STT+ Single-span Steel Beam

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

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

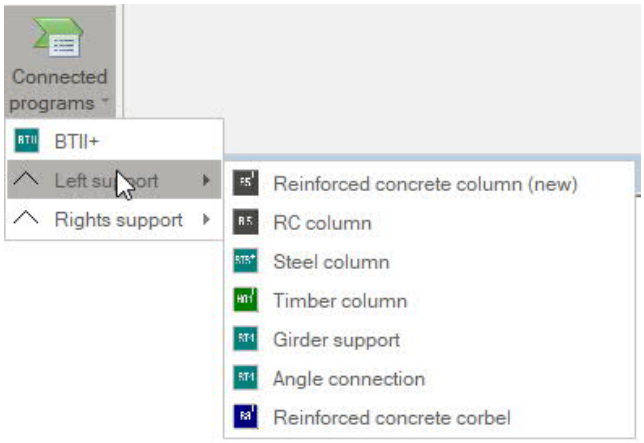
STT+ generates automatically the appropriate load cases and load case combinations depending on the defined actions and performs the necessary analyses, whereby the decisive load case combination is determined for each limit state.

Interfaces to other applications

The characteristic support reactions can be transferred to the applications

- Single-span Steel Column STS+ ,
- Reinforced Concrete Column B5+/B5 and
- Timber Column HO1+.

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

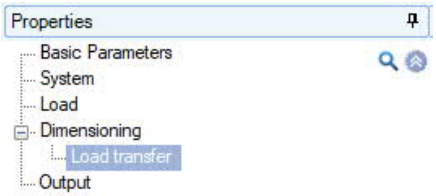


Design values and support reactions can be transferred to the

- Steel Girder Support ST4 and
- Reinforced Concrete Corbel B9+

software applications.

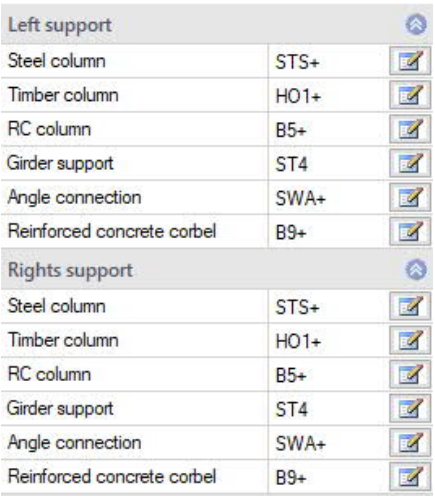
The desired load combination can be selected in a dialog box.



Load transfer to the Angle Connection program SWA+ 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 BTII+ 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.



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

See Chapter Load transfer

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

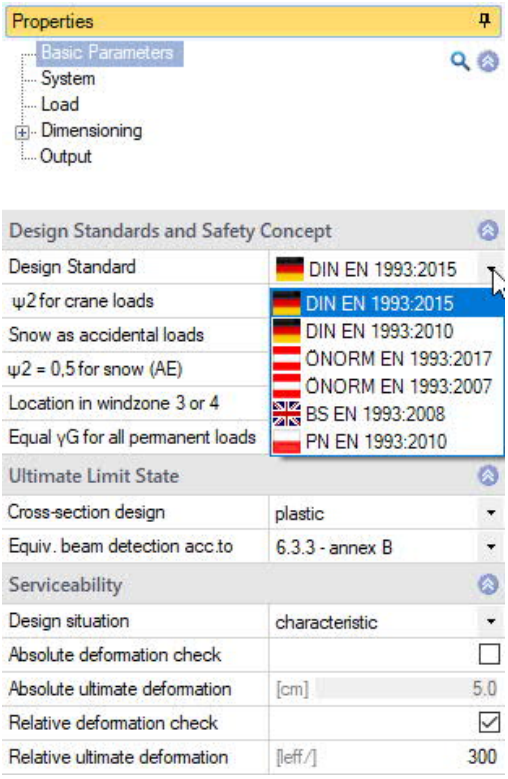
Load transfer

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 the load-bearing capacity verification as per EC3.

