Shear Panel Stiffness ST13

Contents

Basic Documentation – Overview

In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage www.frilo.com in the Campus-download-section.

Tip: Go back - e.g. after a link to another chapter / document - in the PDF with the key combination "ALT" + "left arrow key".

Application options

For beams under bending stress, there is always a risk of lateral shift and torsion. The examination of lateral torsional buckling is based on the assumption that the lateral shift v und the torsion ϑ can occur independently of each other.

In many cases, structural parts such as trapezoidal steel sheeting are connected to the beams that provide elastic support. You can map the effect of stabilising components in the calculation through rotational springs c_ϑ and through the ideal shear stiffness S_i. The total prevention of the lateral shift v at the distance f from the shear centre M constitutes a limit case, in which we speak of as “fixed axis of rotation”.

The stabilising effect of the trapezoidal steel sheeting on bending beams can be considered from two different points of view. On the one hand, the fixity against lateral shift and torsion can be proven by establishing evidence of sufficient shear stiffness and torsional restraint. In this case, a verification of the beam’s resistance to lateral torsional buckling is not required. On the other hand, it is permitted to consider the effective shear stiffness and the effective torsional restraint in the determination of the ideal lateral torsional buckling moment $M_{Ki,y}$ instead of performing the afore-mentioned verification. The verification of the resistance to lateral buckling must be performed accordingly in this case.

The ST13 application calculates the rotational spring c_ϑ [kNm/m], the ideal shear stiffness S [kN] as well as the translational restraint c_y [kN/m²]. These values allow you to take the stabilising effect of trapezoidal steel sheeting into account. In addition to this, the application verifies the fixity against lateral shift and torsion. If the verification is not successful, an additional lateral stability verification is required. In practice, the verification whether the torsional restraint is sufficient is hardly ever successful. A lateral torsional buckling analysis is required in most cases. The spring constants calculated by ST13 can be transferred to the relevant applications such as BTII.

Basis of calculation

See the document ST13 Basis of Calculation.pdf (only in German).

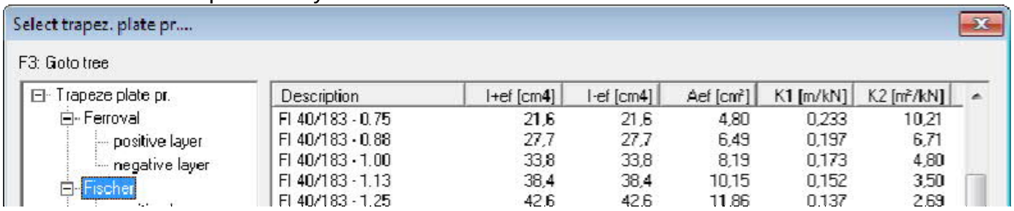
Data entry

Definition of the structural system

Shear field

Trapez. plate pr

Click on the button to access the dialog 'Select trapezoidal plate profile' The sheeting types of various manufacturers are listed in this section. The calculation of the restraint constants of a selected trapezoidal steel sheeting is based on the border conditions specified by the user.



After selecting a trapezoidal steel sheeting, the position (positive, negative) in which it is to be used is shown below the display field.

The selection of the trapezoidal steel sheeting determines implicitly whether the profile is used in the positive or negative position.
Note: You can access this selection dialog also via the menu item 'Trapezoidal sheeting'.

Beam cr. section — Click on the button to access the dialog Select - edit cross section. A list of the available cross-sections is displayed. When selecting a cross-section, the calculation of the restraint constants is based on the border conditions specified by the user.
You can access this selection dialog also via the menu item 'Profile - beam'.

Loading — type of loading. The following options are available for selection:

- structural load; the trapezoidal steel sheeting is pressed against the beam under bending stress
- suction; the trapezoidal steel sheeting lifts up from the beam under bending stress

Number of spans — the total span is defined via the number of partial spans n with the span length l_0. Consequently, the resulting total length is $l_0 \cdot n$.

Span length — length l_0 of a partial span in [m];
corresponds to the spacing of the components to be strutted (e.g. spacing of portal frames).

