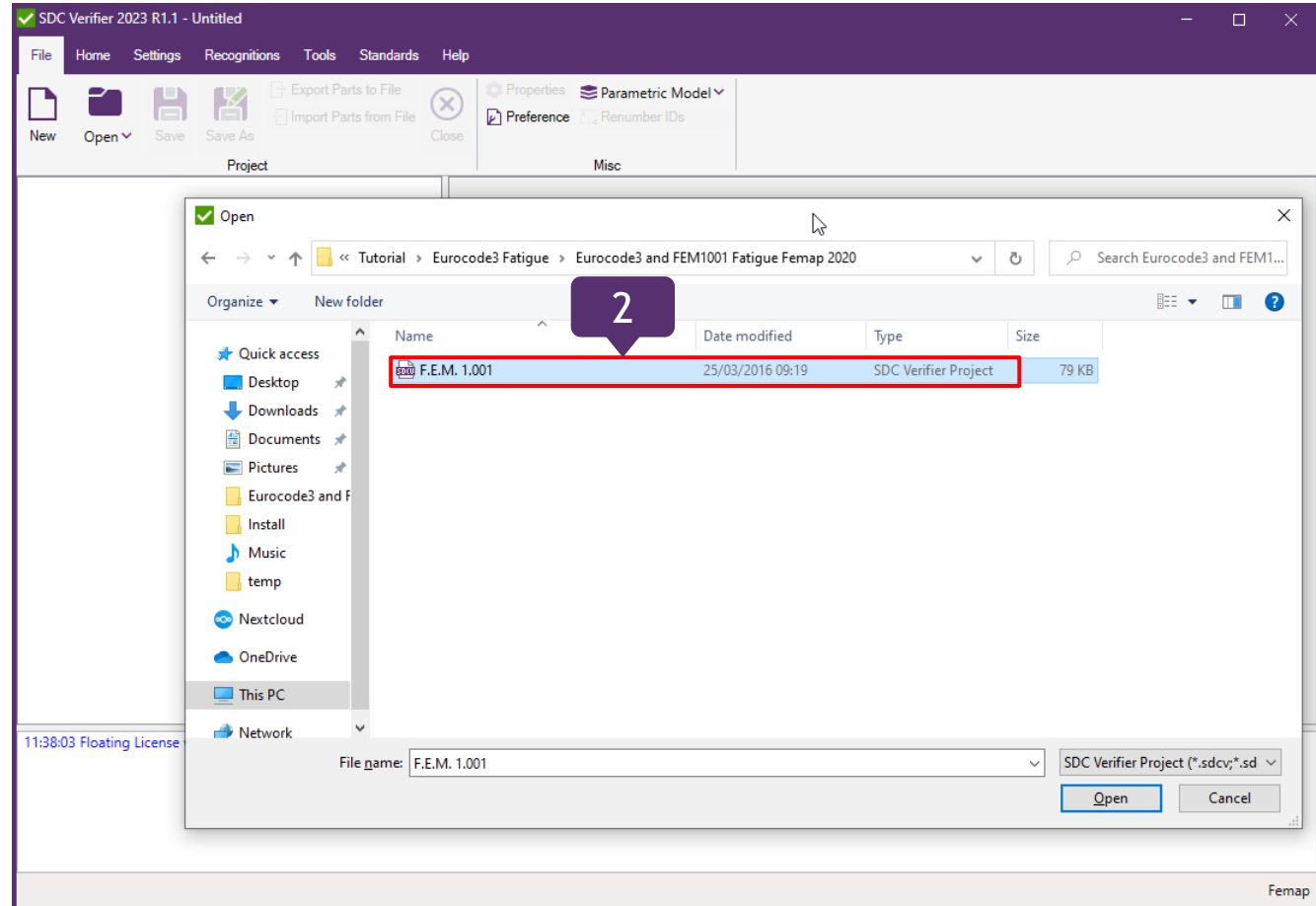
# Open the starter model

1

Launch **SDC Verifier** ✓

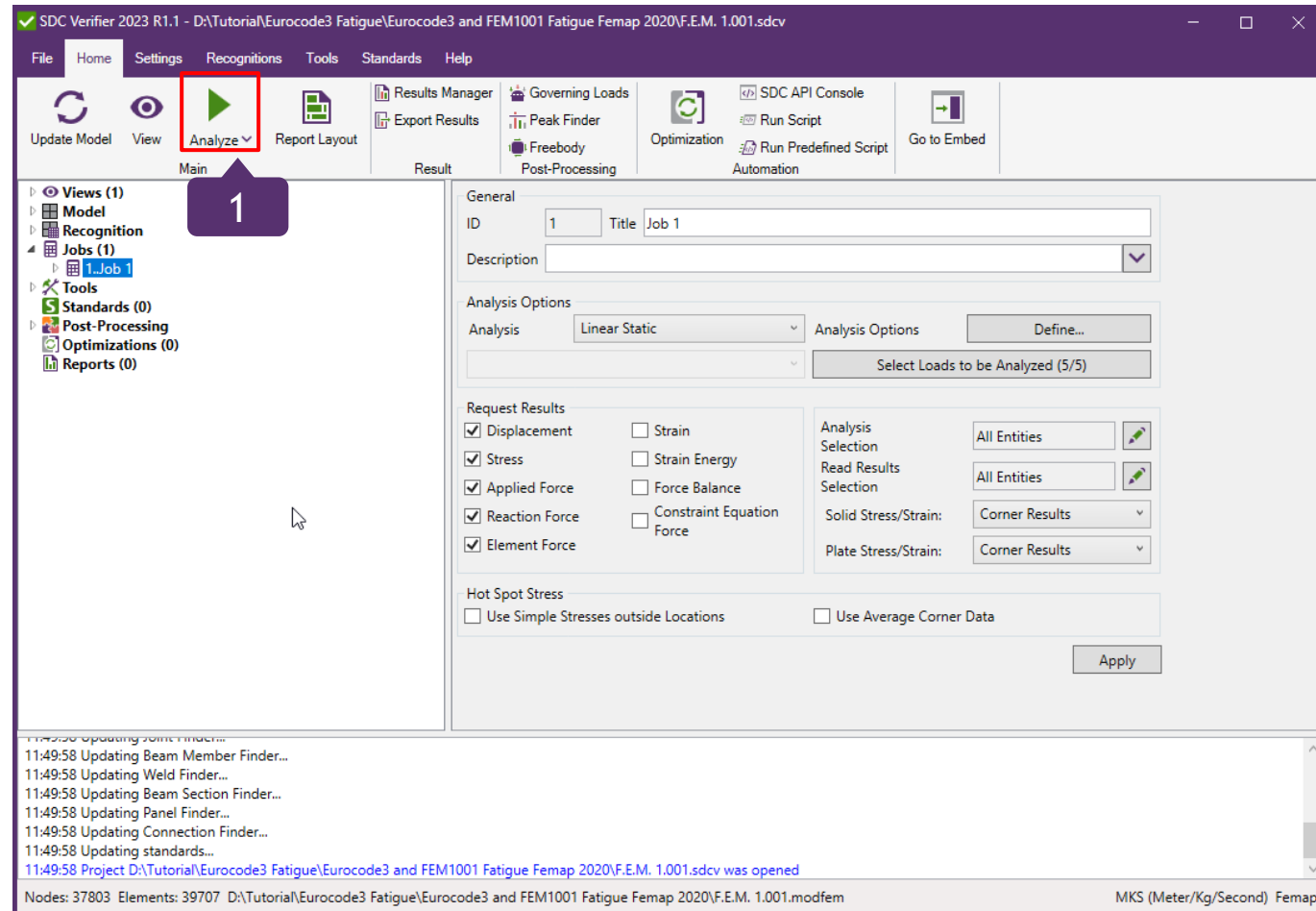
2

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



1

Press  to start Analysis in Femap



# Weld Finder

1

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


2

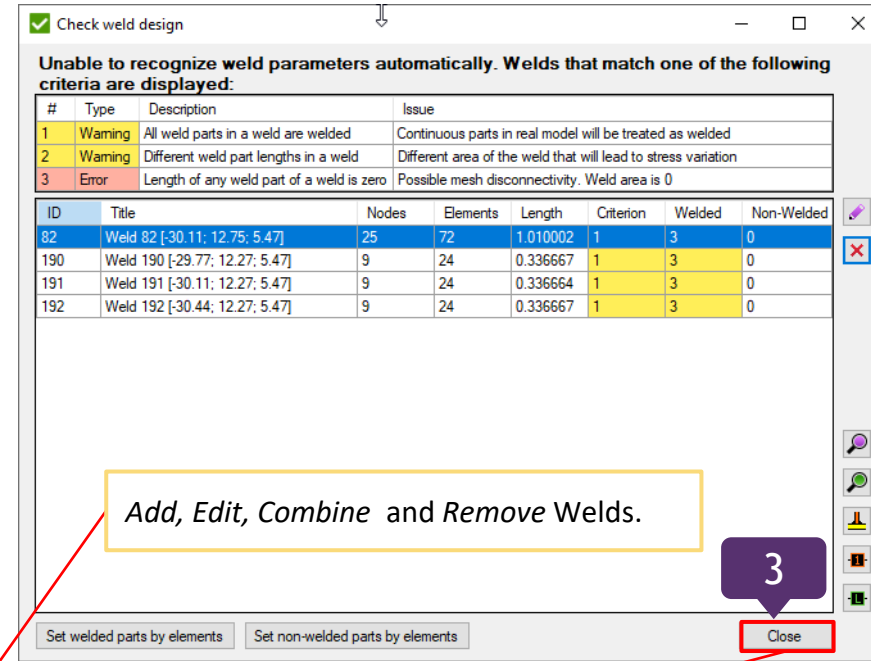
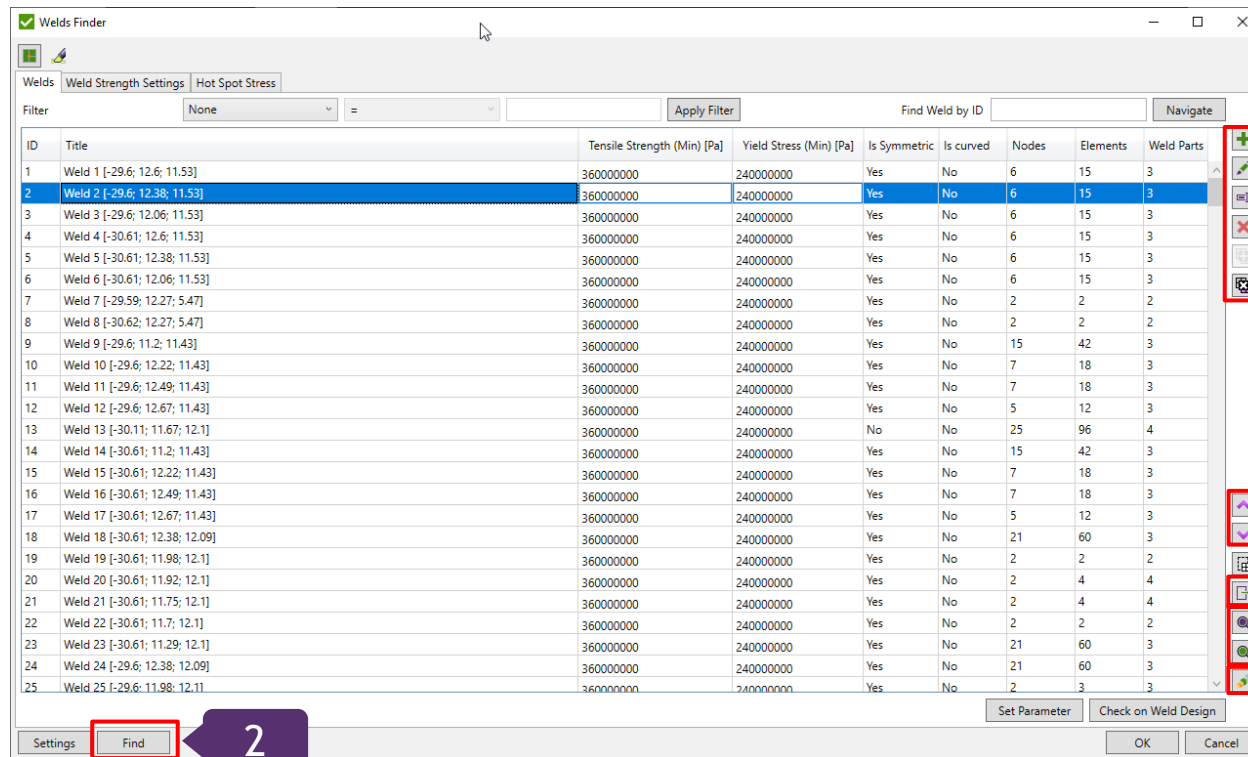
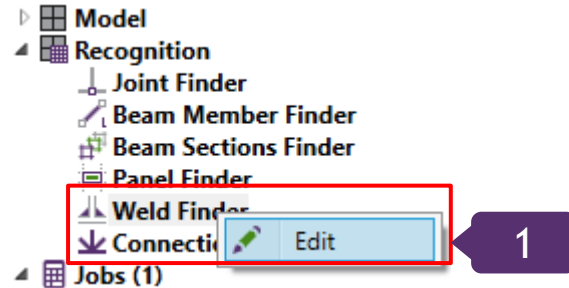
Press **Find**.