ψ2 for crane loads — Specifies the load combination factor ψ2 for crane loads (= ratio of permanent part to total crane load)

Snow as accidental loads — Check this option if the snow loads shall be included automatically not only in the typical design situations but also as an accidental action. You can either specify a load factor for the accidental snow loads or have it determined automatically by the software (select the corresponding checkbox).

ψ2 = 0.5 for snow — Check this option to increase the value of the combination coefficient **ψ**2 to 0.5 for snow action in the seismic design situation. (See introductory decree of the federal states, e.g. Baden-Württemberg)

Wind zone 3 or 4 — Check this option if the building is situated in wind zone 3 or 4. In this case, you need not consider snow as an accompanying action with wind being the leading action.

Equal γG for permanent loads — Check this option if all permanent loads or load cases shall be included with the same partial safety factor (γG,sup or γG,inf). Otherwise, all permanent loads or load cases are combined with each other with γG,sup and γG,inf.

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 cross section design is optionally performed in accordance with the
- elastic method or the
- plastic method as per Para. 6.2

Equivalent member verification — the verification in accordance with the equivalent member method is based on
- 6.3.3 (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.

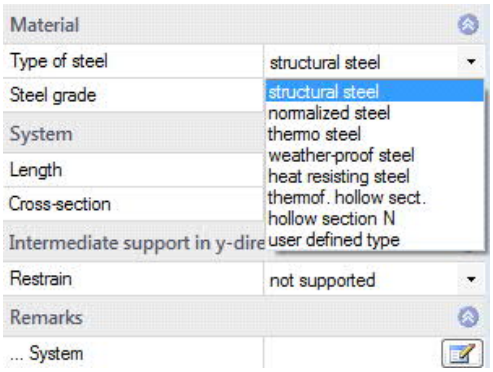
Verify relative deformation — performs the serviceability verification with regard to the effective lengths, which are determined by the turning points (moment passage) of the bending line.

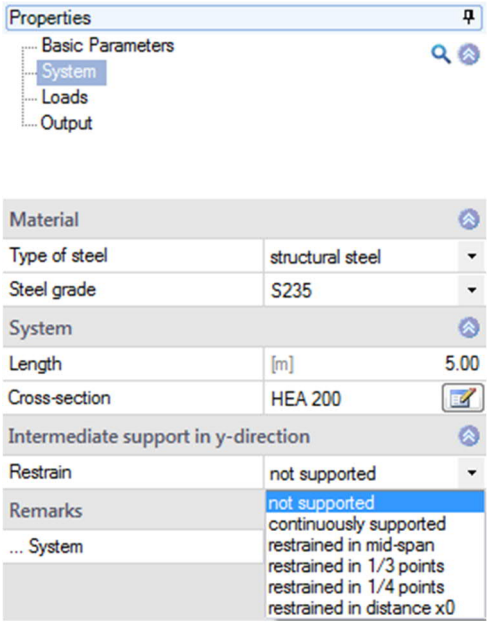
Relative limit deformation — the permitted maximum relative deformation of the structural system.

Structural system

Material

Steel type — the following steel types are currently available for selection:





Steel grade — the available options for the steel grade depend on the selected steel type.

Parameters — if you have selected "user-defined steel type", you can display a dialog for the definition of the steel parameters by activating the button. Otherwise, the parameters of the selected steel are displayed in this section.

Structural system

Length — length of the beam in the x-direction.

Cross section — activating the button displays a dialog for the selection of the steel shape.

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

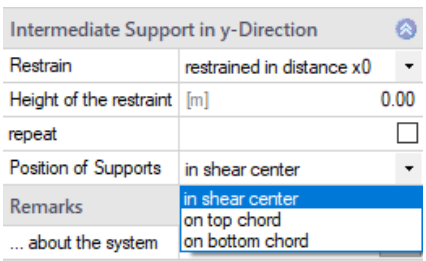
You can define lateral supports in this section. This allows you to simulate bracing (discrete supports) or plate-type stiffening structures (continuous supports).

