

# ST5 - Weld Design

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The screenshot displays the ST5 Weld Design software interface. The main window shows a 3D model of a welded I-beam connection with various weld seams labeled '2'. The interface includes a menu bar (File, Edit, Options, Layout, Help), a toolbar, and a left-hand navigation pane with categories like Standard, Input, Output, and Output design.

The central configuration panel is divided into several sections:

- Material:** structural steel
- Steel:** S235
- Action:** Design loads
- Design loads:** Nd = -10,00 kN, GammaM0 = 1,00
- Other loads:** Vz = 10,00 kN, My = 0,00 kNm, Vy = 0,00 kN, Mz = 0,00 kNm
- Cross section:** Section select. IPE 80
- Material thickness connected m t =** 0,0 mm
- Weld seams:** circumferential
- Weld seam parameters:**
  - lw1 = 59,6 mm, aw1 = 2,0 mm
  - lw2 = 46,0 mm, aw2 = 2,0 mm
  - lw3 = 0,0 mm, aw3 = 0,0 mm
  - lw4 = 0,0 mm, aw4 = 0,0 mm
  - lw5 = 0,0 mm, aw5 = 0,0 mm
  - lw6 = 0,0 mm, aw6 = 0,0 mm
  - lw7 = 0,0 mm, aw7 = 0,0 mm

At the bottom right, the software displays calculated values for the weld seam and section:

Weld seam  
 $\eta = 0,23 = F_w,Ed / F_w,Rd = 1,93 \text{ kN/cm} / 8,31 \text{ kN/cm}$   
 $\eta_{tN} = 0,11 = F_w,EdN / F_w,RdN = -0,95 \text{ kN/cm} / 8,31 \text{ kN/cm}$      $\eta_{tVz} = 0,20 = F_w,Ed,Vz / F_w,Rd,Vz = 10,00 \text{ kN} / 49,55 \text{ kN}$

Section  
 $\eta = 0,29 < 1$   
 $\sigma_V = 67,3 \text{ N/mm}^2$      $\sigma = -13,1 \text{ N/mm}^2$      $\tau = 38,1 \text{ N/mm}^2$

The bottom status bar shows coordinates: X: 0,00, Y: 0,00, Z: 0,00 [m] CS NUM.



# ST5 – Weld Design

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Further information and descriptions are available in the relevant documentations:

<a href="#">FDC – Output and printing</a>	Output and printing
<a href="#">FDC - Import and export</a>	Interfaces to other applications (ASCII, RTF, DXF ...)
<a href="#">FCC</a>	Frilo.Control.Center - the easy-to-use administration module for projects and items
<a href="#">FDD</a>	Frilo.Document.Designer - document management based on PDF
<a href="#">Frilo.System.Next</a>	Installation, configuration, network, database

## Application options

This software application allows the verification of welding seams for any type of standard rolled profile section (with the exception of Z profiles).

The loading comprises axial force  $N_{d1}$ , bending moments  $M_{y,d1}$ ,  $M_{z,d1}$  and shear forces  $V_{z,d1}$  and  $V_{y,d1}$  (in kN, kNm).

The user can either select a profile from a file with standard rolled sections or define it by entering the cross sectional dimensions.

## Basis of calculation

### Verification of welding seams

The structural values (welding seam area  $A_w$ , 2<sup>nd</sup> order moments of area  $I_w$ ) are calculated for the welding pattern. The axial bending stresses are calculated with the help of the following formula:

$$\sigma_w = \frac{N}{A_w} + \frac{M}{I_w} \cdot a$$

The centroidal axes of the cross-sectional areas are assumed in the theoretical root points of the fillet welds. The 2<sup>nd</sup> order moments of area are calculated in the same way as on a cross section composed of slender rectangles.

The shear forces are calculated with the help of the following formula:

$$\tau = \frac{V \cdot S}{I \cdot a_w}$$

With  $I = 2^{\text{nd}}$  order area moment of inertia of the total cross section.  
 $S = 1^{\text{st}}$  order moment of area of the connected cross-sectional areas.  
 $a_w =$  sum of the welding seam thicknesses for the connection of the cross sectional areas.

