

Shear Panel Stiffness ST13

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Basic Documentation – Overview

In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage <u>www.frilo.com</u> 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 **9** 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 <u>ST13 Basis of Calculation.pdf</u> (only in German).



Data entry

Definition of the structural system

Shear field

Trapez. plate pr

	Click on the button	to access the dialog	g 'Select tra	pezoidal	plate pro	ofile' The			
	sheeting types of variou	us manufacturers ar	e listed in t	his sectio	n. The ca	alculation o	of		
	the restraint constants	of a selected trapez	oidal steel	sheeting	is based	on the			
	border conditions speci	ified by the user.							
	Select trapez. plate pr						2		
	F3: Goto tree		[
	Irapeze plate pr. Ferroval positive layer negative layer Fischer	Description FI 40/183 - 0.75 FI 40/183 - 0.88 FI 40/183 - 1.00 FI 40/183 - 1.13 FI 40/183 - 1.25	1+et [cm4] 21,6 27,7 33,8 38,4 42,6	1-et [cm4] 21,6 27,7 33,8 38,4 42,6	Aet [cmf] 4,80 6,49 8,19 10,15 11,86	K1 [m/kN]] K2 0,233 0,197 0,173 0,152 0.137	2 [mf/kN] * 10,21 6,71 4,80 3,50 2,69		
	After selecting a trapez it is to be used is shown	oidal steel sheeting h below the display	, the positic field.	on (positiv	ve, negati	ive) in whic	h		
	Trapez, plate pr. FI	100/275 - 0.75 >>> e position)							
	The selection of the tra profile is used in the po <i>Note: You can access th</i> <i>sheeting</i> '.	pezoidal steel sheet sitive or negative po nis selection dialog a	ting determ osition. also via the	ines impl <i>menu iter</i>	icitly whe m ′Trapez	ether the z <i>oidal</i>			
Beam cr. section	Click on the button to access the dialog <u>Select - edit cross section</u> . 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. <i>You can access this selection dialog also via the menu item 'Profile - beam'</i>								
Loading	type of loading. The following options are available for selection:								
	 structural load; the t bending stress 	rapezoidal steel she	eeting is pre	essed aga	ainst the	beam unde	r		
	 suction; the trapezo stress 	idal steel sheeting l	ifts up from	the bear	n under k	bending			
Number of spans	the total span is defined Consequently, the resul	d via the number of ting total length is	partial spar I₀ · n.	ns n with	the span	length I ₀ .			
Span length	length I ₀ of a partial spa corresponds to the spa- frames).	n in [m]; cing of the compon	ents to be s	trutted (e	e.g. spaci	ing of porta	I		
Span height	height H _s of the shear p corresponds to the leng member of a portal frar	anel in [m]; jth of the componer ne)	nt to be stru	tted (e.g.	length o	f the vertica	al		
Shear field	from axis (0 to n), at w	hich the structurally	effective s	hear pane	el starts.				
	to axis (0 to n), at whic These specifications ar by the shear panel. The numbering of the a	the structurally ef e used to determine xes starts with zero	ffective she e the numbe and is indic	ar panel e er of com cated in t	ends. ponents he graph	to be strutte ical	ed		
	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 - beam	—
	Type of steel General structure st	Grade of steel
 System input Cross-section STP CS - beam Material - beam Fastening - TPP 	Fine grain structural Tempering steel Cast steel user defined	\$275 \$355
Parameters	GammaM= 1,10	user defined
Remarks		OK Cancel

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.

Description			Partial safety I	factor	
Sxxx			GammaM	1,10	
Strengthes			Moduli		
Elastic limit	240	N/mm²	E-modulus	210000	N/mm²
Tensile strength	360	N/mm²	G-modulus	81000	N/mm²



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:

- $1 \cdot br$; 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 <u>torsional restraint</u>.
- max bt 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].
- Ls 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.