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

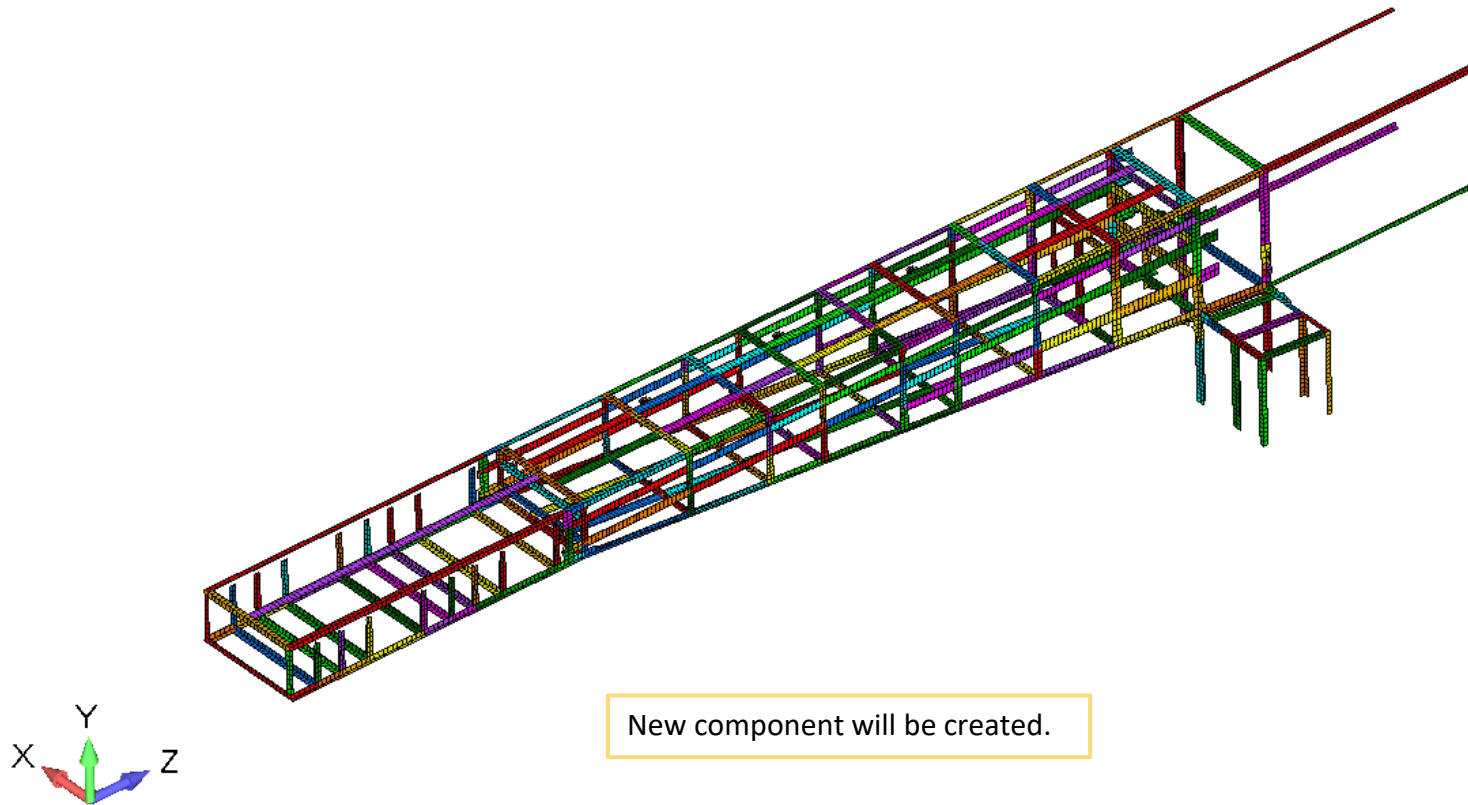
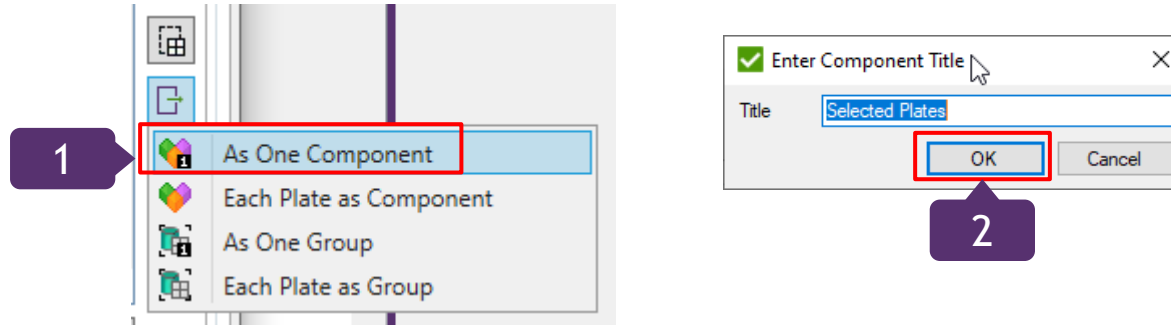
4

1

Click *As One Component*

2

Press *OK*.

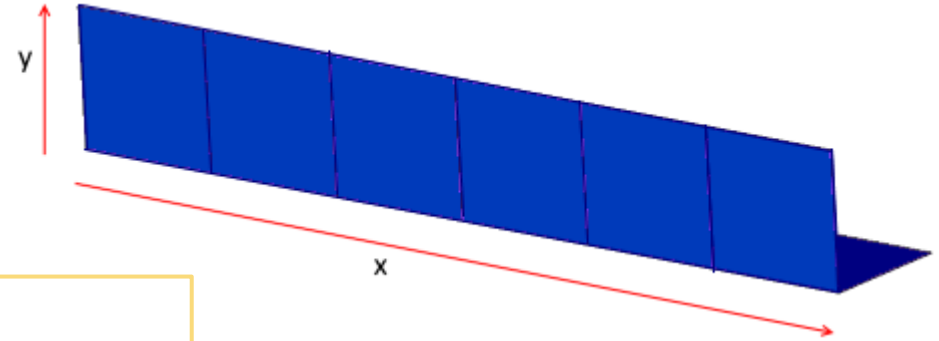


New component will be created.

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.

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

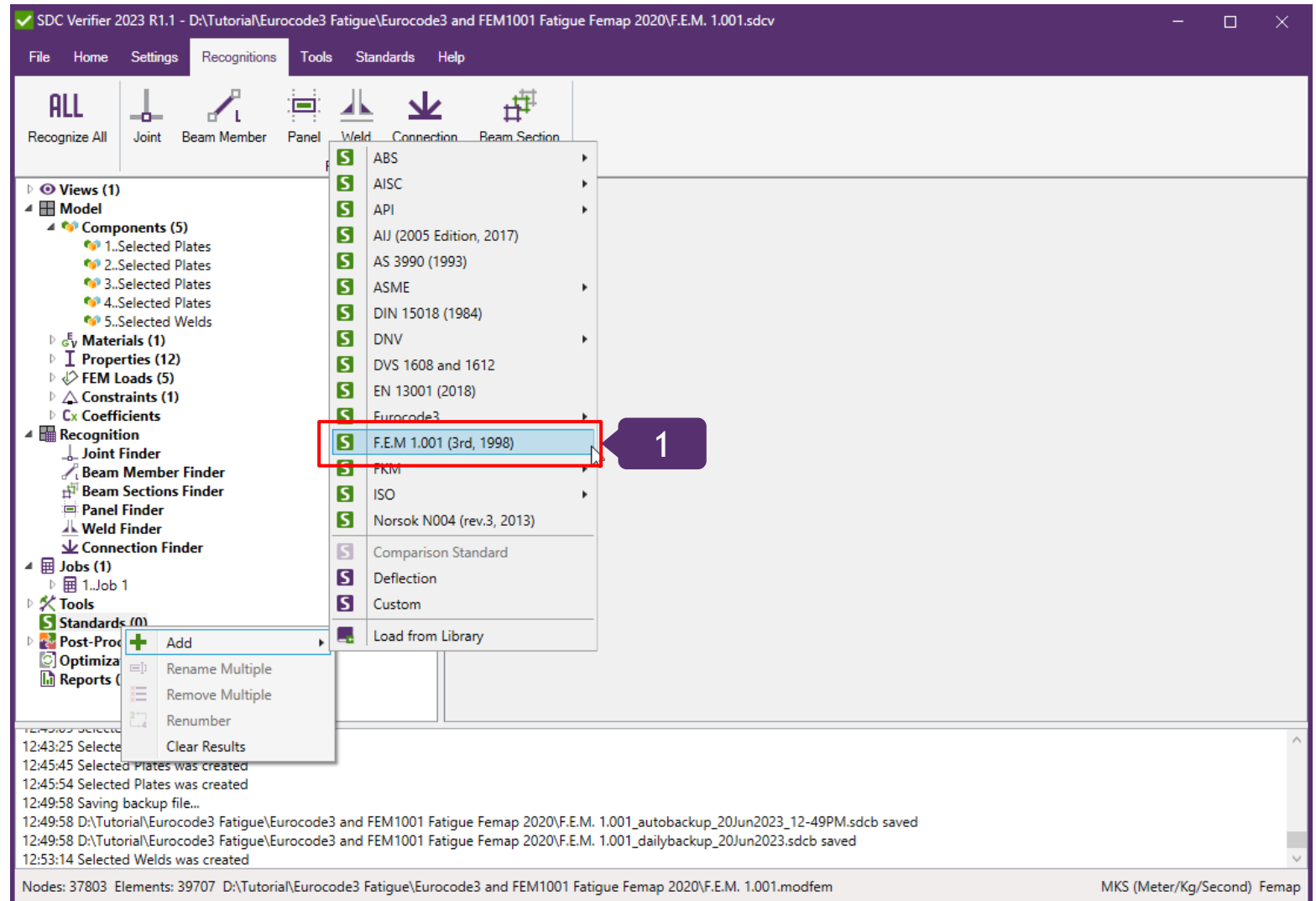
$\sigma_{xx}, \sigma_{yy}, \tau_{xy}$  – original x,y and shear stress in local element x,y and shear directions  
 $\sigma_{tt}, \sigma_{nn}, \tau_{nt}$  – transformed x,y and shear stress in weld x,y and shear directions  
 $\theta$  – angle between the element and weld x directions.



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).



1

Selection: **All Entities**

2

Press  to edit material properties.

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

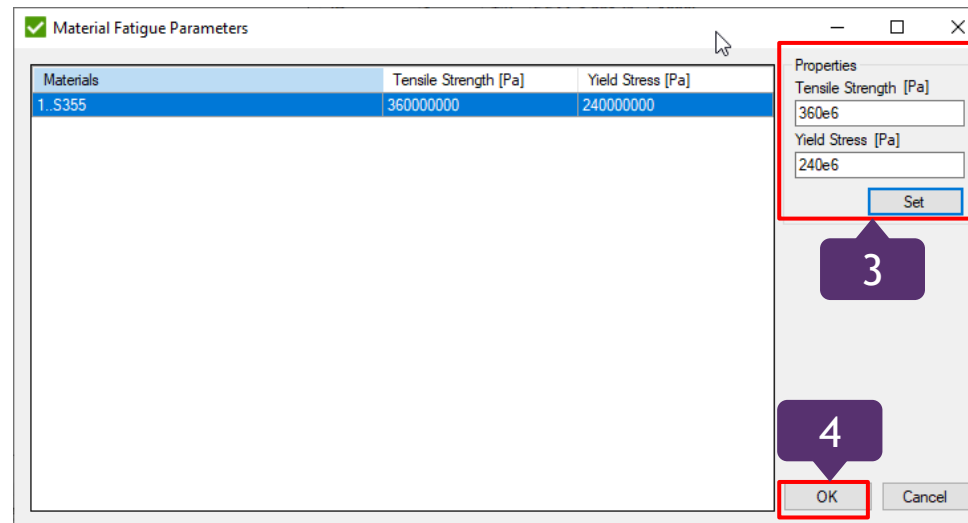
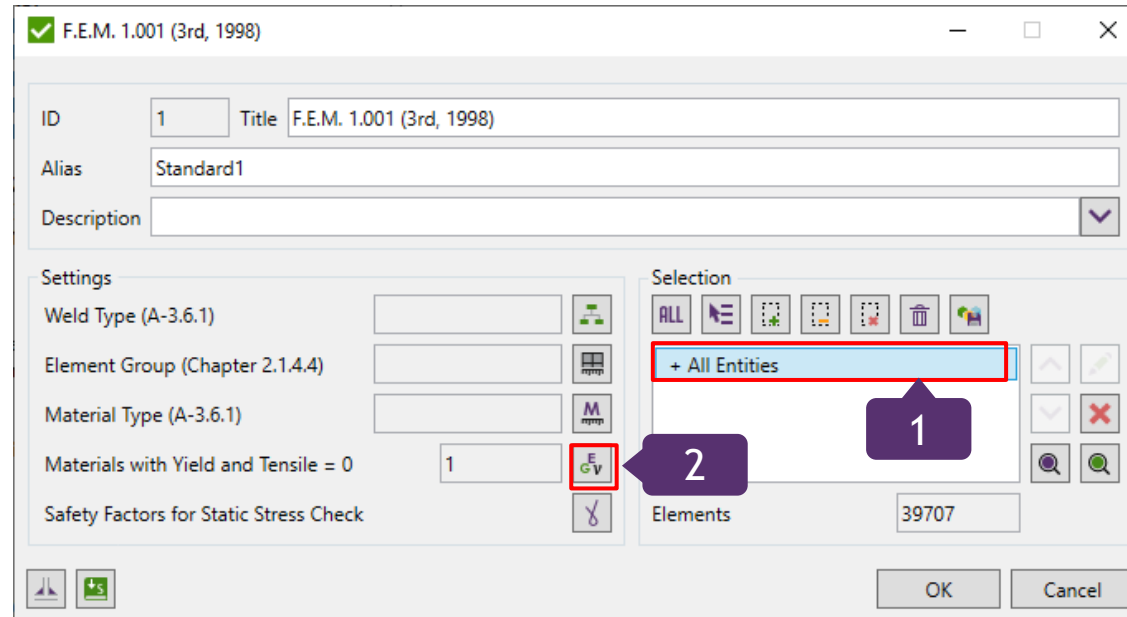
3

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.



