

STT+ Single-span Steel Beam

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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

The *STT+* application performs structural safety analyses in accordance with the equivalent member method for single-span beams of steel profiles as per EN 1993-1-1 with consideration of regulations in National Annexes.

- DIN EN 1993
- ÖNORM B 1993
- BS EN 1993
- PN EN 1993

Supporting conditions / lateral supports

The supporting conditions correspond to the statically determined single-span beam with fork supports. These supporting conditions always apply to both main axes.

Lateral supports can be defined to secure the beams against stability failure. You can enter a lateral supports in STT+ either in the form of an elastic continuous support or as discrete supports in

- the centre of the span
- the third points
- the quarter points or
- at a point x0.

For more complex supporting conditions, an interface to the **BTII**+ application is available.

Verifications

The following verifications are performed:

- Elastic or plastic cross sectional resistance.
- Load-bearing capacity of the system with the help of the equivalent member method
- Serviceability

Cross sections

- Standard I-sections
- User-defined double-symmetrical I-sections
- Standard round and square hollow sections
- User-defined round and square hollow sections

Actions

You can apply vertical and horizontal loading on the beam system and define concentrated moments. However, you cannot define loading that produces planned torsion.

Calculation

STT+ generates automatically the appropriate load cases and load case combinations depending on the defined actions and performs the necessary analyses, whereby the decisive load case combination is determined for each limit state.



Interfaces to other applications

The characteristic support reactions can be transferred to the applications

- Single-span Steel Column <u>STS+</u>,
- Reinforced Concrete Column <u>B5+</u>/B5 and
- Timber Column <u>H01+</u>.

Parameters such as column height, height of the load application point and eccentricity can be specified in a dialog.

Design values and support reactions can be transferred to the

- Steel Girder Support <u>ST4</u> and
- Reinforced Concrete Corbel <u>B9+</u>

software applications.

The desired load combination can be selected in a dialog box.

Load transfer to the Angle Connection program <u>SWA+</u> is also possible.

If the real load conditions do not comply with the selected standard or the loading situation leads to planned torsion, you cannot use STT+ for the calculation. The BTII+ application is available for this purpose.

If you have a valid licence for the <u>BTII+</u> application (2nd Order Buckling Torsion Analyses) you can transfer the structural system from STT+ to BTII+ via the data export function. The BTII+ application allows you to calculate more complex systems also in second-order buckling torsion analyses.

See Chapter Load transfer





Left support		0
Steel column	STS+	
Timber column	HO1+	1
RC column	B5+	
Girder support	ST4	1
Angle connection	SWA+	
Reinforced concrete corbel	B9+	
Rights support		0
Steel column	STS+	
Timber column	HO1+	
RC column	B5+	
Girder support	ST4	
Angle connection	SWA+	
Reinforced concrete corbel	B9+	1



Basis of calculation

The basis of calculation of the STS+ application are the series of standards of Eurocode 3. The National Annexes for Austria and Great Britain are implemented in the current version of the application.

Design values of the internal forces

The internal forces for the decisive load combination are calculated in a first-order analysis.

All necessary combinations of actions are automatically taken into account in accordance with the safety concept set forth in the Eurocode 0.

The decisive internal forces combinations in the ultimate limit state are calculated for the verification of the cross-sectional resistance and the stability verification of the component.

The user must specify the design situation on which the serviceability analyses should be based.

The internal forces combinations for the design values of the support reactions are determined in addition.

Verification process

Analyses in the ultimate limit states

The load-bearing capacity verifications are based on the internal forces determined in the first-order analysis.

The stability verification of the component is based on the equivalent member method. This analysis is preceded by a numerical calculation of the respective buckling load factors.

Analyses in the serviceability limit states

The serviceability verification refers exclusively to the calculation of the displacement, separately for the different main axis and the resultants.

Deformations are also calculated in a first-order analysis. You should note that second-order deformations can be considerably greater than first-order deformations. If the deformations are of particular importance, you should perform an extended second-order analysis. If you have a valid licence for *BTII*+ you can use this application for this task

Load transfer

See Interfaces to other applications.

You should note in this connection that the reaction forces are calculated as characteristic values in first-order analyses for each load case.