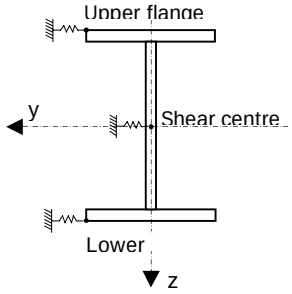
Note: The supports are generated with a very high default spring value that produces a quasi-rigid support. If you like to define more refined springs you should use the BTII+ application. (See Interface to BTII+).

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:



Shear centre	
Upper flange	
Lower flange	

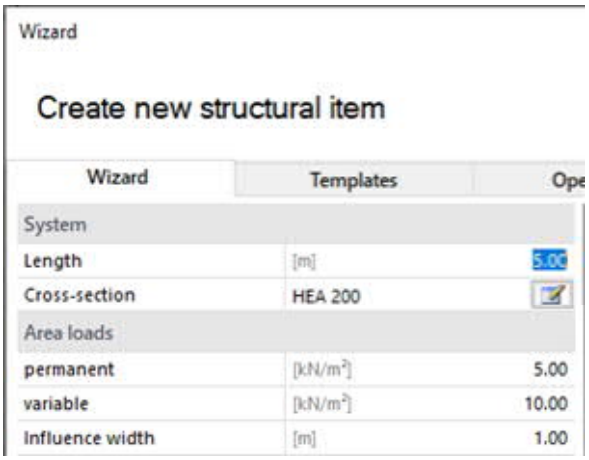
Remarks

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

Loading

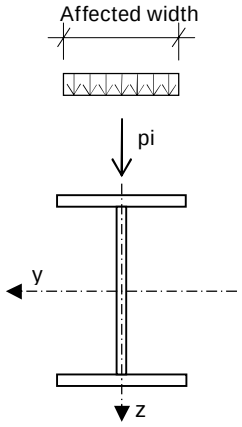
Standard loads / wizard

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.



Area loads

Load definition

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

The vertical area loads are always classified as "imposed loads of class A" (action group 1).
You can edit the actions 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.

Member loads

Enter the data of the first load case in the data-entry mask or directly in the load case table, which you can display by activating the Loads button.

To add additional loads, insert a new row first by activating the button.

Tip: A description is displayed in the status line each time you click into a particular data-entry field.

Loads

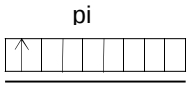
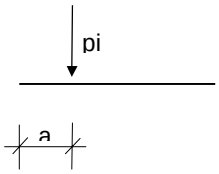
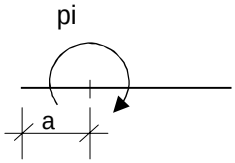
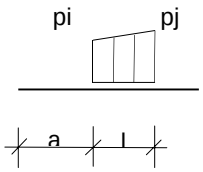
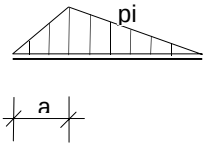
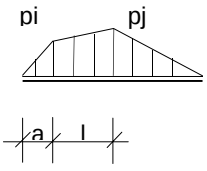
	load type	Direction	pi	pj	a [m]	l [m]	Description	Load attack point	Action	Sim	Alt
1	Uniformly distrib.load	in z-direction	5.00	---	---	---	5.00 kN/m²	Axis	Permanent loads	0	0
2	Uniformly distrib.load	in z-direction	10.00	---	---	---	10.00 kN/m	Axis	Cat. A: domestic, residental areas	0	0

Uniformly distrib.load
Concentrated load at a
Concentrated moment at a
Line load from a to a+l
Triangular load
Trapezoidal load over l

Load value compilation

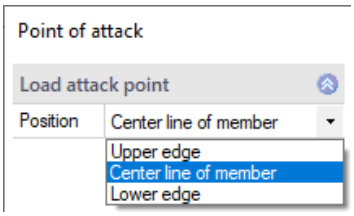
A load value compilation can be called up via the "arrow symbol" at pi/pj - see description in the LAST+ program.