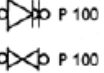
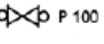
- ▶ Weld/notch category determines fatigue resistance
- ▶ Division in welds / non welds for FEM 1.001:
  - ▶ W category is for non welded parts
  - ▶ K category is for welded parts
- ▶ Fatigue resistance is further specified by adding classes
  - ▶ W0-W2 for non-welded parts
  - ▶ K0-K4 for welded parts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

# Weld Classes depends on Weld Type


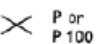
## Non-weld group W0

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

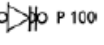
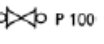
## Slight notch behavior group K0

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

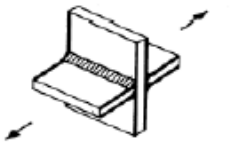
## Medium notch behavior group K2

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

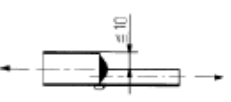


## Great notch behavior group K3

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.		>
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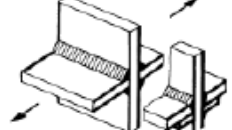


## and a different connection type 351

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

## 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.		 P  P

## and a different connection type 451

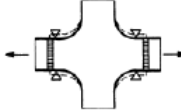


451	Fillet welds of normal quality or single bevel weld (included fillet weld) with backing, perpendicular to the direction of force, between crossing parts.		 D  D
-----	---	---	--

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

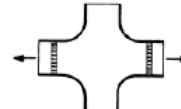


Steel Grade	$\sigma_D(-1)$ for $\kappa=-1$ element group 5 St 52-3							
Notch group	<b>W0</b>	<b>W1</b>	<b>W2</b>	<b>K0</b>	<b>K1</b>	<b>K2</b>	<b>K3</b>	<b>K4</b>
Stress amplitude	163.8	130.3	104.2	118.8	106.1	89.1	63.6	38.2

Depends on Stress concentrations:

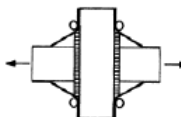


## Slight notch behavior group K0

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

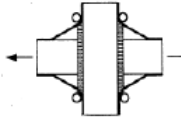


## Moderate notch behavior group K1

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

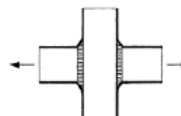


## Medium notch behavior group K2

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

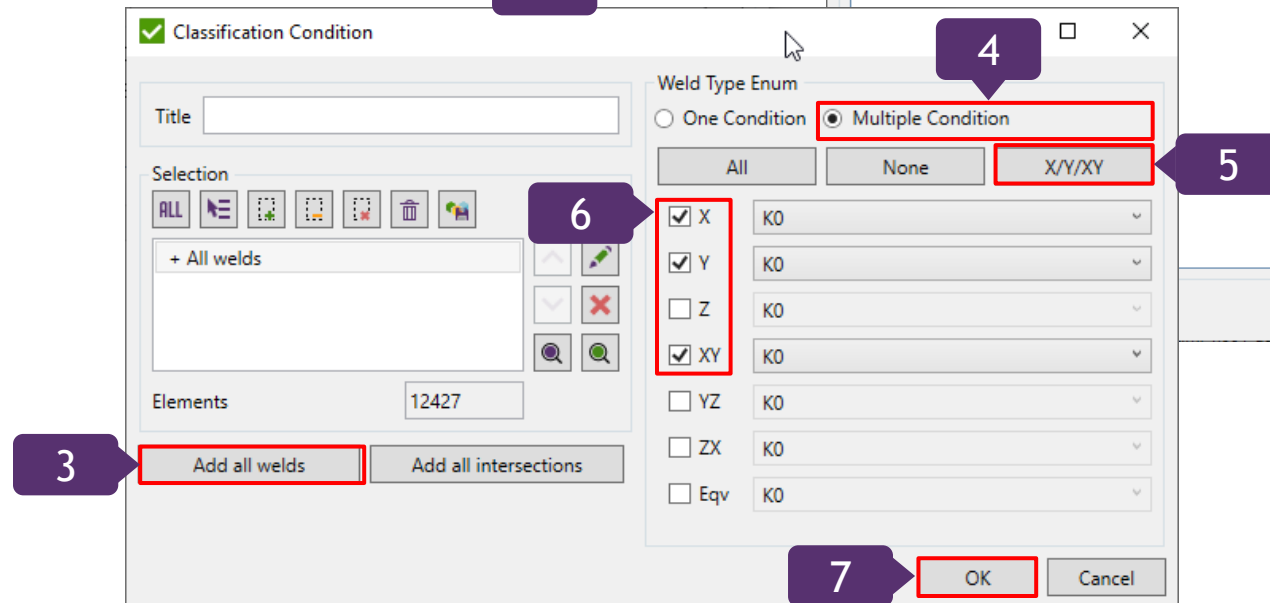
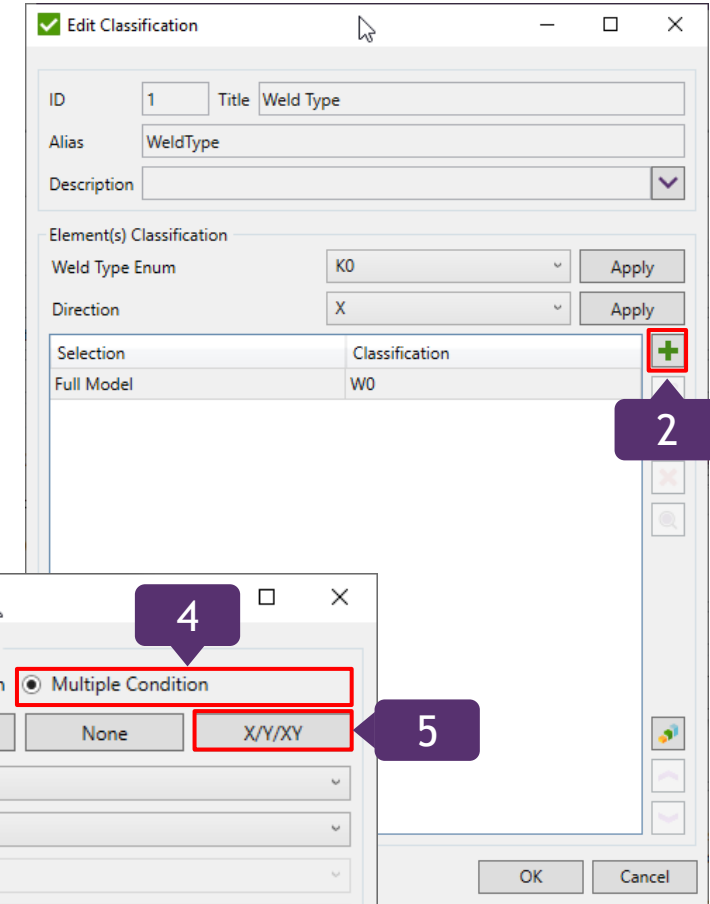
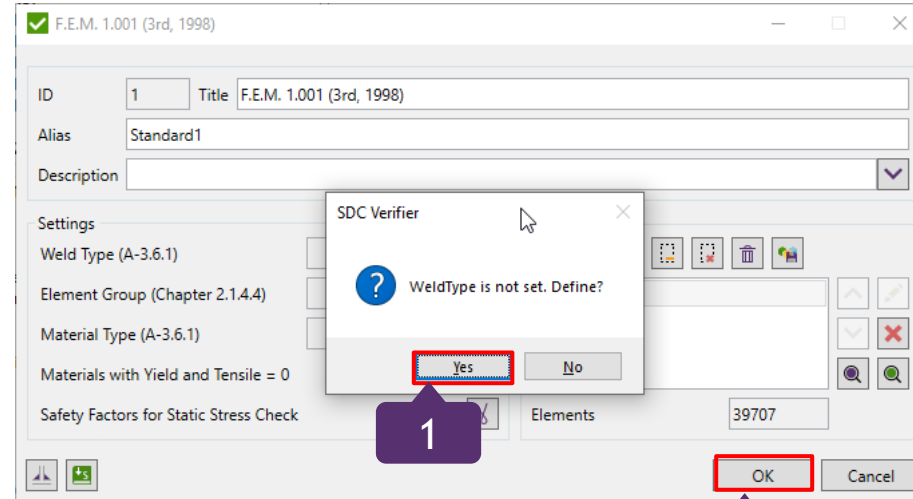
Press X/Y/XY

6

X: **K1** Y: **K2** XY: **K0**

7

Press *OK*



# Weld Type classification intersecting welds

1

Press  to Add Condition.

2

Click *All welds intersections*

3

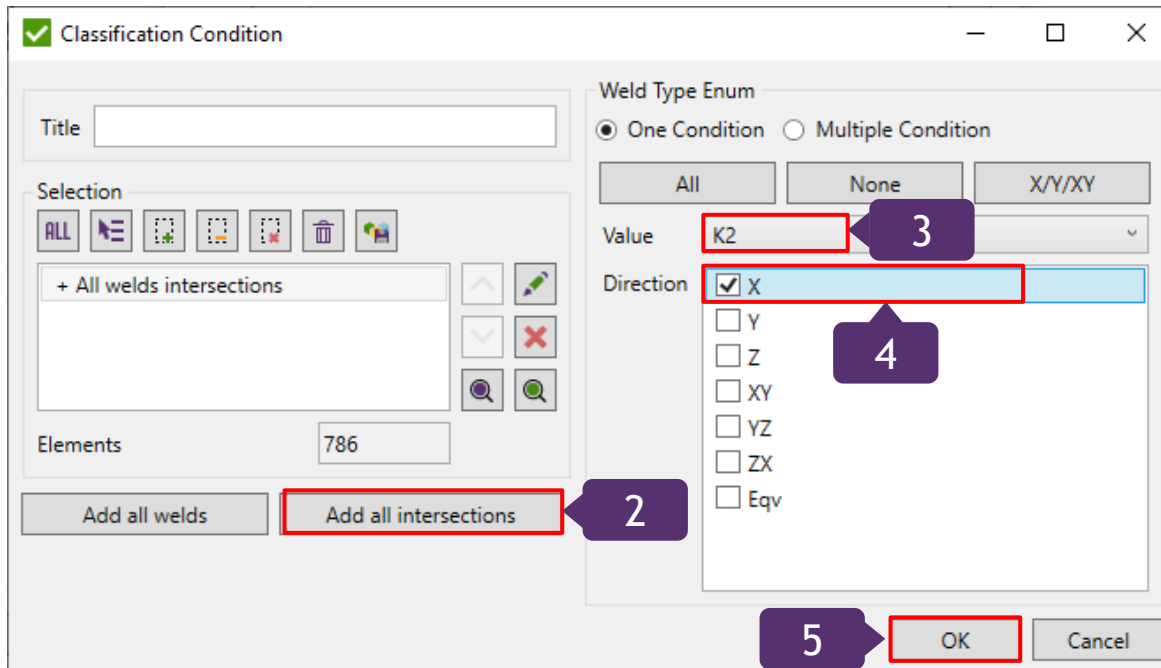
Value: **K2**

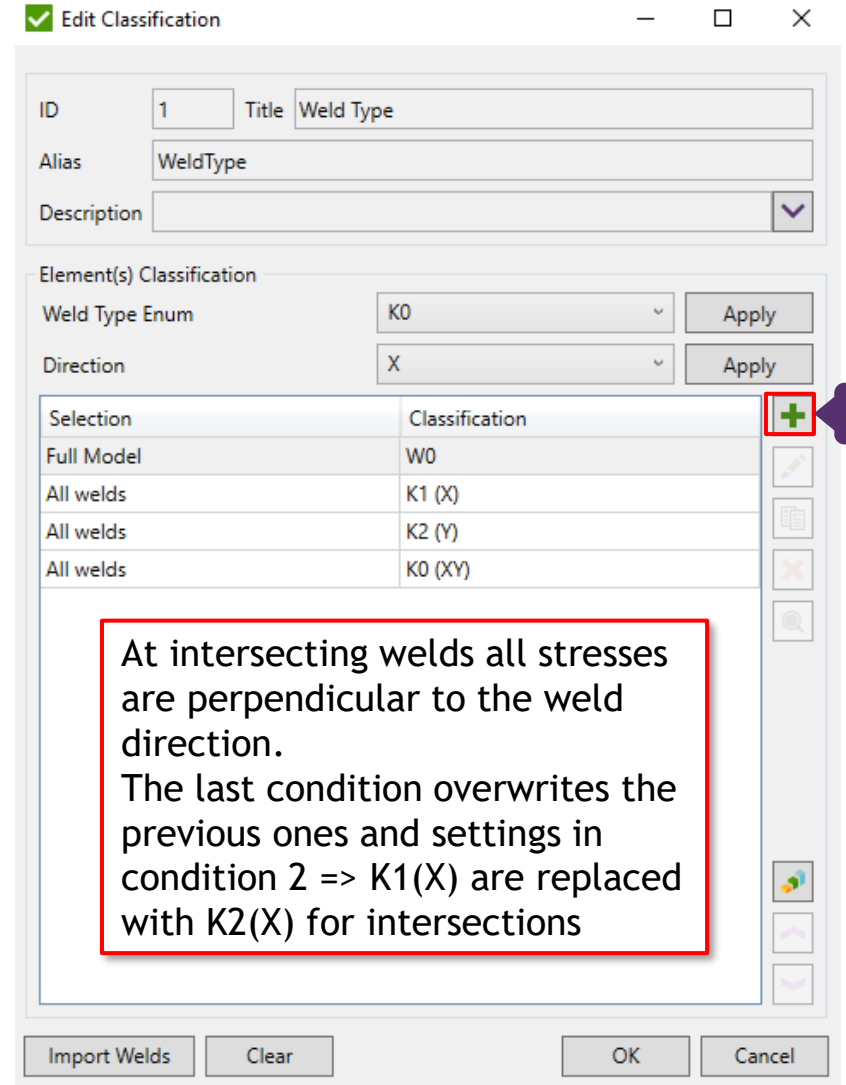
4

Directions: **X**

5

Press *OK*

 The dialog box is titled "Classification Condition". It has a "Title" field. Under "Selection", there are icons for "ALL", "Welds", "Intersections", "Stresses", "Displacements", "Reactions", and "Supports". The "Intersections" icon is highlighted. Below it is a list with "+ All welds intersections". To the right of the list are "Add" and "Remove" buttons. Below the list is a text field showing "Elements 786". At the bottom left are "Add all welds" and "Add all intersections" buttons. The "Add all intersections" button is highlighted. On the right, there are radio buttons for "One Condition" (selected) and "Multiple Condition". Below them are buttons for "All", "None", and "X/Y/XY". The "Value" field is set to "K2". The "Direction" section has a list of checkboxes: "X" (checked), "Y", "Z", "XY", "YZ", "ZX", and "Eqv". At the bottom are "OK" and "Cancel" buttons.