Basic parameters

Standard and safety concept

Design standard	selection of the relevant National Annex for	Properties		Ļ
	the load-bearing capacity verification as per EC3.	Basic Parameters System	(۹.0
ψ2 for crane loads	Specifies the load combination factor ψ^2 for crane loads (= ratio of permanent part to total crane load)	 Dimensioning Output 		
Snow as accidental loads	Check this option if the snow loads shall be	Design Standards and Safety	Concept	0
	included automatically not only in the	Design Standard	EN 1993:2015	i T
	typical design situations but also as an	ψ2 for crane loads	DIN EN 1993:2015	h
	accidental action. You can either specify a	Snow as accidental loads	DIN EN 1993:2010	
	load factor for the accidental snow loads or	ψ2 = 0,5 for snow (AE)	ONORM EN 1993:	2017
	have it determined automatically by the	Location in windzone 3 or 4	BS EN 1993-2008	
	software (select the corresponding	Equal yG for all permanent loads	PN EN 1993:2010	
	checkbox).	Ultimate Limit State		0
ψ 2 = 0.5 for snow	Check this option to increase the value of	Cross-section design	plastic	•
	the combination coefficient ψ^2 to 0.5 for	Equiv. beam detection acc.to	6.3.3 - annex B	-
	Show action in the seismic design situation.	Serviceability		0
	states e a Baden-Württemberg)	Design situation	characteristic	+
		Absolute deformation check		
wind zone 3 or 4	Check this option if the building is situated	Absolute ultimate deformation	[cm]	5.0
	not consider show as an accompanying	Relative deformation check		\checkmark
	action with wind being the leading action.	Relative ultimate deformation	[leff/]	300
Equal γG for permanent loa	ds Check this option if all permanent load with the same partial safety factor (γG,sup or γ loads or load cases are combined with each o	ds or load cases shall be in γG,inf). Otherwise, all pern ther with γG,sup and γG,in	ncluded nanent if.	

Consequence class allows you to define the consequence class on which the safety concept should be based: CC1, CC2 or CC3.

Ultimate Linit State

Cross section design	the cr - elas - plas	ross section design is optionally performed in accordance with the tic method or the tic method as per Para. 6.2
Equivalent member verifi	cation	the verification in accordance with the equivalent member method is
	based	don
	- 6.3.3	3 (annex A or B) or on

- 6.3.4

Serviceability

Design situation	defines the design situation for the verifications in the limit state of serviceability.
Verify absolute deformation	performs the serviceability verification with consideration of the difference in deformation in comparison to the undeformed system.
Absolute limit deformation	the permitted maximum absolute deformation of the structural system.
Verify relative deformation	performs the serviceability verification with regard to the effective lengths, which are determined by the turning points (moment passage) of the bending line.
Relative limit deformation	the permitted maximum relative deformation of the structural system.



Structural system

Material Properties 무 the following steel types are currently available for Steel type Basic Parameters selection: 90 Material Loads Type of steel structural steel Output Steel grade structu normalized steel System thermo steel weather-proof steel Material Length heat resisting steel Type of steel structural steel thermof. hollow sect. Cross-section hollow section N Steel grade S235 • Intermediate support in y-dire user defined type System 0 Restrain not supported Length [m] 5.00 Remarks 6 Cross-section **HEA 200** ... System 0 Intermediate support in y-direction Restrain not supported -Steel grade the available options for the steel grade depend on not Remarks the selected steel type. continuously supported System restrained in mid-span restrained in 1/3 points restrained in 1/4 points Parameters if you have selected "user-defined steel type", you can restrained in distance x0 display a dialog for the definition of the steel

parameters by activating the III button. Otherwise, the parameters of the selected steel are displayed in this section.

Structural system

Length length of the beam in the x-direction.

activating the witton displays a dialog for the selection of the steel shape. Cross section The manipulation of the dialog is described for all applications that include this dialog in the document "Select - edit cross section - PLUS."

Only steel shapes that are approved for the equivalent member method are displayed.

Intermediate support in the y-direction

You can define lateral supports in this section. This allows you to simulate bracing (discrete supports) or plate-type stiffening structures (continuous supports).

Note: The supports are generated with a very high default spring value that produces a quasi-rigid support. If you like to define more refined springs you should use the BTII+ application. (See Interface to BTII+).

Location of the support

It is of essential importance for the examination of the stability to define where the lateral supports apply to the cross section.

The selection list allows you to specify the point of application of the lateral support.

See also the following drawing:

Intermediate Support in y-Direction		
Restrain	restrained in distance x0	•
Height of the restraint	[m]	0.00
repeat		
Position of Supports	in shear center	-
Remarks	in shear center on top chord	
about the system	on bottom chord	





Remarks

... about the system activating the *is* button displays a dialog where you can enter an explanatory text. You can optionally display or hide this text in the <u>Output</u>.