Span height — height H_s of the shear panel in [m];
corresponds to the length of the component to be strutted (e.g. length of the vertical member of a portal frame)

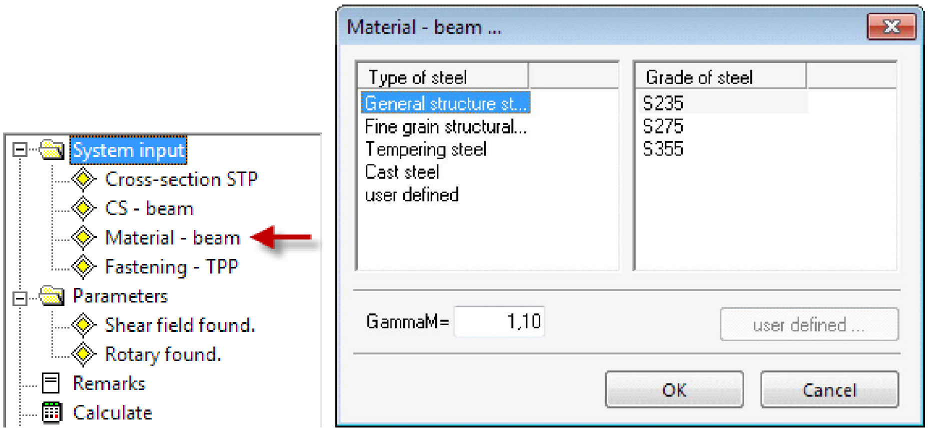
Shear field — from axis (0 to n), at which the structurally effective shear panel starts.

to axis (0 to n), at which the structurally effective shear panel ends.
These specifications are used to determine the number of components to be strutted by the shear panel.
The numbering of the axes starts with zero and is indicated in the graphical representation.

Material - beam

Access the material definition dialog by double-clicking on the item ‘Material - beam’ in the main menu.

You can select the material as per DIN 18800 part 1, table 1, from the displayed lists (type, grade) or enter user-defined values. The software assumes a constant module of elasticity E_k and a constant yield stress $_{yk}$ over the total beam.



Material

First select the type of steel and then the grade.

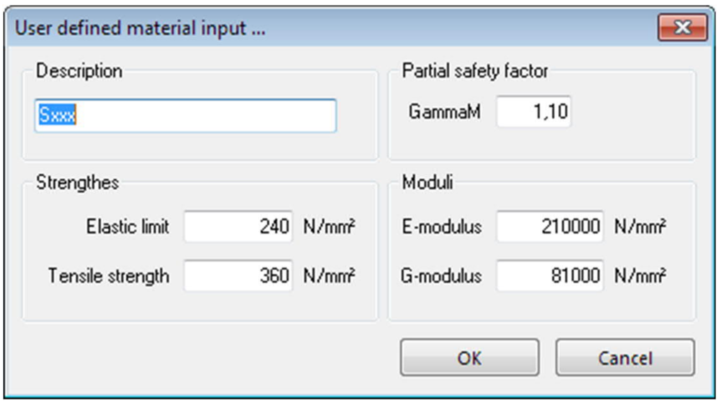
For the available steel types, the characteristic values of the moduli of elasticity and shear are considered in the calculation. In connection with the stress verification, you should note, that the characteristic value of the yield strength f_{yk} is set to the standard value, the product thickness of the cross-sections must be taken into account, however, and must be reduced if required.

User-defined material parameters

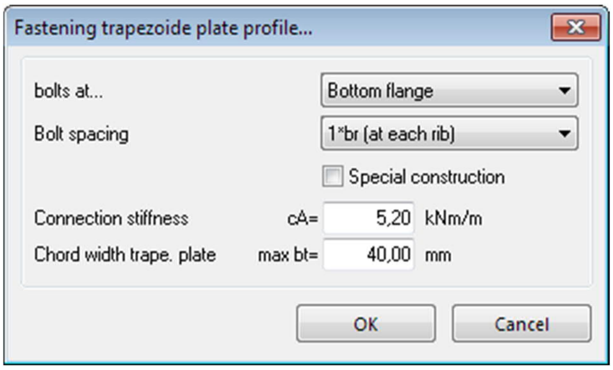
Click on ‘User-defined’ in the type menu and then on the ‘User-defined’ button.