Parameters shear stiffness			×
Coefficient shear field	K1=	0,259	m/kN
Coefficient shear field	K2=	38,64	m²/kN
Shear field length	Ls=	12,00	m
Number of beams	n=	2,00	Stk
Shear mudulus trapezoid plate	Gs=	2874,39	kN/m
Calculation acc. to DIN 18800-2 ed	ą.(7)	۲	
Calculation acc. to Vogel/Heil		\odot	
req. shear stiffness	Smin=	10635,71	kN
ОК	Can	cel	

Calculation in accordance with Vogel/Heil

Check this option if the minimum shear stiffness is to be calculated in accordance with <u>Vogel/Heil</u> [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)

stening trapezoide plate	profile					
bolts at	E	Bottom flan	ge 🗸 🗸			
Bolt spacing	pacing 1*br (at each rib)					
		Special o	construction			
Connection stiffness	cA=	5,20	kNm/m			
Chord width trape, plate	max bt=	40,00	mm			
Lhord width trape, plate	max bt=	40,00 OK	mm Cance			



Parameters for the calculation of the torsional restraint

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

Free axis of rotation	coefficient <i>ktheta</i> 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 <i>ktheta</i> 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 c	system coefficient						
	k = 2	for single-span and double-span beams						
	k = 4	for three-span and multi-span beams						
E _k	characte	ristic value in [kN/cm ²] of the modulus of elasticity.						
la	area mor	area moment of inertia of the trapezoidal profile in [cm ⁴].						
а	spacing	of the components to be strutted (beams) in [m].						
c theta M	characte the trape	ristic value in [kNm/m] for the torsional restraint provided by the bending stiffness of zoidal steel sheeting.						

at free lakis of rolation	kthota-	4.00		at fixed recary axis	ktheta-	C,00	
Rotary found. from bending stiffness	s of supporte	ed membe	:				
Eeam coeïfcient	k	2		Moment of inertia	la-	155	or4
Characteristic E-module	Ek=	210000	N/mm ²	Partia field length	Э=	E,00	٣
Rotary lound app. DIN 18800 2ol.(309)	olhota M=	103.57	kNr/r				
Rotary found. from deformation of c	unniect			🔽 otheta A, ki alwaya s	et		
Not Fource acc. to DIN 10000-2 tab.7	othets A-	5,20	>>	Loading capacity	-	C 00	<\/r
Flange width	b=	10,00	сп		- 444 –		
Rotary lound app. DIN 18900 2ol.(309)	othota A=	5,20	kNm/m				
Botary found from profile deform							
Profile height in [cm]	h=	200	mm	Flange width	ר=	100	ΥM
Wab thickings:	÷-	5,6	mm	Flange this knews	t-	8,5	ΥM
CS coefficient	c1=	050					
Rotary lound: acc. DIN 18800-2el.(309)	ctheta P-	17,28	kNm/m				

Torsional restraint provided by the deformation of the connection

c'theta A characteristic value in [kNm/m] for the connection stiffness $\overline{c}_{9A,k}$ 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.

stary foun	dation acc.	to DIN 1880	0-1 tab.7						
Line	Trapeze	pr. layer	Bolt	ts in	bolt s	pacing	Washer	c	max bt
	Positive	Negative	Bottom fl	Top flang	br	2"br	diameter	v	
Loading									
1	×		X		×		22	5,20	40
2	x		х			х	22	3,10	40
3		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.
- c1 for I-shapes under structural load or suction load c1 = 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]	Foundation const	tants		
Translational restraint cy	translational restraint in [kN/m]	Shear field found.	S=	17246	kN
Torsional restraint c	torsional restraint in [kNm/m]	Transl foundation	су=	14560	kN/m²
	R		c theta=	4,49	kNm/m
Verification of sufficient shear	stiffness and torsional restraint	verification of su	fficient obstruct	ion	
Of lateral shift S _{min}	verification of the minimum shear stiffness in [kN] as per DIN 18800-2, eq. (7) or in accordance	of lat. displacemt. of rotation (E-E) of rotation (E-P)	S min= c theta min= c theta min=	10636 < Sv 0,00 < cth 0,00 < cth	orh eta exist eta exist
	with reference [7].		Text outp	ut	
Of the torsion (e - e) c	verification of the minimum torsional restraint as per DIN 18800-2 in [kNm/m].	2, eq. (8) for the v	verification m	ethod e -	e;
Of the torsion (e - p) c	verification of the minimum torsional the verification method e - $p;$ in [kNm/ $\!\!\!$	restraint as per 'm].	DIN 18800-2,	eq. (8) fc	or



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.



File > Page view displays a print preview as a PDF



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