Loading

Standard loads / wizard

The wizard allows the user to generate a calculable basic system by defining a few parameters (Standard loads ...). The user can enhance and customize the item subsequently. Wizard

Create new structural item

Wizard	Templates	Ope
System		
Length	[m]	5.00
Cross-section	HEA 200	1
Area loads		
permanent	[kN/m ²]	5.00
variable [kN/m ²]		10.00
Influence width	[m]	1.00

Area loads

Load definition

Value	Description	System sketch
Permanent	Permanent portion of the characteristic vertical load.	Affected width
Variable	Variable portion of the characteristic vertical load.	
Affected width	Affected width of the vertical area load.	 ✓ ✓ ✓ ✓ Z

The vertical area loads are always classified as "imposed loads of class A" (action group 1). You can edit the <u>actions</u> at a later time in the load table.

Self-weight

...consider automatically

if you activate this option, the self-weight of the beam is taken into account automatically.



Sim Alt

0

0 0

Member loads

Enter	the data of the first	load case in th	ne data-en	try mas	k or dir	ectly i	in the load	Pro	perties	lê.	
case t To ad	able, which you can d additional loads, ii	n display by act nsert a new row	ivating the	e 📃 l	oads	butto	on. utton.		Basic I Systen Load Dimen Output	Parameters 1 sioning	
Tip:	A description is dis	splayed in the s	status line	each tir	ne you	click I	into a	Me	mber l	oads	
		ry neia.						Loa	ds		to the tabl
								Sel	f-weig	ht	
								Con	isider a	utomatically	
								use	r defin	ed actions	
											Edit
								Rer	marks		
								a	about th	ne actions	
Loa	load type	Direction	pi	Pj	a	1	Description	Load attac	ck point	,	Action
	المتقومين والتعليق لوسط	ab to a draw them	E 00 10		[m]	[m]	E 001-N1/2	A	1002	Democratical	ž.
2	Uniformly distrib load Uniformly distrib load Concentrated load at a	in z-direction	10.00			-	- 10.00 kN/m ²	Axis Axis	2	Cat. A: domestic,	residental areas
	Concentrated moment at a Line load from a to a+l Triangular load Trapezoidal load over l										

Load value compilation

A load value compilation can be called up via the "arrow symbol" 📓 at pi/pj - see description in the LAST+ program.





Load type select a load type from the list. pi, pj are characteristic load values.

Uniformly distributed linear load	A linear load that applies constantly over the total length of the beam.	pi
(point load)	the distance <i>a</i> from the left support.	
Concentrated moment (point moment)	A moment applying at a distance <i>a</i> from the left support.	pi
Line load from a to a+l	A linearly variable load distributed over the beam length <i>I</i> applying at a distance <i>a</i> from the left support.	pi pj
Triangular load over entire member	A triangular load variable over the total length of the beam.	
Trapezoidal load over entire member	A trapezoidal load variable over the total length of the beam.	p_i p_j $\downarrow a \downarrow 1 \downarrow$

Direction selection of the direction of action. The loads or concentrated moments act in the direction of or about the global y-axis or z-axis. Concentrated loads also act in the direction of the x-axis.



Load position	selection of the load position at the cross section (top/center/bottom). You can display the corresponding dialog in	Point of attack		
		Load at	tack point	8
	the load table by activating the 🕮 button.	Position	Center line of member	•
Action	category or kind of action of the load		Upper edge Center line of member Lower edge	
Sim group	assignment of the load to a group of loads acting simultaneously. The group is defined by a group number entered by the user. Loads that are assigned to the same simultaneous group always appl simultaneously. Loads in a simultaneous group must also be member of an action group.	Perm Cat. Cat. Cat. Cat. Cat. Cat. Cat. Cat.	An comestic, residental area B: office areas C: congregation areas D: shopping areas E: storage areas F: traffic F <= 30 kN G: traffic 30 kN < F <= 160 H: roofs H: coofs Hoads v loads H < 1000 m v loads H > 1000 m perature	3S kN
Alternative group	assignment of the load to a group of loads excluding each other. The group is defined by a group number entered by the user.	Settle Accie Seisr	ements dental actions nic loads	
Description	you can optionally enter a short note that appears in the output.			
Remarks	allows you to enter personal comments on the loads. You can optional these comments in the <u>output</u> .	ally hide	or display	

III.:

Principle representation of the simultaneous and alternative groups. Load 1 and 3 act together and are therefore assigned to the simultaneous Load 1 Load 3 Load 2 Load 4 group 1. The same applies to load 2 and 4 (simultaneous group 2). ╈ The simultaneous groups 1 and 2 are Simultaneous group 1 Simultaneous group 2 assigned to the alternative group 1. Therefore, the loads of these two groups cannot apply simultaneously.