Enter a name for the material and the characteristic values for the yield strength f_{yk} and the tensile strength f_{uk} as well as for the modulus of elasticity E_k and the shear modulus G_k an.

If you specify material parameters that correspond to a standard steel according to DIN EN, the values are reset to those of the corresponding type and grade.



Fasteners - trapezoidal plate profile



Bolts in...

Select the type of fasteners from the selection list:

- bottom flange, the trapezoidal steel sheeting is fixed to the lower flange
- top flange, the trapezoidal steel sheeting is fixed to the upper flange

Bolt spacing

Select the desired bolt spacing from the selection list:

- 1 · br; the trapezoidal steel sheeting is fixed at each profile rib.
- 2 · br; the trapezoidal steel sheeting is fixed at every second profile rib.

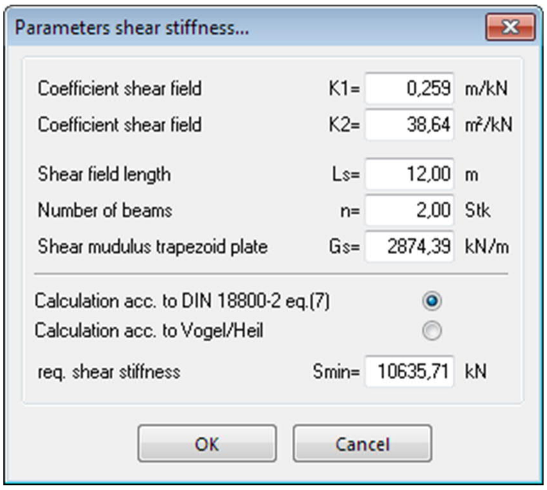
Special construction

Check this options when the trapezoidal steel sheeting is fixed in accordance with DIN 18807-3, figure 7.

c_A connection stiffness resulting from the border conditions specified by the user. The connection stiffness is part of the torsional restraint.

max b_t maximum permissible flange width of the trapezoidal steel sheeting, which results from the border conditions specified by the user.

Shear-field restraint - parameters



K1/K2 shear panel values in accordance with the building inspection approval for the configuration of the fasteners in accordance with DIN 18807-3, figure 7 for the calculation of the ideal shear modulus in [m/kN] / [m²/kN].

L_S length of the structurally effective shear panel in [m].

n number of components to be strutted.
Please keep in mind that the edge beams are only included half in the calculation.

G_S ideal shear modulus in [kN/m].

Calculation as per DIN 18800-27, eq. (7)

Check this option if the minimum shear stiffness is to be calculated with equation (7) DIN 18800-2.

Calculation in accordance with Vogel/Heil

Check this option if the minimum shear stiffness is to be calculated in accordance with Vogel/Heil [9], page 232.

S_{min} required shear stiffness, an additional examination of lateral torsional buckling of the beam under bending stress is not required (fixed axis of rotation)