 The dialog box is titled "Edit Classification". It has fields for "ID" (1), "Title" (Weld Type), "Alias" (WeldType), and "Description". Below these are "Element(s) Classification" settings: "Weld Type Enum" (K0) and "Direction" (X), each with an "Apply" button. A table shows the classification for different selections:

Selection	Classification
Full Model	W0
All welds	K1 (X)
All welds	K2 (Y)
All welds	K0 (XY)

At the bottom are "Import Welds", "Clear", "OK", and "Cancel" buttons.

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

✓

Edit Classification

ID

1

Title

Weld Type

Alias

WeldType

Description

▼

Element(s) Classification

Weld Type Enum

K0

▼

Apply

Direction

X

▼

Apply

Selection

Classification

Full Model

W0

All welds

K1 (X)

All welds

K2 (Y)

All welds

K0 (XY)

All welds intersections

K2 (X)

Import Welds

Clear

OK

Cancel

Values

Labels

Selection

X

Y

Z

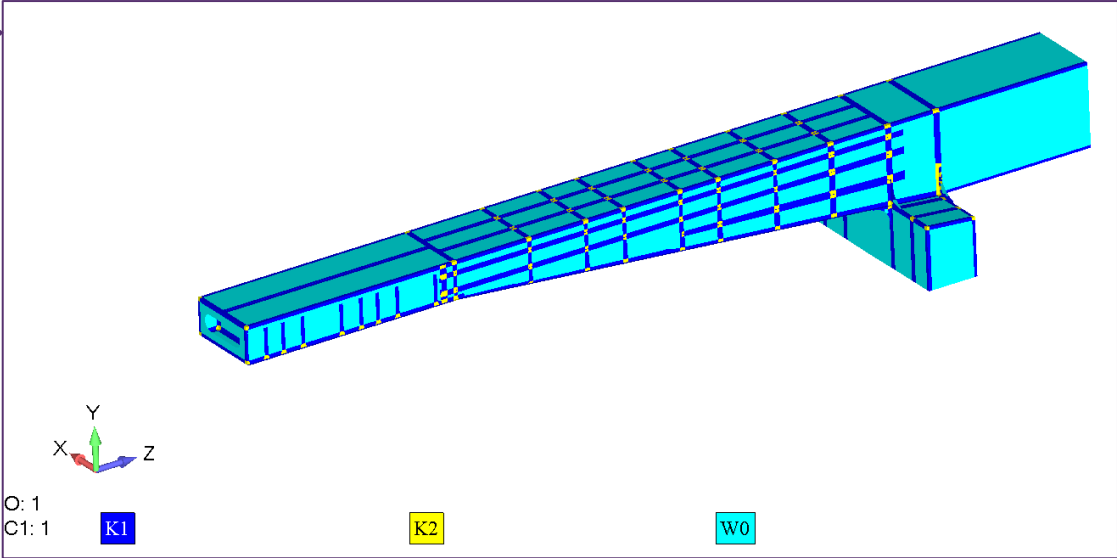
XY

YZ

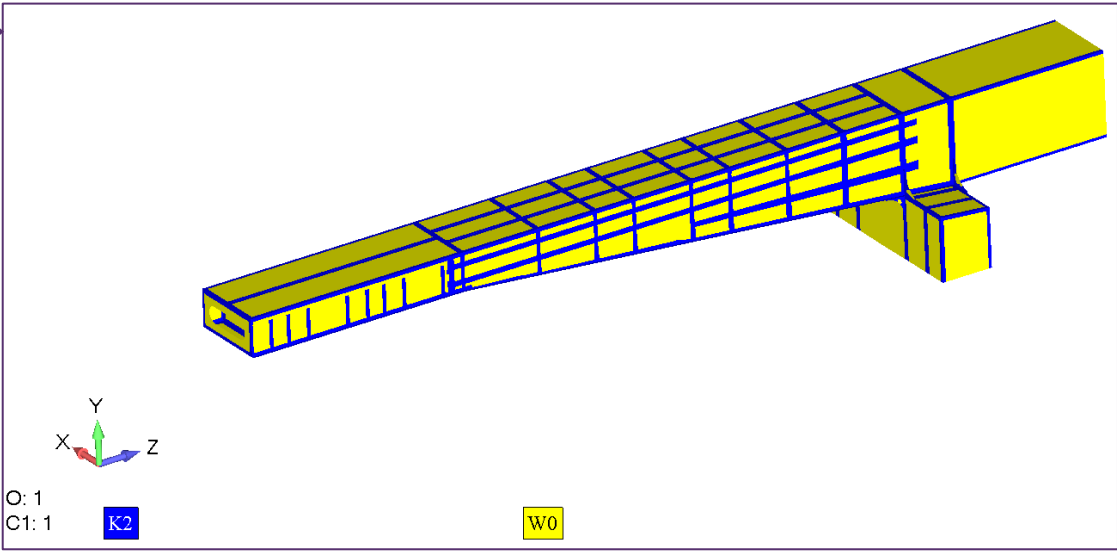
ZX

Equivalent


1



2

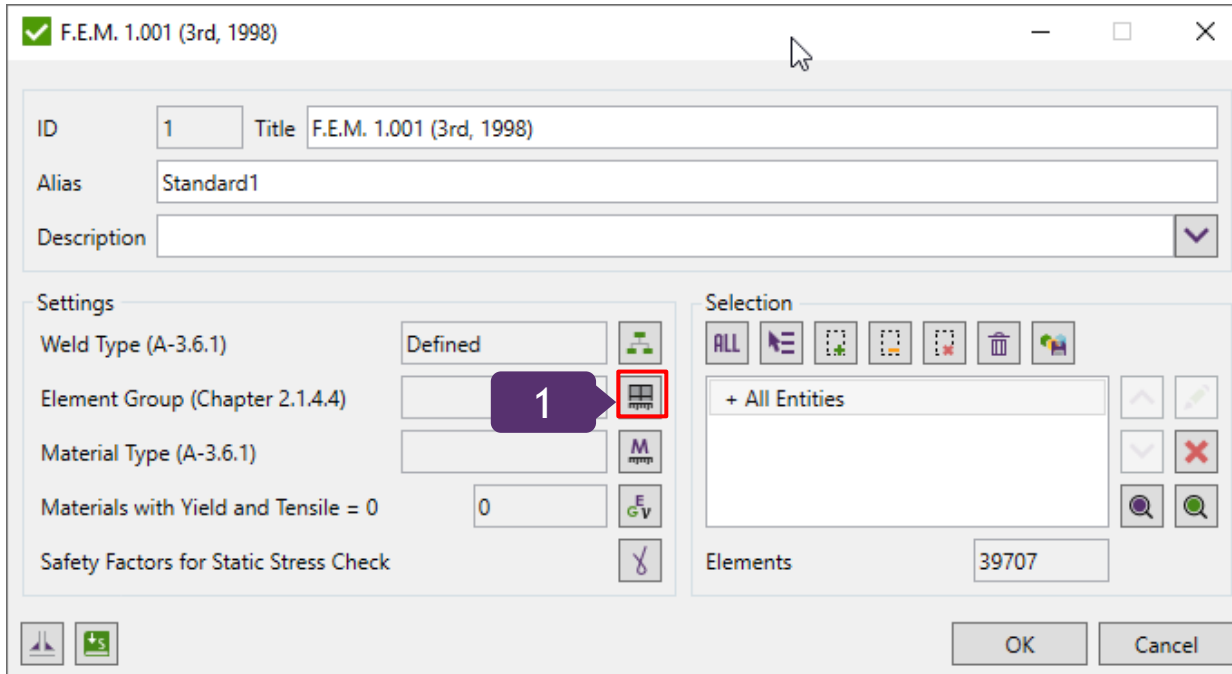


# Element Group classification

1 Press  for the Element Group.

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

3 Press *OK*.



✓ F.E.M. 1.001 (3rd, 1998)

ID: 1 Title: F.E.M. 1.001 (3rd, 1998)

Alias: Standard1

Description:

Settings

Weld Type (A-3.6.1): Defined

Element Group (Chapter 2.1.4.4): **E6** (highlighted with a red box and a purple arrow labeled '1')

Material Type (A-3.6.1):

Materials with Yield and Tensile = 0: 0

Safety Factors for Static Stress Check:

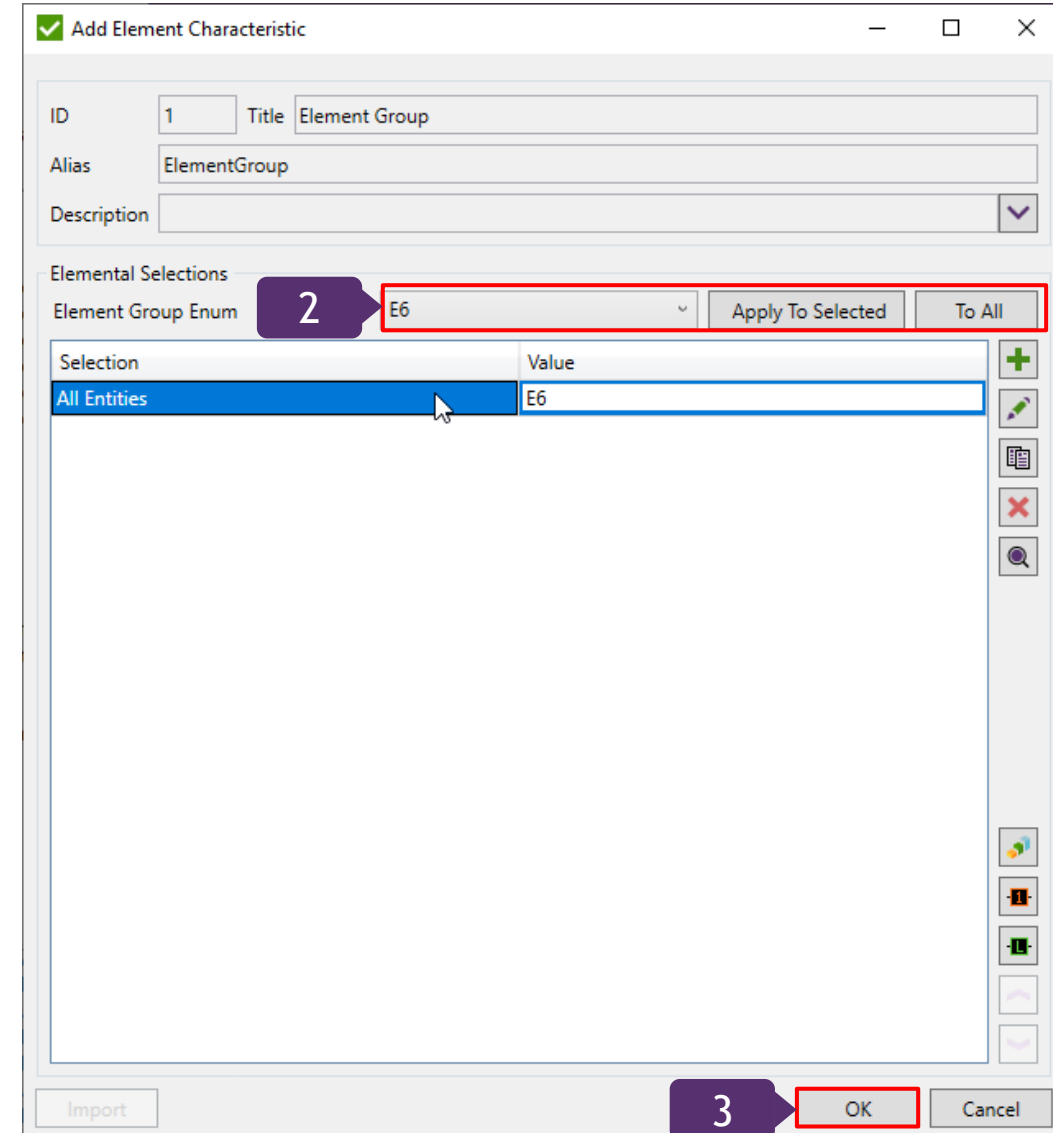
Selection

ALL

+ All Entities

Elements: 39707

OK Cancel



✓ Add Element Characteristic

ID: 1 Title: Element Group

Alias: ElementGroup

Description:

Elemental Selections

Element Group Enum: **E6** (highlighted with a red box and a purple arrow labeled '2')

Apply To Selected To All


Selection	Value
All Entities	E6

Import

**OK** (highlighted with a red box and a purple arrow labeled '3') Cancel

# Material Type classification

1

Press  for the Material Type.

2

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

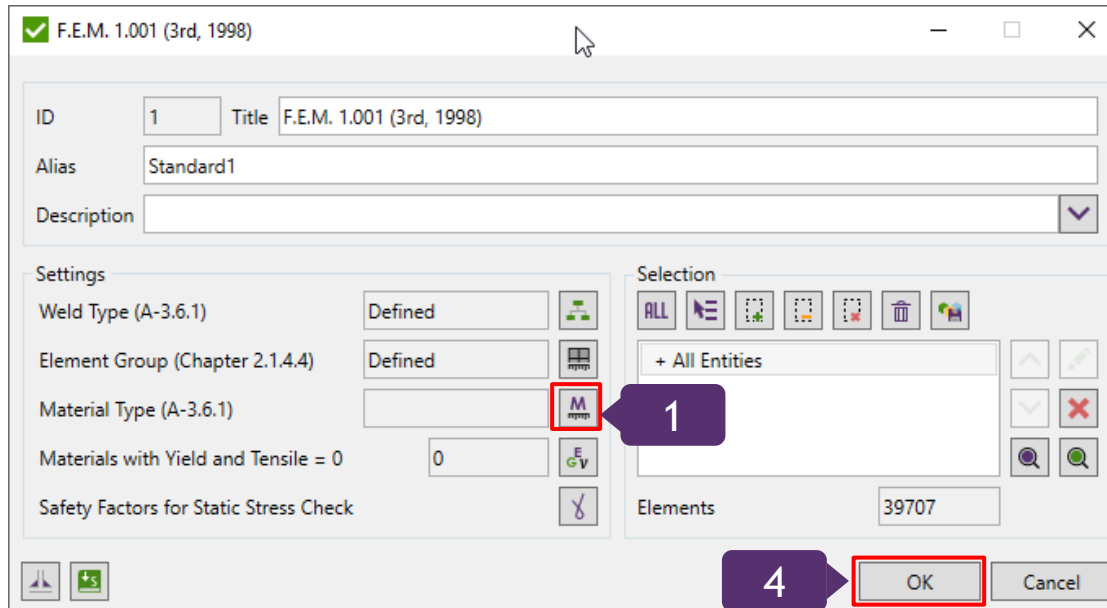
3

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.