Alternative group 1



Design and analysis

Verifications in the ultimate limit state

The analyses in the ultimate limit state include the following individual verifications:

- Verification of the cross-sectional resistance with consideration of local buckling failure (verification of the c/t-limiting values and assignment to cross section classes).
- Verification of the plastic cross-sectional resistance as per EN 1996-1-1, para. 6.2. If you have activated the "Elastic design" option when defining the basic parameters, the elastic verification is performed in accordance with equation 6.1.
- Stability verification as per EN 1993-1-1, para. 6.3.3 or 6.3.4.

The stability analyses of lateral buckling and lateral torsional buckling are based on the so-called equivalent member method.

When applying the simplified analysis, an eigenvalue calculation is performed using the subspace method. The eigenvalue determination for the FE problem requires the solution of the general matrix eigenvalue problem for the smallest eigenvalue η Ki. This task is handled in STT+ via the calculation module of the BTII+ application The examination is performed for each load case combination separately for each applicable design situation. This method ensures that the actually decisive failure situation in accordance with the safety concept can be determined.

Verifications in the serviceability limit state

The displacements in direction of the different main axes and the resulting displacement are calculated in a first-order analysis. The results are compared to the parameters defined by the user. The verification is considered successful when the calculated displacements are smaller or equal to the user-defined values.



Load transfer

Calling up further FRILO design programs - see also Interfaces.

The term load transfer refers basically to two extended functions, the transfer of the structural system to BTII and the transfer of support reactions for the calculation of connected structures.

System transfer to the BTII+ application

The first extended function consists in exporting the beam system to the <u>BTII+</u> application allowing the user to calculate more complex structural systems or to perform comparative calculations.

Higher requirements on the calculation of beam systems which cannot be fulfilled by an application such as STT+, become relevant if the supporting conditions do not comply with the relevant standard or if loads have to be included that produce either planned torsion or inconstant behaviour of the axial forces. Such systems cannot be verified using the equivalent member method. They require second-order analyses with consideration of warping torsion. The BTII+ application offers the necessary performance parameters for this task.

The column system is represented as a system section in the BTII+ application. The supporting conditions correspond to the structural system of the beam including the lateral supports.

Transferring supporting forces

STT+ offers a load transfer feature to other applications for the calculation of connected structures and foundations.

The characteristic support reactions can be transferred to the applications

- Single-span Steel Column <u>STS+</u>,
- Reinforced Concrete Column <u>B5+</u>/B5 and
- Timber Column <u>H01+</u>.

Parameters such as column height, height of the load application point and eccentricity can be specified in a dialog.

Design values and support reactions can be transferred to the

- Steel Girder Support <u>ST4</u> and
- Reinforced Concrete Corbel <u>B9+</u>

software applications.

The desired load combination can be selected in a dialog box.

Load transfer to the Angle Connection program <u>SWA+</u> is also possible.

Properties		д
Basic Parameters System Load Dimensioning Load transfer Output		Q (2)
Left support		0
Steel column	STS+	
Tim <mark>ber colum</mark> n	HO1+	
RC column	B5+	
Girder support	ST4	
Angle connection	SWA+	
Reinforced concrete corbel	B9+	
Rights support		0
Steel column	STS+	
Timber column	HO1+	
RC column	B5+	
Girder support	ST4	1

SWA+

B9+

Z

1

Angle connection

Reinforced concrete corbel



Output

By checking or unchecking the various output options, you can define the scope of the output (if an option is checked, the associated contents is integrated in the output document)

The options are described by tooltips and explanatory notes in the information section on the bottom of the screen.

Scale of system graph

by modifying the default scale you can adjust the size of the graph in the output document according to your requirements.

Output as a PDF file

The Document tab displays the document in PDF format. You can display, save and print the PDF document.

A general description of the output options is available in the document:

Output and Printing

Properties	Р
Basic Parameters	۹ 🔕
Loads	

General		0
Brief output		V
Notes		
System		0
System- and load- graphics 2D		1
System graphics 3D		
System graphics scale	[1:]	50
Loads		0
Actions		V
Results		0
Support reaction- characteristic per loadcase		1
Support reactions - design values		