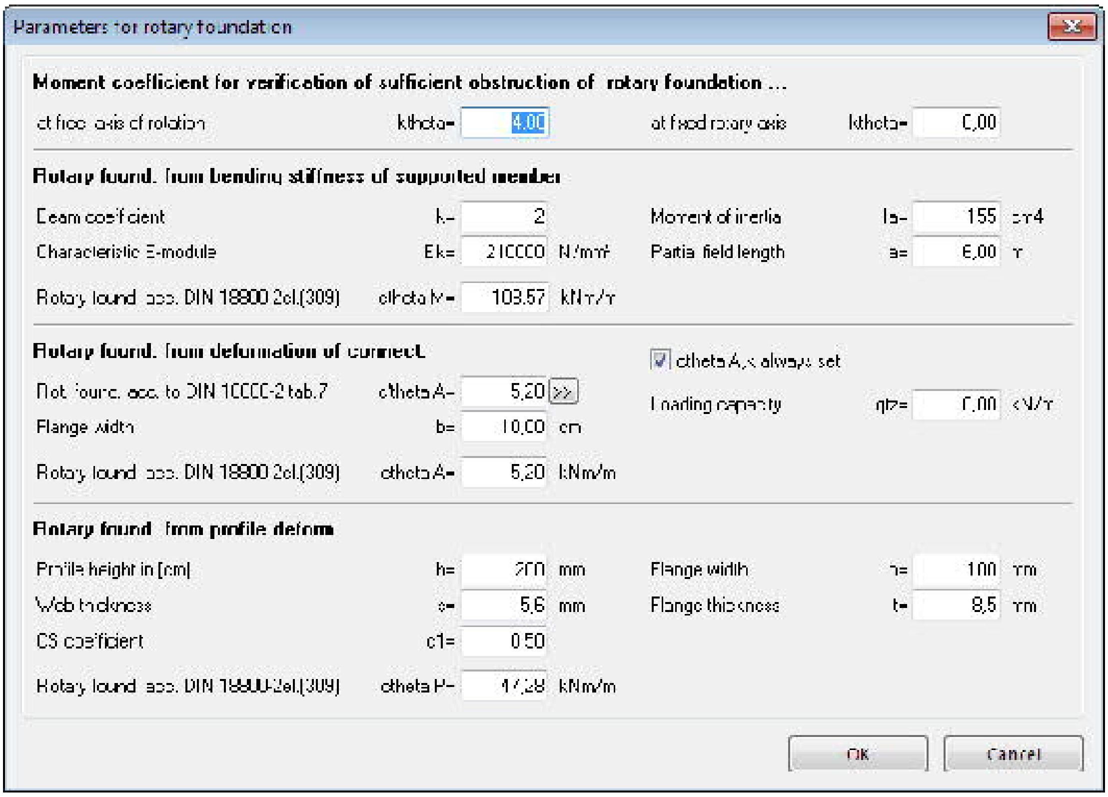
Parameters for the calculation of the torsional restraint

Moment coefficient for the verification of a sufficient torsional restraint ...

Free axis of rotation	coefficient *ktheta* as per DIN 18800-2, table 6, column 2. A free axis of rotation must be assumed if the condition formulated in equation (7) of DIN 18800-2 is not satisfied.
Fixed axis of rotation	coefficient *ktheta* as per DIN 18800-2, table 6, column 3. A fixed axis of rotation may be assumed if the condition formulated in equation (7) of DIN 18800-2 is satisfied.

Torsional restraint through bending stiffness of the component to be strutted

k	system coefficient	
	k = 2	for single-span and double-span beams
	k = 4	for three-span and multi-span beams
E_k	characteristic value in [kN/cm²] of the modulus of elasticity .	
Ia	area moment of inertia of the trapezoidal profile in [cm⁴].	
a	spacing of the components to be strutted (beams) in [m].	
c theta M	characteristic value in [kNm/m] for the torsional restraint provided by the bending stiffness of the trapezoidal steel sheeting.	



Torsional restraint provided by the deformation of the connection

c'theta A characteristic value in [kNm/m] for the connection stiffness $\bar{c}_{\vartheta A,k}$ of trapezoidal steel sheeting referenced to a flange width of 100 mm as per DIN 18800-2, table 7.

Click on the button to access the dialog 'Torsional restraint as per DIN 18800-2, table.7..."
The displayed dialog corresponds to table 7 of DIN 18800-2.
The concrete value for the characteristic connection stiffness of trapezoidal steel sheeting

depends on the border conditions specified by the user and is referenced to a flange with of 100 mm.
You should note in this connection that when selecting a different value in column ‘c’, also different border conditions are required as a basis. When you confirm your selection with ‘OK’, the corresponding new border conditions are applied automatically to the structural system.

Rotary foundation acc. to DIN 18800-1 tab.7...