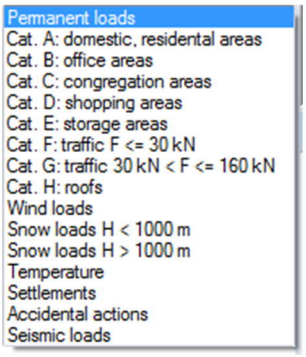
Load type select a load type from the list.
pi, pj are characteristic load values.

Uniformly distributed linear load	A linear load that applies constantly over the total length of the beam.	
Concentrated load (point load)	A concentrated load applying at the distance *a* from the left support.	
Concentrated moment (point moment)	A moment applying at a distance *a* from the left support.	
Line load from a to a+l	A linearly variable load distributed over the beam length *l* applying at a distance *a* from the left support.	
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.	

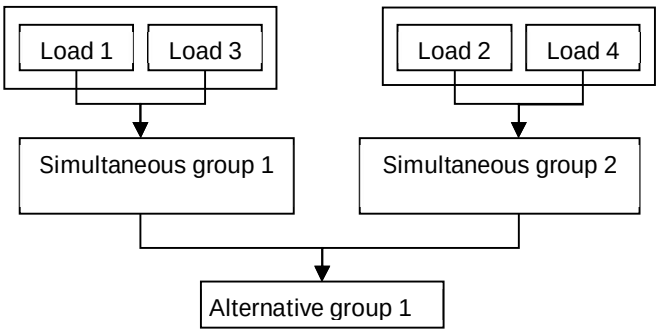
Direction selection of the direction of action. The loads or concentrated moments act in the direction of or about the global y-axis or z-axis. Concentrated loads also act in the direction of the x-axis.

Load position	selection of the load position at the cross section (top/center/bottom). You can display the corresponding dialog in the load table by activating the button.
Action	category or kind of action of the load
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 apply simultaneously. Loads in a simultaneous group must also be member of an action group.
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.
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 optionally hide or display these comments in the output.





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



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.

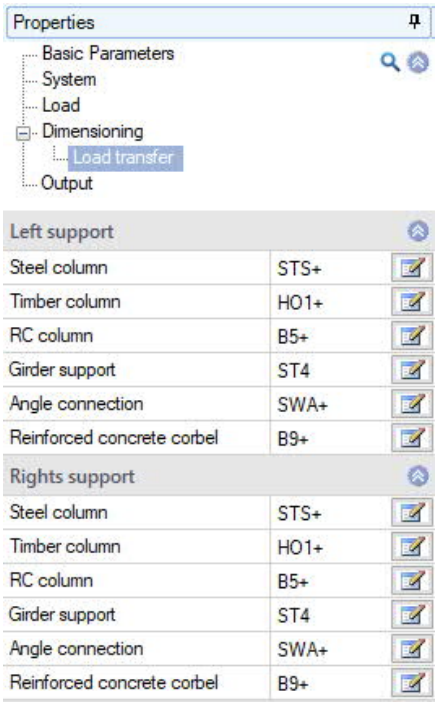
Verifications in the serviceability limit state

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 BTII+ 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 STS+ ,
- Reinforced Concrete Column B5+/B5 and
- Timber Column HO1+.

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 ST4 and
- Reinforced Concrete Corbel B9+

software applications.

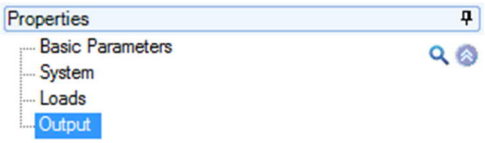
The desired load combination can be selected in a dialog box.

Load transfer to the Angle Connection program SWA+ is also possible.