Tel: +49 711 810020 Stuttgarter Str. 40 Tel: +49 711 810020 70469 Stuttgart Fax: +49 711 858020 Cross-section - HEA 200 Section h = 19.0 cm Web (clearance) h = 13.4 cm s = Top and bottom chord b = 20.0 cm t = Curvature r = 1.8 cm² Area A = 55.8 cm² Static values l = 1340 cm ⁴ W ₂ = Actions Id Type Situation Name	Project: Manuais Item: STT+D2002 4/26/2016 0.7 cm 1.0 cm 389 cm ³ 134 cm ³	Page: 2		
$\begin{array}{cccc} \hline & & & & & & & & & & & & & & & & & & $	4/26/2016 0.7 cm 1.0 cm 389 cm ³ 134 cm ³	Page: :		
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$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	0.7 cm 1.0 cm 389 cm ³ 134 cm ³	- vet dia		
Top and bottom chord b = 2.0.0 cm t = Curvature r = 1.8 cm Area A = 53.8 cm ² Static values I _y = 3690 cm ⁴ W _y = Iz = 1340 cm ⁴ W _z = Actions Id Type Situation Name	1.0 cm 389 cm ³ 134 cm ³	- v-s dia		4-
Curvature $r = 1.8 \text{ cm}$ Area $A = 53.8 \text{ cm}^2$ Static values $l_y = 3690 \text{ cm}^4$ $W_y = l_z = 1340 \text{ cm}^4$ $W_z = $ Actions Id Type Situation Name	389 cm ³ 134 cm ³ γευρ	area alua		
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	389 cm ³ 134 cm ³ γ₂υρ	- year duo		4
Actions Id Type Situation Name	Ysup		1	4.5
Id Type Situation Name	Ysup			1.22
		γιαι φυ	ψ1 ψ	ψz
99 G P/T Permanent loads 1 Q P/T Cat. A: domestic, resident	ntal areas 1.35	1.00 1.00 0.00 0.70	1.00 1.0 0.50 0.3	00 30
Loads				- W.
Type 2 = Uniformly distributed load kN/m The dead load is automatically taken into account.		מר		
No. : Number of load Type : Type of load pl : Load ordinate at x = a a : Ordinate of the first load value pl : Load ordinate at x = a a : Ordinate of the first load value pl : Load ordinate at x = a a : Ordinate of the first load value pl : Load ordinate at x = a c : Detainse to Orpoint in y-direction Description : Description of load Act Act : Action				
No. Type pi a pj l [m] [m]	l ey ez Description [cm] [cm]		A	Act
1 2 4.0	0.0 -9.5 5.00 kN/m ²	× 1.00 m	<u>c</u>	99
	Type 2 = Uniform ly distributed load kN/m The dead load is automatically taken into account. No. : Number of load pi : Load ordinate atx = a a : Ordinate of the final load value pj : Load ordinate atx = a+1 i : Data ordinate atx = a+1 i : Da	Type 2 = Uniformly distributed load kN/m The dead load is automatically taken into account. No. : Number of load Type : Type of load Type : Used ordinate strue activity and pi : Load ordinate strue activity a	Type 2 = Uniformly distributed load kN/m The dead load is automatically taken into account. No. : Number of load Type : Type of load P : : Under of the first load value P : : Langth of the load ey : Distance to Opplint in y-direction Rescription :: Description of load Act : Action No. Type pi a pj ey ez Description [m] [m] [cm] [cm] 1 2 4.0 0.0 -9.5 5.00 kN/m ² × 1.00 m 2 7 10.0 0.00 3.0 5.00 0.0 -9.5 10.00 kN/m ² × 1.00 m	Type 2 = Uniformly distributed load kN/m The dead load is automatically taken into account. Legend output option No. : Number of load pi : Led ordinate at x = 1 a : Ordinate of load pi : Led ordinate at x = 1 a : Ordinate of order pi : Led ordinate at x = 1 a : Ordinate of order pi : Led ordinate at x = 1 a : Distance to Oppoint in adirection exercision Description of load Act :: Ration No. Type pi a pj l ey ez Description [m] [m] 1 2 4.0 0.0 -9.5 5.00 kN/m² × 1.00 m



Frequently asked questions

Structural system

Can I also calculate multi-span systems in STT+?

No. STT+ allows the calculation of single-span beams only. However, you can define lateral supports in the form of discrete or continuous supports. The application point relevant for the stability analyses can be defined either on the top chord, the bottom cord or in the shear centre.

Loads

Can I specify loads that produce planned torsion?

No. Loads that produce planned torsion are not considered in STT+. The most important reason for this restriction is that the equivalent member verification must not be used in a comparable load situation. In such a case, a second-order analysis of torsional warping is required. We like to point out in this connection that our BTII+ module is able to perform this task.

Calculation

Can I perform a second-order analysis in addition to the verification based on the equivalent member method?

No. Systems requiring second-order analyses can be calculated with our BTII+ module.