Line	Trapeze pr. layer		Bolts in		bolt spacing		Washer diameter	c	max bt
	Positive	Negative	Bottom fl	Top flang	br	2*br			
Loading									
1	x		x		x		22	5,20	40
2	x		x			x	22	3,10	40
3		x		x	x		Ka	10,00	40

b flange width of the beam profile in [cm].

Always include ctheta A

Check this option if the resilience of the connections should always be considered (as required by Lindner [6]).

Uncheck this option if the software should check whether the resilience of the connections can be disregarded because of the contact moment (in accordance with Krüger [7]).

Load-bearing capacity qtz
load-bearing capacity of the beam under bending stress in [kN/m].

ctheta A characteristic value in [kNm/m] for the torsional restraint resulting from the deformation of the connection.

Rotational restraint resulting from the deformation of the profile

h profile height in [cm] of the beam under bending stress.

s web thickness in [cm] of the beam under bending stress.

b flange width in [cm] of the beam under bending stress.

t flange thickness in [cm] of the beam under bending stress.

c_1 for I-shapes under structural load or suction load $c_1 = 0.5$

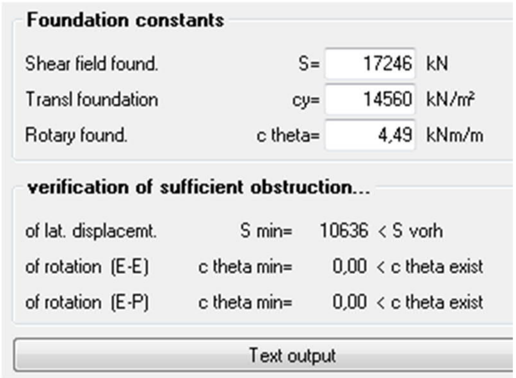
For C-shapes under structural load $c_1 = 0.5$

For C-shapes under suction load $c_1 = 2.0$

ctheta P characteristic value in [kNm/m] for the torsional restraint resulting from the deformation of the beam profile.

Calculation and results

Restraint constants



Shear panel restraint S	ideal shear stiffness in [kN]
Translational restraint c_y	translational restraint in [kN/m]
Torsional restraint c	torsional restraint in [kNm/m]

Verification of sufficient shear stiffness and torsional restraint

Of lateral shift S_{min}	verification of the minimum shear stiffness in [kN] as per DIN 18800-2, eq. (7) or in accordance with reference [7].
Of the torsion (e - e) c	verification of the minimum torsional restraint as per DIN 18800-2, eq. (8) for the verification method e - e; in [kNm/m].
Of the torsion (e - p) c	verification of the minimum torsional restraint as per DIN 18800-2, eq. (8) for the verification method e - p; in [kNm/m].

Output

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

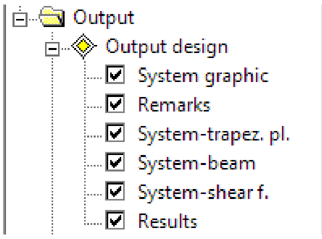
Word	output to MS-Word, if this software is installed on the computer.
Screen	displays the data in a text window on the screen
Print	starts the output on the printer

Remarks

The ‘Remarks’ item in the left menu allows you to enter user-defined texts that are included in the output.

Output profile

The dialog offers comprehensive options for the control of the output scope. Check the items to be put out.



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Reference literature

[1] DIN 18800-2

[2] Stahlbauten-Erläuterungen zu DIN 18800 Teile 1 bis Teil 4

[3] DIN 18807, Part 1 to Part 3

[4] Stahltrapezprofile, 2. Auflage, Maaß, Hünersen und Fritzsche, Werner Verlag 2000

[5] Stabilisierung von Biegträgern durch Trapezbleche, Stahlbau 56 (1987), p. 9-15

[6] Stabilisierung von Biegträgern durch Drehbettung – eine Klarstellung, Stahlbau 56 (1987), p. 365 - 373

[7] Stahlbau Part 2, 2nd Edition, Ulrich Krüger, Ernst & Sohn Verlag 2000

[8] Vogel; Heil: Traglasttabellen, 4th Edition 1996, Verlag Stahleisen GmbH, Düsseldorf