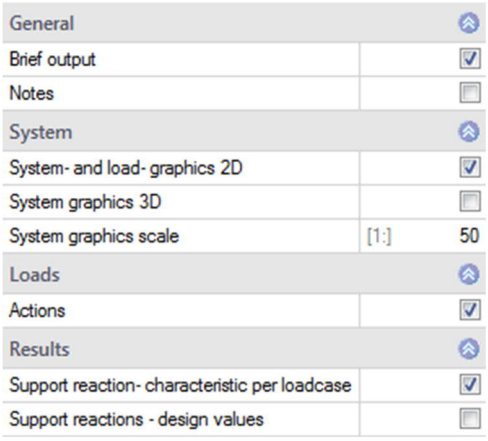
Output

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.

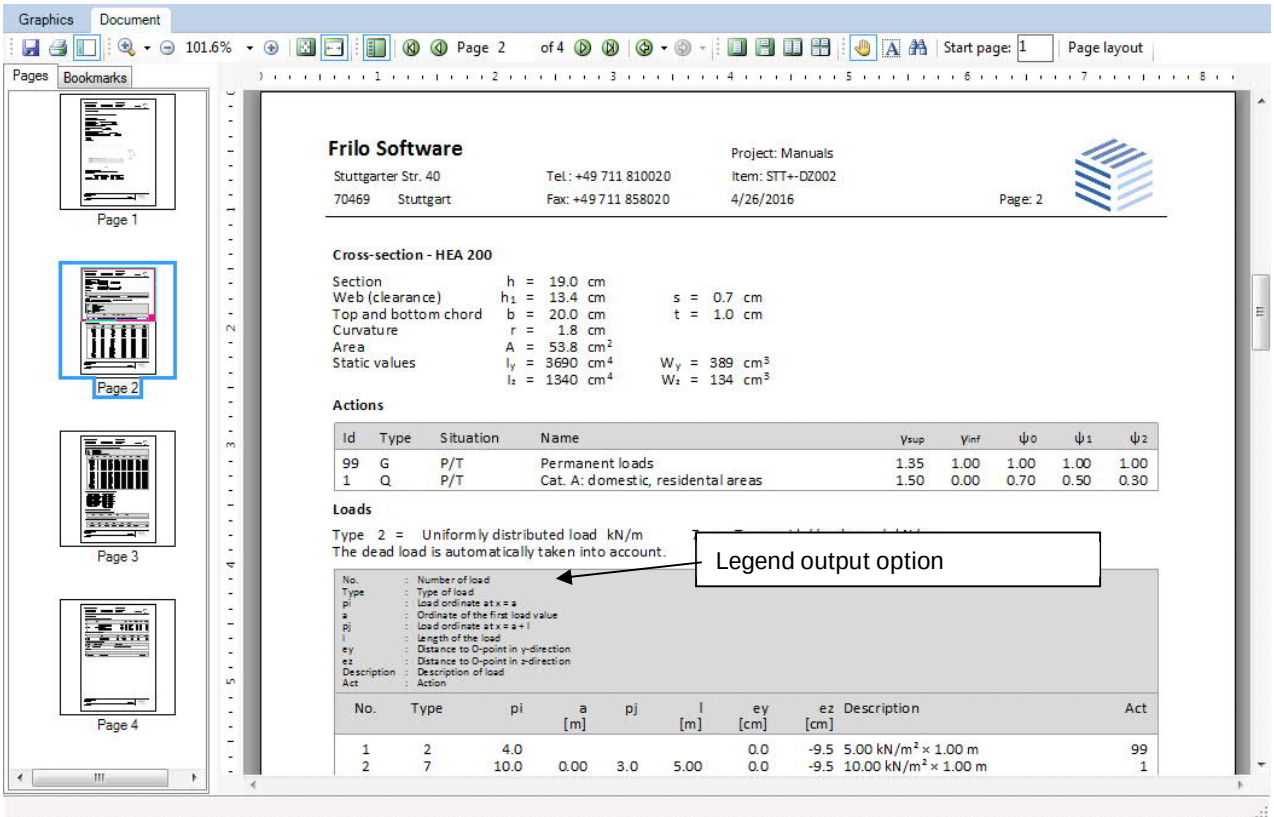


Output as a PDF file

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



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.