✓ F.E.M. 1.001 (3rd, 1998)

ID: 1 Title: F.E.M. 1.001 (3rd, 1998)


Alias: Standard1

Description:


Settings

Weld Type (A-3.6.1): Defined

Element Group (Chapter 2.1.4.4): Defined

Material Type (A-3.6.1):  1

Materials with Yield and Tensile = 0: 0

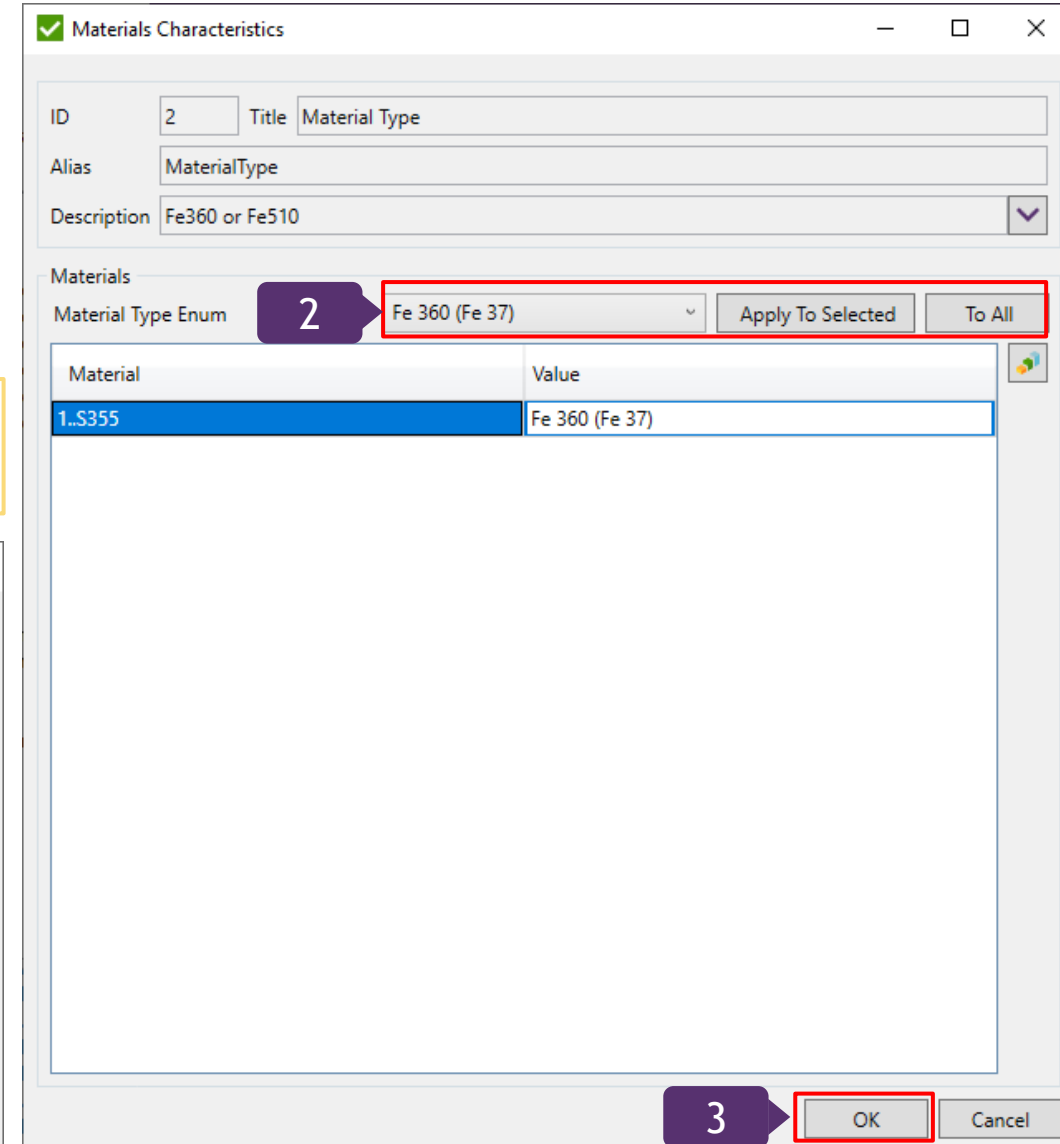
Safety Factors for Static Stress Check: 

Selection

+ All Entities

Elements: 39707

4 OK Cancel



✓ Materials Characteristics

ID: 2 Title: Material Type

Alias: MaterialType

Description: Fe360 or Fe510

Materials


Material Type Enum: 2 Fe 360 (Fe 37) Apply To Selected To All

Material	Value
1..S355	Fe 360 (Fe 37)

3 OK 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

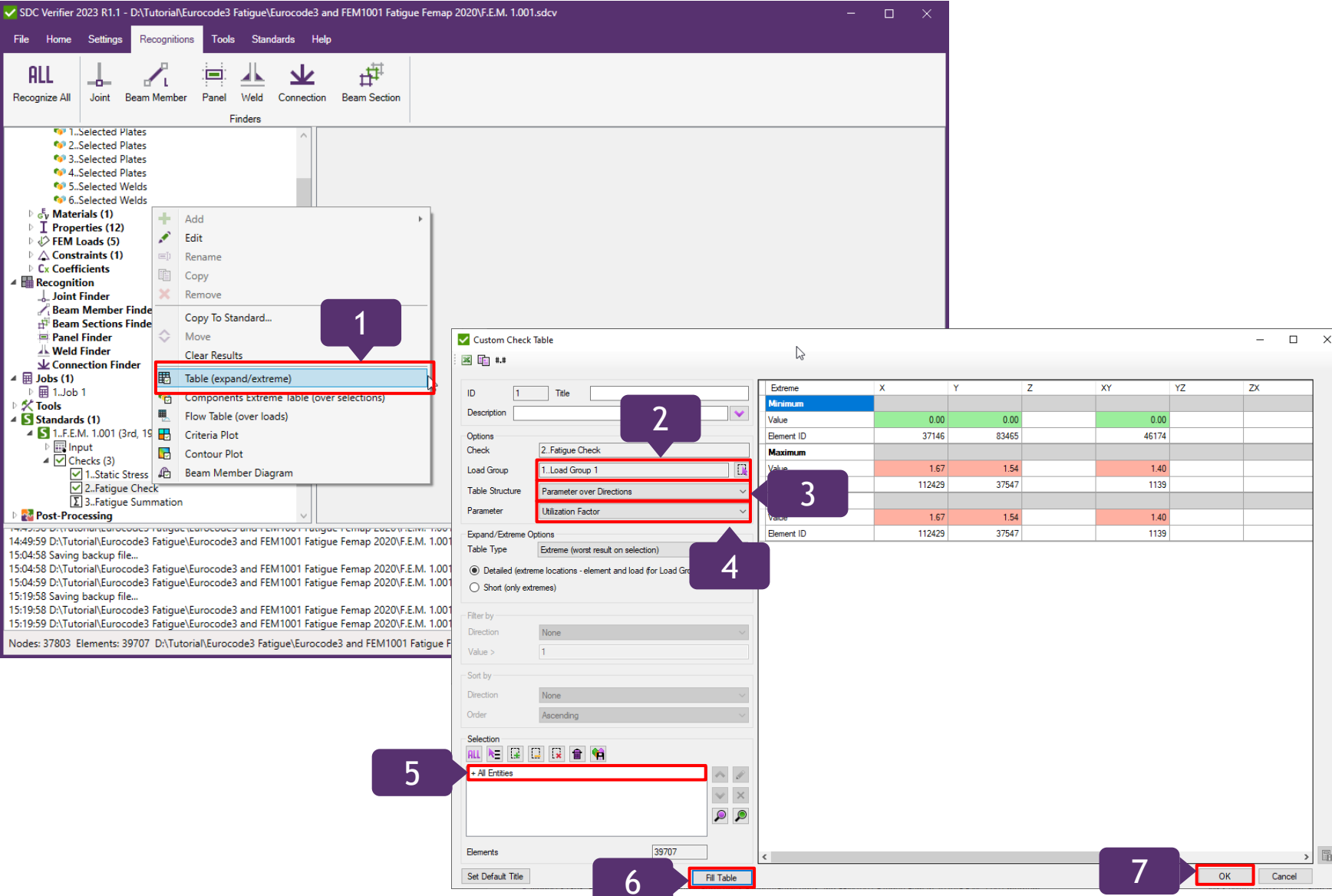
Selection: **All Entities**.

6

Press **Fill Table**.

7

Press **OK**.



1

2

3

4


5

6

7

Extreme	X	Y	Z	XY	YZ	ZX
Minimum						
Value	0.00	0.00		0.00		
Element ID	37146	83465		46174		
Maximum						
Value	1.67	1.54		1.40		
Element ID	112429	37547		1139		

# Create criteria plot

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

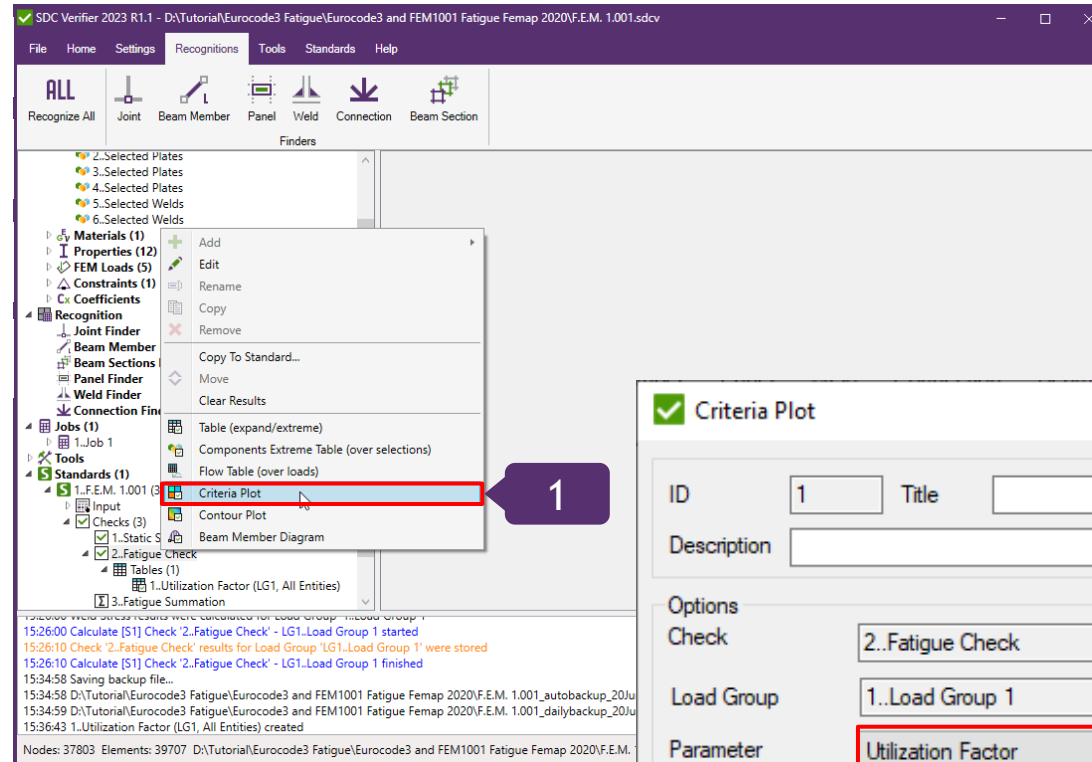
2 Parameter: **Utilization Factor**

3 Direction: **Overall**

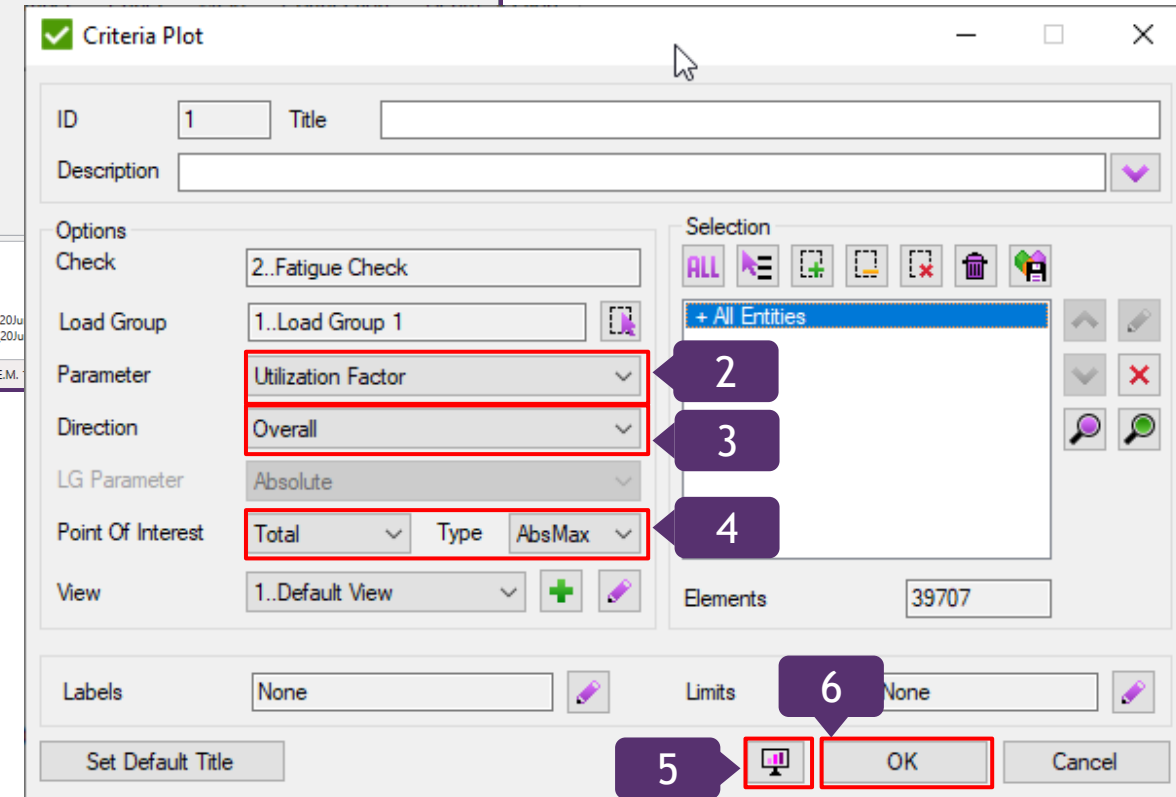
4 Point of interest: **Total** Type: **AbsMax**

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**.