Simultaneously, the shear stresses for each shear force and the associated welding seam area are calculated internally (with I profiles  $V_{z,d1}$ , for instance, the welding seam area at the flange). If the shear force  $\tau$  calculated with this method is higher than that mentioned above, it is put out instead. In general, if only shear stress applies, shear force is calculated with the help of the following formula:

$$\tau = \frac{V}{A_w}$$

Comparison stress:

$$\sigma_{V,w} = \sqrt{\sigma_w^2 + \tau_w^2}$$

## Constructive limiting values

The seam thickness  $a_w$  should not exceed or fall below the following limiting values:

$$\text{Min } a_w \leq a_w \leq 0.7 \cdot \text{mint}$$

$$\text{min } a_w = 3 \text{ mm (EN 1993)}$$

and

$$a_w \geq \sqrt{\text{max } t} - 0.50$$

The application checks compliance with these limits.

The length of the welding seam  $l_w$  may only be taken into account in the calculation if

$$l_w \geq 6 \cdot a_w \text{ or } l_w \text{ is at least } 30 \text{ mm.}$$

## Verification as per EN 1993

The fillet welds are verified with the help of the simplified method as per EN 1993-1-8, para. 4.5.3.3.

In this calculation, the resultant  $F_{w,Ed}$  of all forces applying to the effective fillet weld area per length unit are calculated in each point along the seam and compared to the design value of the bearing capacity  $F_{w,Rd}$  of the welding seam per length unit.

$F_{w,Rd}$  results from  $f_{vw,d} \cdot a$

$a$  = effective seam thickness of the fillet weld according to para. 4.5.2.

$f_{vw,d}$  = shear strength of the welding seam in accordance with para. 4.5.3.3 eq. (4.4)

$$f_{vw,d} = \frac{f_u}{\sqrt{3} \cdot \beta_w \cdot \gamma_{M2}}$$

$\beta_w$  = correlation coefficient for fillet welds table 4.1

$f_u$  = shear strength of the weaker one of the connected components

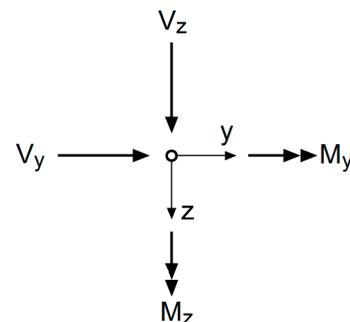
$\gamma_{M2}$  = 1.25

For reasons of clarity, the stress applying to the welding seam is put out in addition.

The verification of the profile section is based on EN 1993-1-1, equation 6.1 or 6.2. For this verification, the profile section is assigned to a cross section class in accordance with its geometry and the loading.

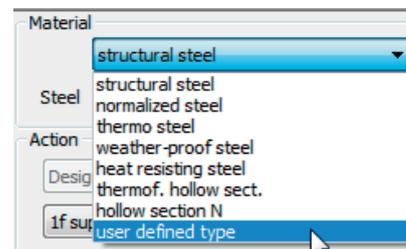
## Loading

The user can perform the design for biaxial moment loading with axial force (negative compression) and shear forces. The signs are defined as follows:



## Input

Depending on the selected profile type, the application proposes the optimum welding pattern. The length and thickness of the welding seam are customizable. A welding seam length below 3 cm is set to zero in the initial automatic pre-setting process. The value proposed for the thickness of the welding seam is the lowest possible with regard to construction. It is calculated from the thickness of the profile section to be connected (e.g. web or flange thickness) and the sheet thickness of the component to be connected. A dialog is displayed for the input of these values. The welding seam thickness is proposed in accordance with the constructive border conditions.



## Standard and material selection

Select first the desired standard. The available input options depend on the selected standard.

Select the material from the standard-specific list or enter the values manually (user-defined steel type).

### Manual input:

Select the option "User-defined steel type" and activate the button  to the right of the steel selection box to display the input window.

Specifications for manual input:

- Material designation
- Yield strength  $f_{yk}$
- Tensile strength  $f_{uk}$
- Modulus of elasticity
- Shear modulus

## Actions

Design loads

Superpositions. Input of several load cases.