Home Insert Results Post Processing Import

Expand/Extreme Components/Extreme Flow Table Summarized Forces (over nodes) Output Vector Criteria Contour Histogram Expand Graph Beam Member Diagram Output Vector Criteria Output Vector Contour Check Tables Check Plots

Search Show Parents

First Page Table of Content Preface Results Appendix

Standard '1..F.E.M. 1.001 (3rd, 1998)'

[S1] 1..Static Stress Check [S1] 2..Fatigue Check [S1] 3..Fatigue Summation

Custom Check Table

Loads Count LG1..Load Group 1

Options Table Type Extreme (worst result on selection) Table Structure Parameter over Directions

Extreme Options Detailed (extreme locations - element and load(for Load Groups)) Short (only extremes)

Filter by Parameter None Value > 1

Sort by Parameter None Order Descending

Parameters Kappa Factor Stress Fatigue Allowable Stress Fatigue Utilization Factor

OK Cancel

Wizard - Empty Wizard - Model Setup Wizard - Results Wizard - Full Designer - Empty Designer - Model Setup Designer - Results Designer - Full Presentation

Group 'LG1..Load Group 1' were stored - LG1..Load Group 1 finished

# Report. Tables and plots

1

Results => *Check Plots*

2

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

3

Load Group: **1..Load Group**

4

Parameters: **Utilization Factor**

5

Direction: **Overall**

6

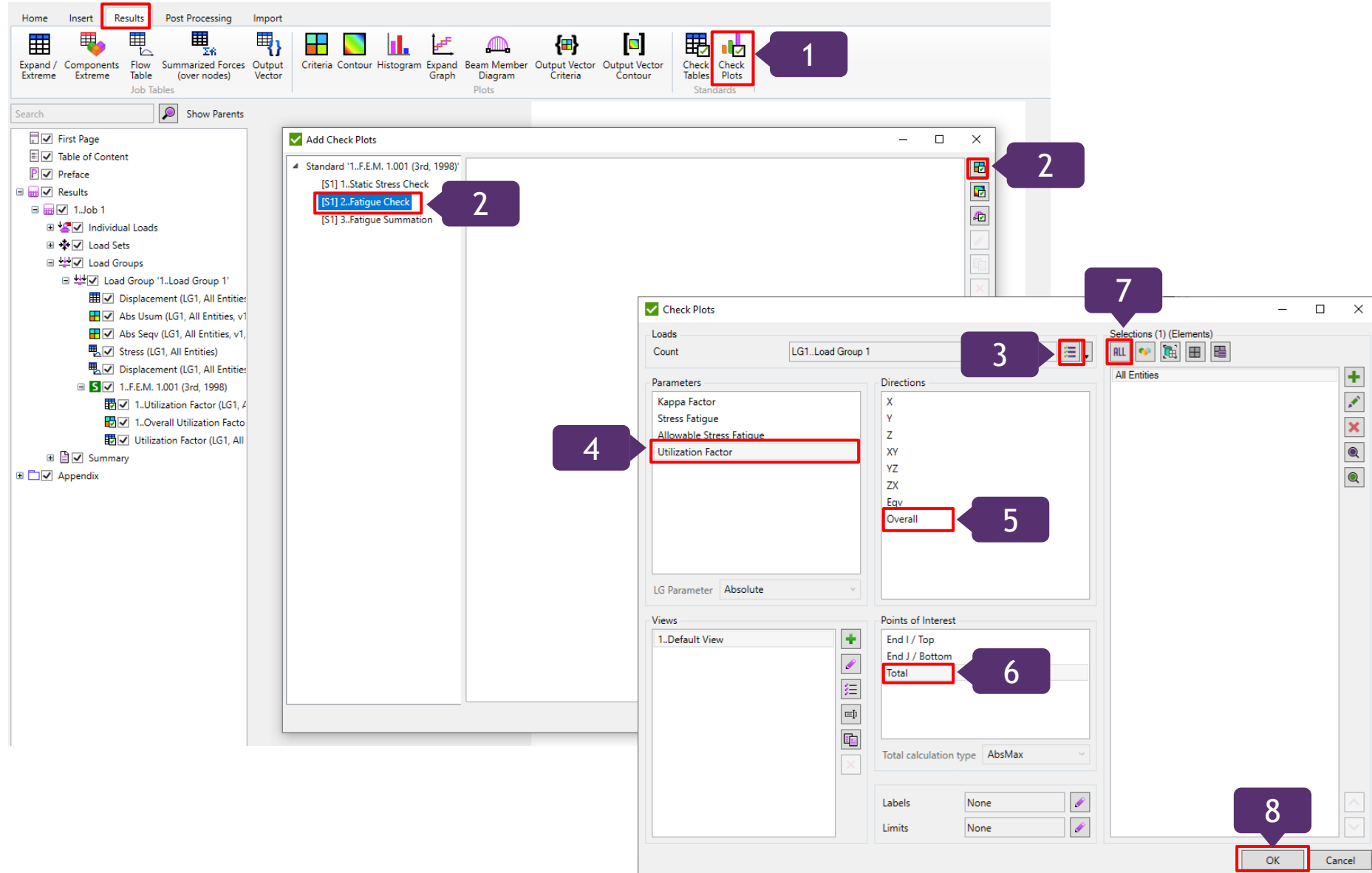
Point of Interest: **Total**.

7

Selection: **All Entities**.

8

Press OK.



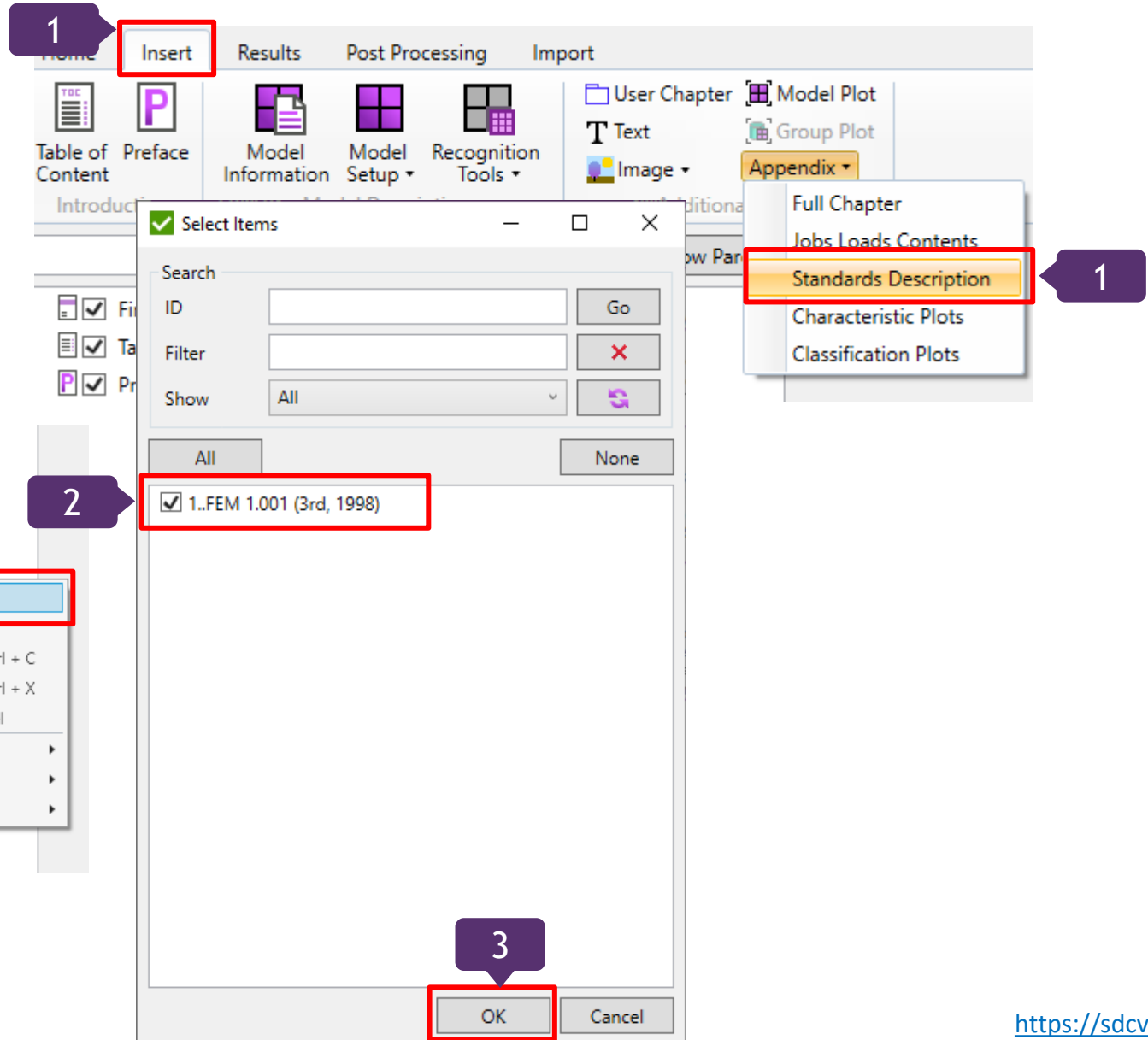
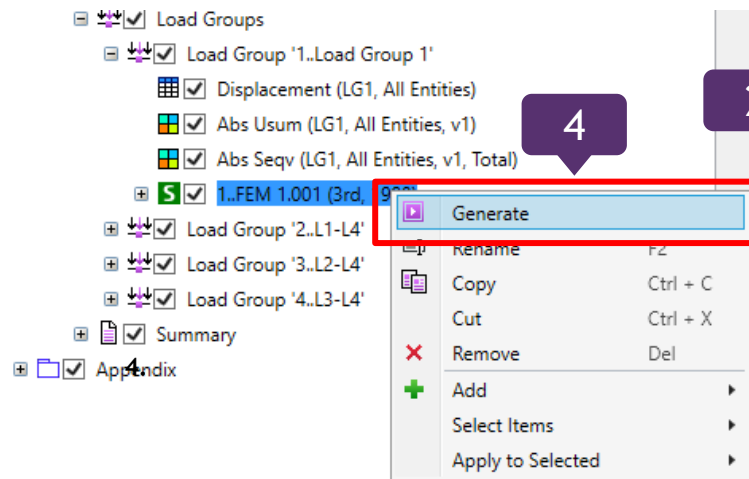
# Report. Fatigue Check

1 Insert => Appendix => Standards Description

2 Choose 1..FEM 1.001

3 Press OK.

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



## 1..F.E.M. 1.001 (3rd, 1998)

### Unit System

Current Unit System = MKS (Meter/Kg/Second). It is used in calculations for the following standards: API RP 2A, ISO 19902, Norsok N004, DIN 15018, FEM 1.001 and Eurocode3.

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

Standard	1..F.E.M. 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		46174			83624	22151
Maximum								
Value	1.67	1.90		1.40			4.04	2.01
Element ID	112429	37547		1139			37547	37547
Absolute								
Value	1.67	1.90		1.40			4.04	2.01
Element ID	112429	37547		1139			37547	37547

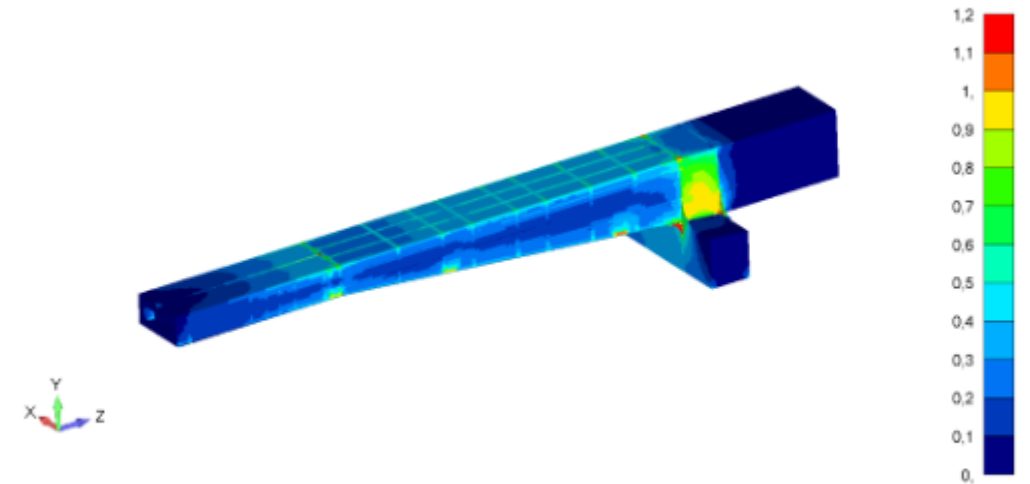
### Utilization Factor (LG1, 9 Selections)

Check	[S1] 2..Fatigue Check						Load Group	LG1..Load Group 1	
Parameter	Utilization Factor						Selection	9 Selections	
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		0.14			0.33	0.58	
Plate '8...stl plt 25 mm thks'									
Plate '10...stl plt 4 mm thks'	0.40	0.49		0.04			0.23	0.49	
Plate '11...stl plt 12 mm thks'	1.05	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..F.E.M. 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	0.00
Maximum	1.67	1.90		1.40			4.04	2.01
Absolute	1.67	1.90		1.40			4.04	2.01

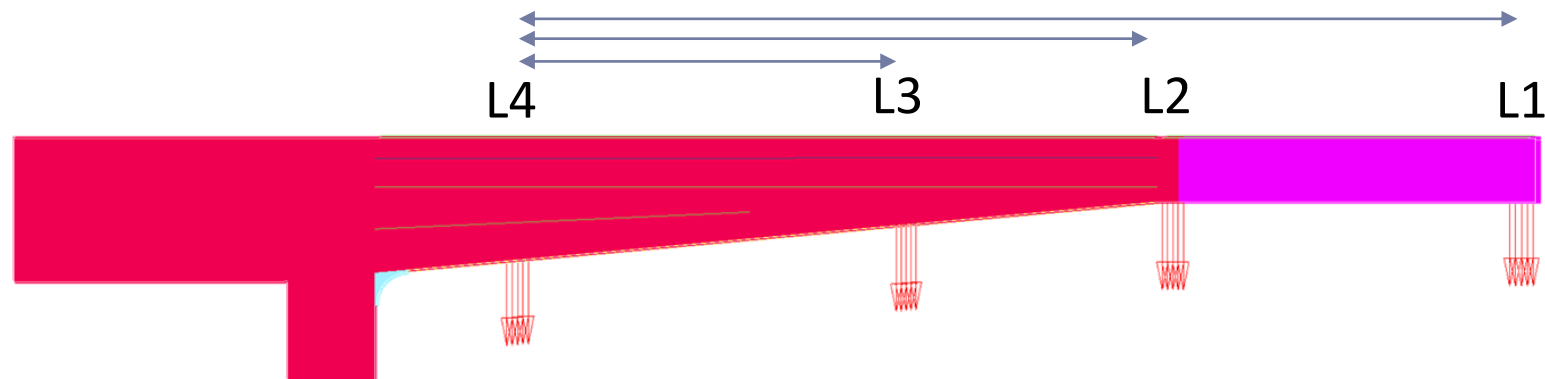
### Overall Utilization Factor (LG1, All Entities, v1, Total)



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..L4-L1** and **3..L4-L3**

5

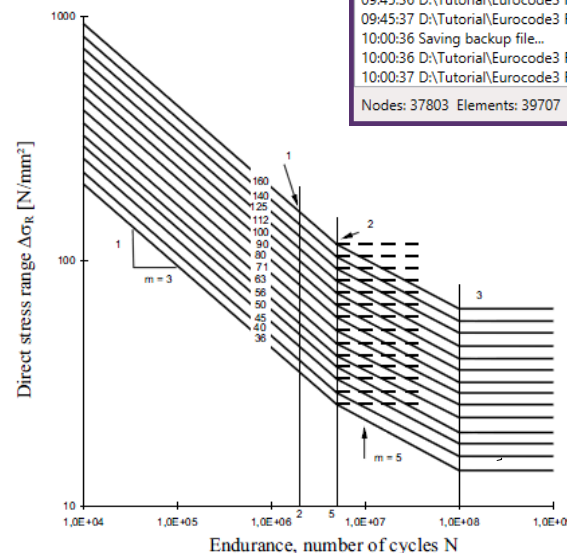
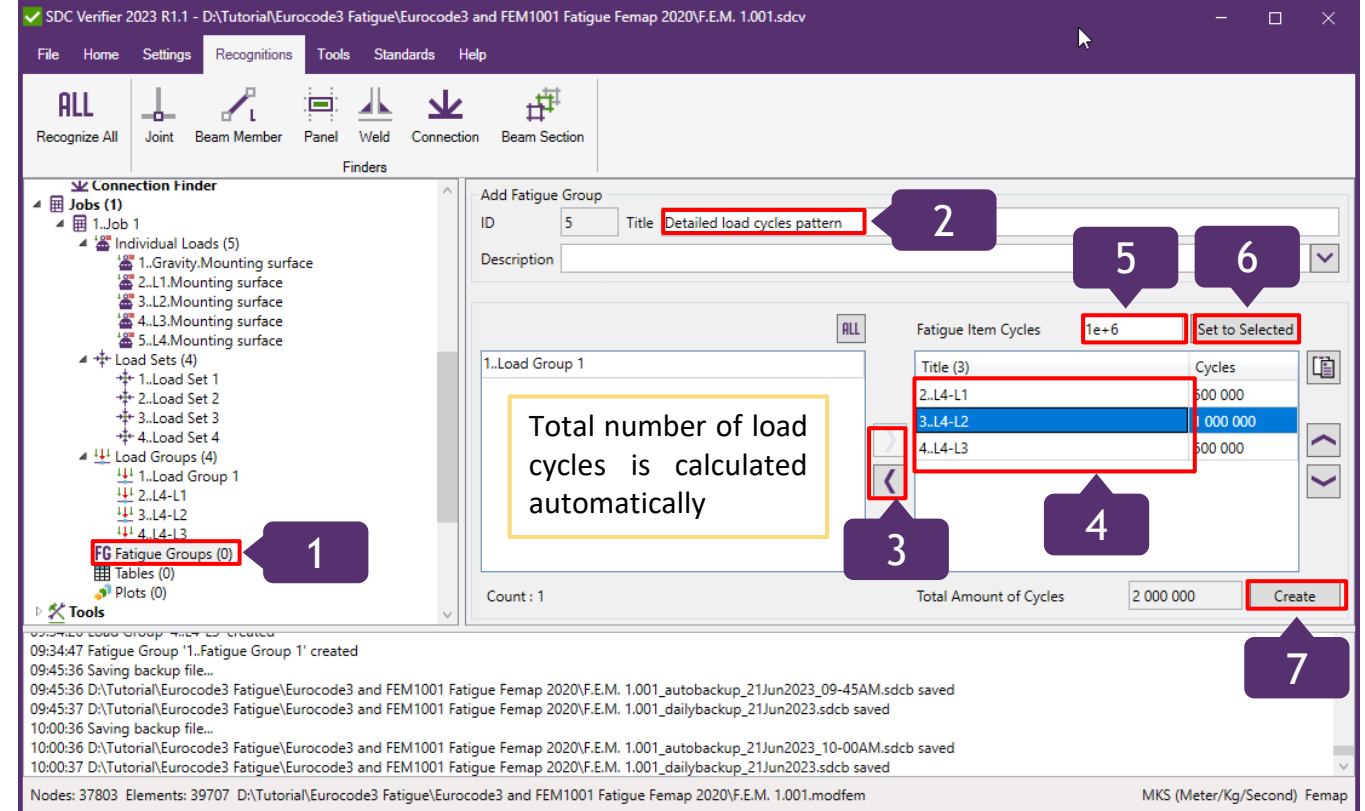
Fatigue Item Cycles: **0.5e+6** and **Set**.

6

Set **1e+6** cycles for 2..L4-L2

7

Press **Create**



# Fatigue calculation with Eurocode 3

1

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

2


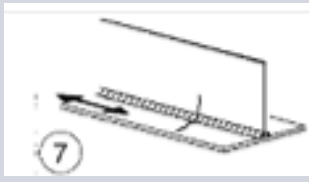
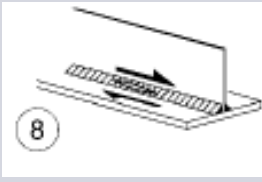


Consequence of Failure: **Low**

3




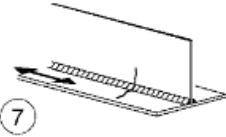
Assessment Method: **Damage tolerant**

The screenshot shows the SDC Verifier 2023 R1.1 interface. The 'Add' menu is open, showing the path: Standards > Eurocode3 > Eurocode3 Fatigue (EN 1993-1-9, 2005). A red box highlights this option, with a callout '1'. Below, the 'Eurocode3 Fatigue (EN1993-1-9, 2005)' configuration dialog is shown. The 'Consequence of Failure' dropdown is set to 'Low' (callout '2') and the 'Assessment Method' dropdown is set to 'Damage Tolerant' (callout '3'). Other fields include ID (2), Title (Eurocode3 Fatigue (EN1993-1-9, 2005)), Alias (Standard2), Description, Option (FAT Class), Reduced Range (Defined), Size Effect (Defined), Safety Factor (Gamma\_Mf) (1), and Materials with Yield = 0 (0). The 'Elements' field shows 39707.

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

	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

1

Press *Define* for the FAT Class.

2

Full Model: **160**

3

All Entities: **100** (No weld)

4

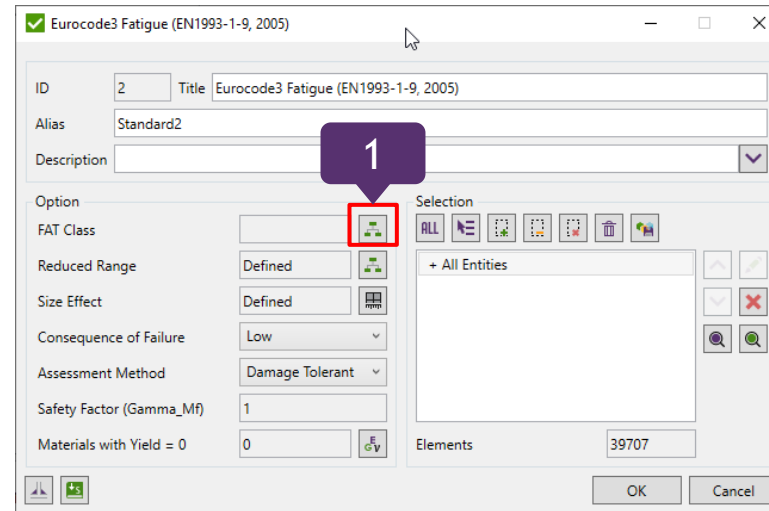
For welds: X: **100**; Y/XY: **80**

5

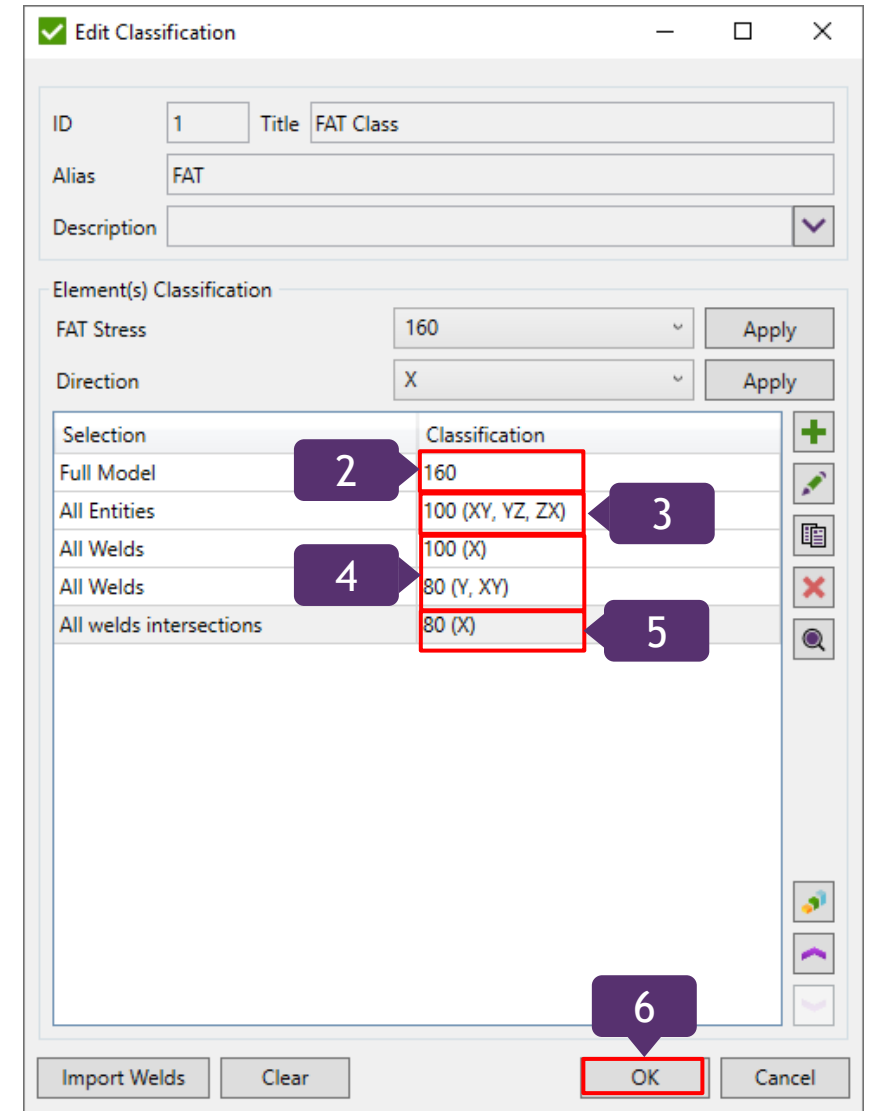
For welds intersections: X: **80**

6

Press *OK*



The dialog box 'Eurocode3 Fatigue (EN1993-1-9, 2005)' is shown. It has fields for ID (2), Title (Eurocode3 Fatigue (EN1993-1-9, 2005)), Alias (Standard2), and Description. Below these are options for FAT Class, Reduced Range, Size Effect, Consequence of Failure, Assessment Method, Safety Factor, and Materials with Yield = 0. A 'Selection' button is highlighted with a red box and a callout '1'. The 'Elements' field shows 39707.



The 'Edit Classification' dialog box is shown. It has fields for ID (1), Title (FAT Class), Alias (FAT), and Description. Below these are 'Element(s) Classification' fields for FAT Stress (160) and Direction (X), each with an 'Apply' button. A table shows the classification for different selection types:

Selection	Classification
Full Model	160
All Entities	100 (XY, YZ, ZX)
All Welds	100 (X)
All Welds	80 (Y, XY)
All welds intersections	80 (X)

Callouts 2, 3, 4, and 5 point to the 'Full Model', 'All Entities', 'All Welds', and 'All welds intersections' rows respectively. A red box highlights the 'All Entities' and 'All Welds' rows. The 'OK' button is highlighted with a red box and a callout '6'.