Activating the button  displays the load dialog with the following input fields:

The internal forces should be specified with their  $\gamma_F$ -fold value.

**Nd** Axial force in [kN], compressive force must be entered with a negative sign

**Vzd** Shear force in [kN] in direction of the z-axis

**Vyd** Shear force in [kN] in direction of the y-axis

**Myd** Moment around the y-axis in [kNm]

**Mzd** Moment around the z-axis in [kNm]

If only a single superposition should be put in, you can enter the loads directly into the input fields Nd, Vzd, Myd ...

The selection list offers existing load cases for selection.

## Cross section

Material thickness  $t$  Thickness of the component to be connected in [mm]

Activate the "Profile selection " button to display the dialog for the input of the cross section.

The displayed window allows you to enter a new cross section or edit an existing one – see the general description in the document [„Select - edit cross section.pdf“](#).

## Fillet welds

**Circumferential** The "Circumferential" button allows you to set or edit all length and thickness values of the welding seam with a single mouse click.

**lw** Welding seam length. The entered value is immediately displayed on the graphic screen. Please observe the notes in the status line.

**aw** Welding seam thickness. The entered values are immediately displayed on the graphic screen and the user can check them there.

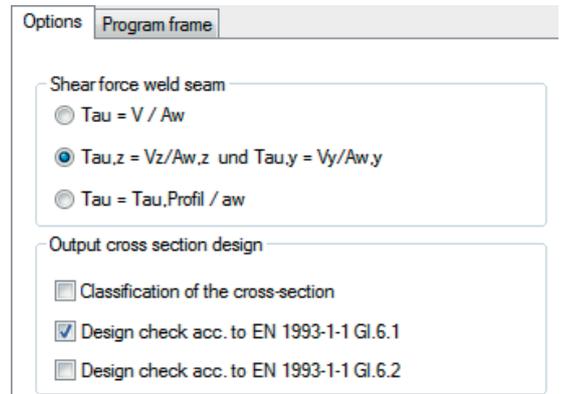
## Options

There are three variants for the calculation of the shear stresses acting on the welding seams:

1. Total shear force  $V_d$  / total welding seam area
2. Shear force  $V_{dz}$  / effective welding seam area in z-direction  
Shear force  $V_{dy}$  / effective welding seam area in y-direction
3. The shear stresses calculated on the profile are converted proportionally to the relation between the profile thickness and the welding seam thickness.

For the verification of the profile as per EN 1993, the following results are available for output:

- Classification of the cross section with  $c/t$ -ratio
- Elastic verification using equation (6.1)
- Plastic verification using equation (6.2)



Options **Program frame**

Shear force weld seam

$\tau = V / A_w$

$\tau_{z,y} = V_{z,y} / A_{w,z,y}$

$\tau = \tau_{\text{profil}} / a_w$

Output cross section design

Classification of the cross-section

Design check acc. to EN 1993-1-1 Gl.6.1

Design check acc. to EN 1993-1-1 Gl.6.2

## Output

Output of the system data, results and graphical representations on the screen or the printer.

Screen	displays the values in a text window on the screen
Preview	Print-preview in PDF-format.
<a href="#">Printer</a>	starts the output on the printer
Word	If installed on your computer, the text editor MS Word is launched and the output data are transferred. You can edit the data to be put out in Word as required.

## Graphical representation



The buttons allow you to display and hide dimension lines, legends and stress values.



Launches the 3D graphical representation

### Toolbar of the 3D graphical screen



Zoom window. Allows you to zoom in (enlarge) the desired screen section with the help of the mouse.



Zoom using the mouse. The mouse cursor is transformed to a hand. Moving the mouse while keeping the mouse button pressed changes the size of the representation.



Zoom full screen. The entire graphical representation is shown on the screen.



Move. An enlarged section can be moved while keeping the mouse button pressed.



Rotate using the mouse. Keep the mouse button pressed to rotate the represented object.



Previous section. The previously displayed section is shown.



Saves the graphical representation in a BMP or WMF file.



Displays the view of the system as shown on the button.