✓ Edit Classification

ID1TitleFAT Class

AliasFAT

Description

Element(s) Classification

FAT Stress160Apply

DirectionXApply

Selection	Classification
Full Model	160
All Entities	100 (XY, YZ, ZX)
All Welds	100 (X)
All Welds	80 (Y, XY)
All welds intersections	80 (X)

Import Welds

Clear

OK

Cancel

- Values

Labels

Selection
- X

Y

Z

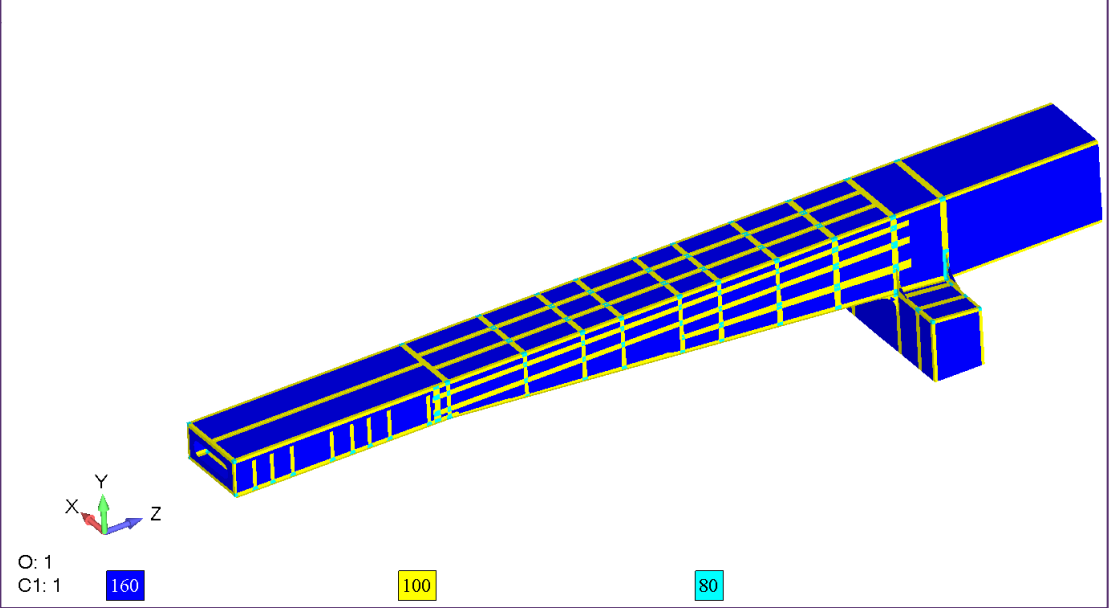
XY

YZ

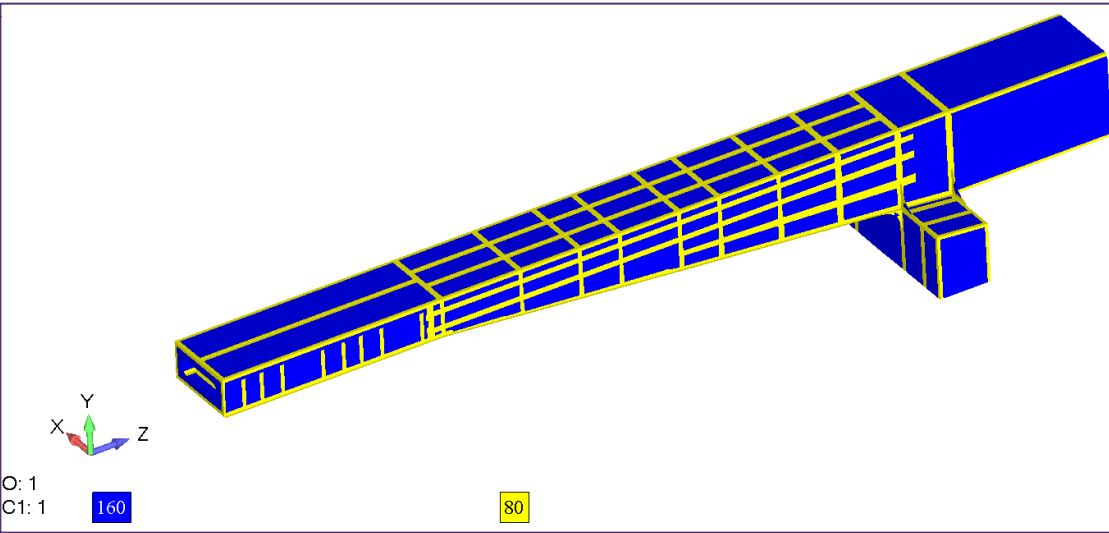
ZX

Equivalent

1



2



# Fatigue Damage Plot

1

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

2

Parameter: **Summed Damage**

3

Direction: **Overall**

4

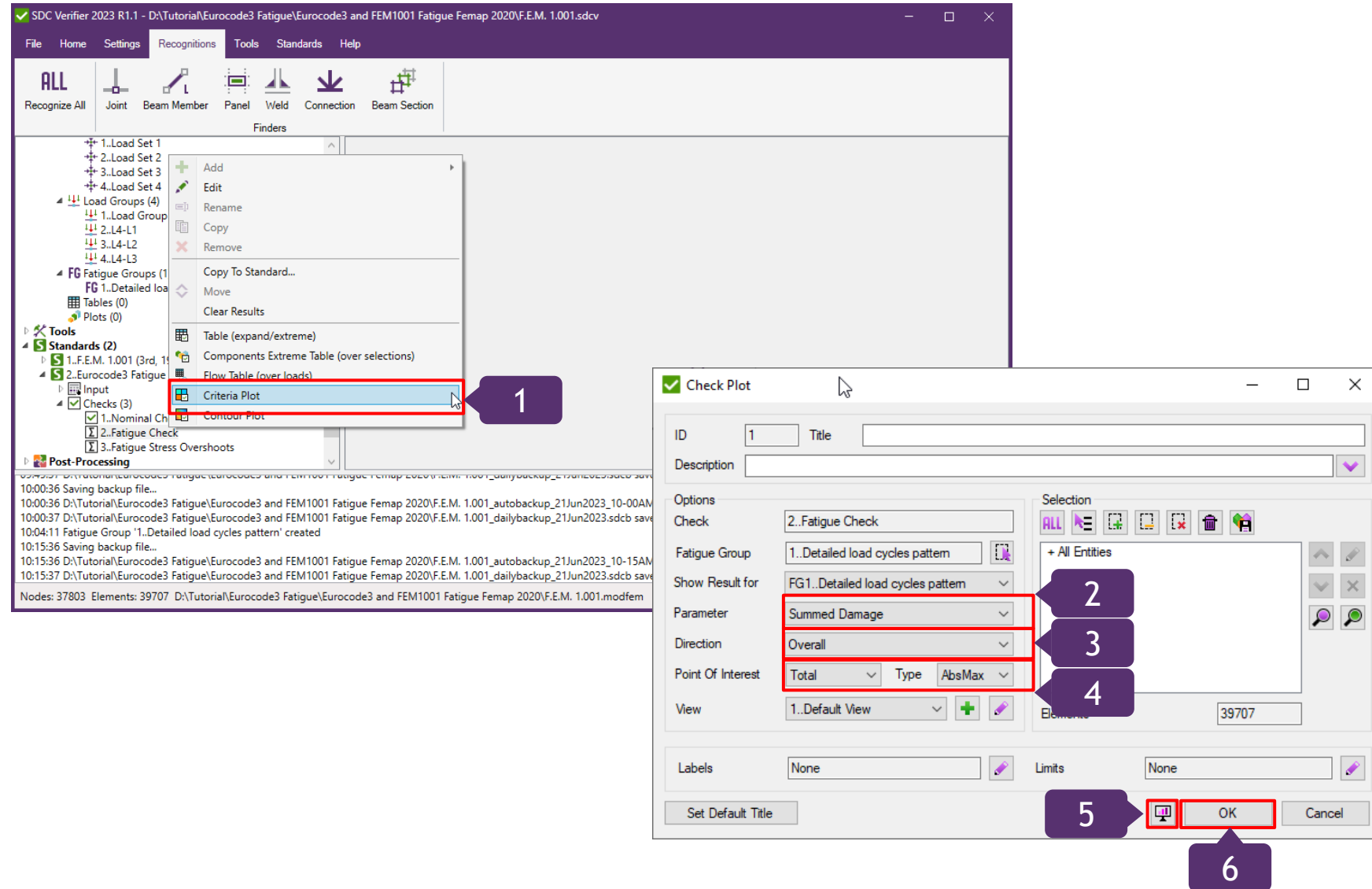
Point of interest: **Total** Type: **AbsMax**

5

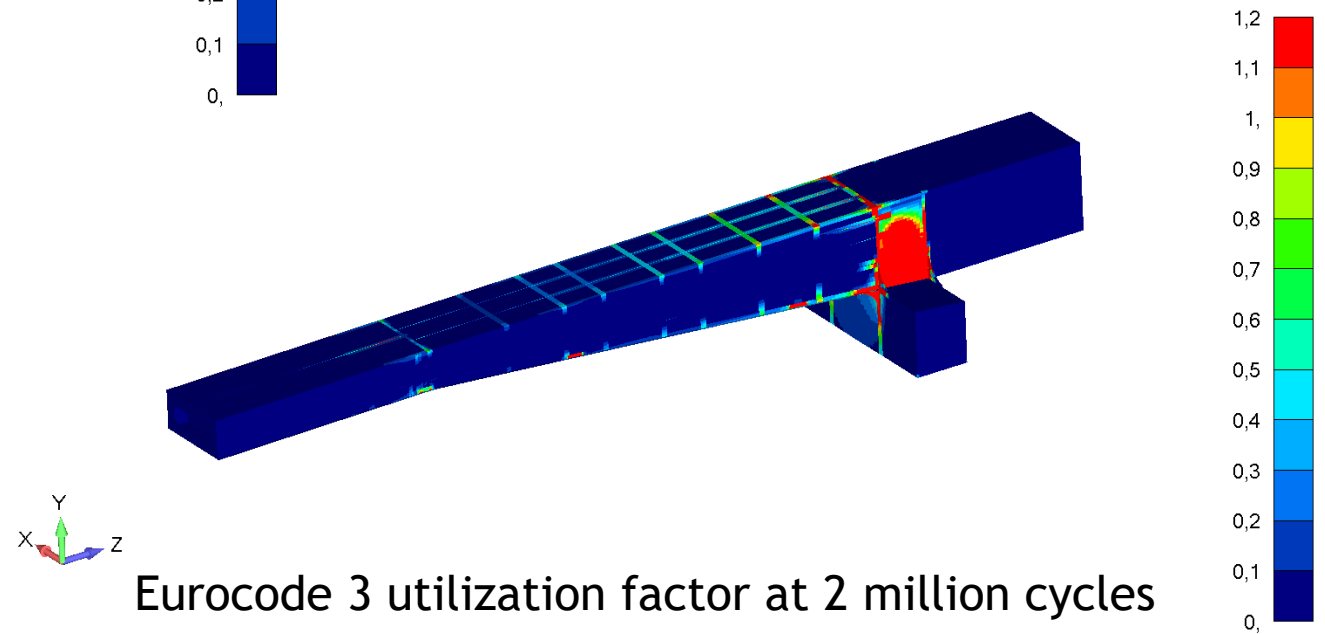
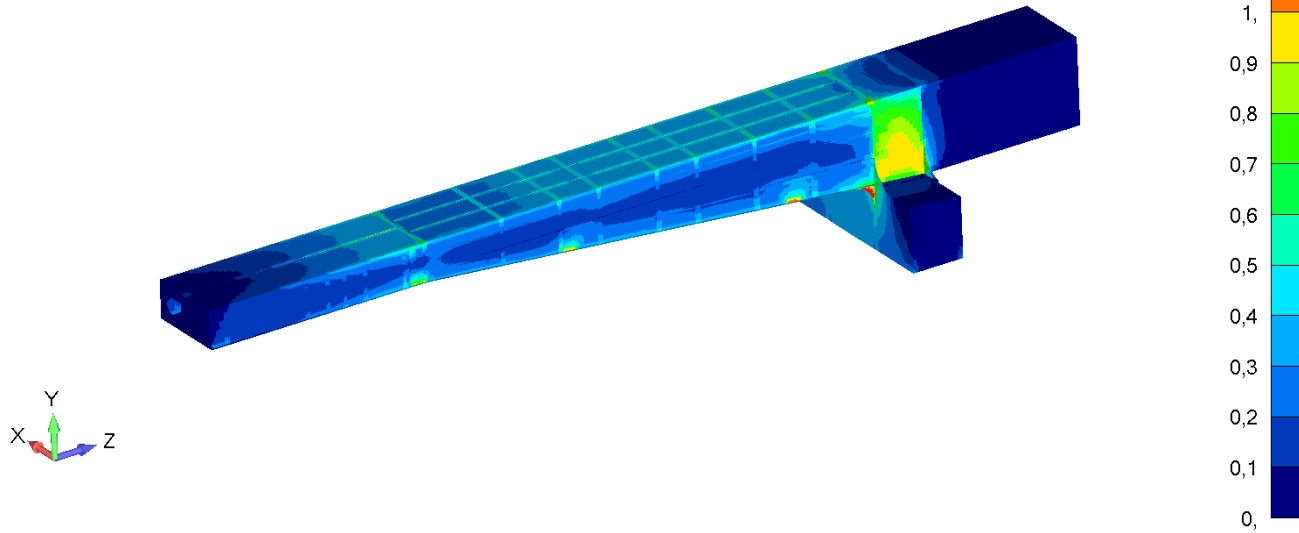
Press  *Preview*

6

Press *OK*



FEM 1.001 utilization factor



Eurocode 3 utilization factor at 2 million cycles