Timber Wall Diaphragms HTW+

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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 www.frilo.com in the Campus-download-section.

Terms: In this manual, the terms Elements, Ribs, Web are used synonymously, as well as sheets / panelling.

Application options

This software application allows the calculation of wall panels in accordance with Eurocode 5 and its National Annexes.

The variety of definable systems ranges from simple walls with regular web spacing and identical panelling on both sides to irregular column placement with different panelling and different panel grids on each side. A horizontal butt joint can be defined for individual, several or all panels. A different material can be assigned to each web and each panelled side.

Vertical continuous end webs (without transversal compression on the base frame) are also available.

Support stiffness is handled with separate tension and compression springs on the end webs.

To anchor the end ribs, the program supports the design of two-piece Würth panel anchors.

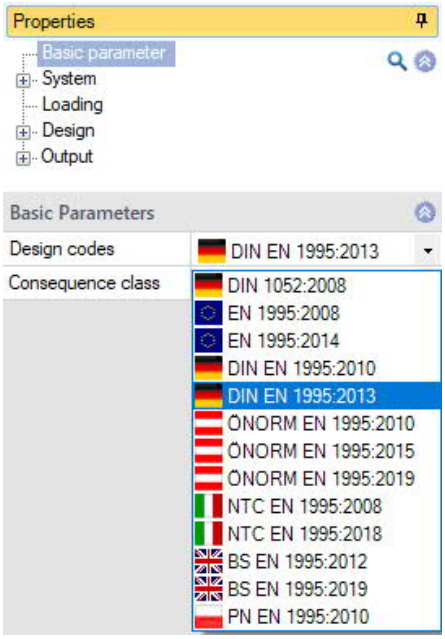
Available loads are vertical loads (concentrated, uniformly distributed and trapezoidal loads), horizontal concentrated loads applying in direction of the wall and area loads applying over the wall height in transverse direction. In addition to typical actions, accidental loads due to earthquake loading can be used.

Extensive output control functions allow detailed and comprehensive output scopes as well as abbreviated versions with summarized results. Graphical representations are added to the text in a context-sensitive manner. The newly implemented Maximum utilization "all-in-one" graph reveals the decisive utilizations at a glance.

Standards and Design

The calculation and design can be carried out in accordance with the following standards:

- DIN EN 1995-1-1/NA: 2010-12 (NA Germany)
- DIN EN 1995-1-1/NA:2013-08 (NA-Germany)
- ÖNORM B 1995-1-1: 2010/2015/2019 (NA Austria)
- NTC EN 1995-1-1:2008/2018
- BS 1995-1-1: 2012/2019 (NA GB)
- PN EN 1995:2010
- EN 1995-1-1: 2004/A1: 2008/2014
- DIN 1052:2008



Note: *The calculation in accordance with DIN 1052 is not described in detail in this document. The eurocode-specific description applies analogously to calculations governed by the DIN standard, however.*

Basis of calculation

The calculation of the wall panel is based on EN 1995, chap. 9.2.4.2 (method A) and the relevant National Annex. In this model, the forces are transferred to the wall via webs. The panelling is calculated as a shear field bearing the horizontal loads in wall direction. Vertical forces are transferred by the vertical webs.

Additional axial forces apply to end webs as well as head and base webs, because they constitute a perimeter chord circumscribing the shear field.

The software application combines the defined loads to load cases in accordance with the assigned load group (either concurrent or alternative).

Subsequently, the internal forces of the webs, the shear flow of the panelling and the deformations are calculated for all load cases.

After this, the load cases are generated in accordance with the combination rules of EN 0 and the relevant National Annex.

Finally, the software performs all required verifications.

Load-bearing capacity verifications (strength STR)

- Stress resistance and stability verifications of the webs (EN 1995, Chap. 6.3.2)
- Transversal web compression from top to bottom (EN 1995, Chap. 6.1.5)
- Verifications of the panelling (shear) and the fasteners, including increasing and reducing factors (EN 1995, Chap. 9.2.4.2)
- If necessary, dimensioning of two-part Würth panel anchors according to approval ETA-14/0274 of 2020/11/30 - Würth Hold Downs.

Position stability verifications (equilibrium EQU)

- Decisive anchoring forces for the design of the anchorage.
- The load-bearing capacity is also verified for the load combinations of the position stability verification.

Serviceability verifications

(EN 1995: stiffness/reductions, chap. 2.2.2(2), fastener stiffness, chap. 7.1; deformation limits as per table 7.2)

In the calculation of the deformation in wall direction, the following portions are considered:

- Shear stiffness of the panels. The actual panel layout is taken into account
- Bending stiffness of the entire wall panels
- Fastener stiffness with consideration of different web materials over proportional web lengths
- Axial force spring on end webs
- Anchor tension spring on end webs
- Compression spring on end webs (also automatically from transverse compression on the bottom frame, if applicable)
- Horizontal spring on base web anchorage
- The following reductions are also taken into account in the design combinations:
  - Reduction of stiffness
  - Additional reduction of the fastener stiffness to 2/3.

Definition / Input

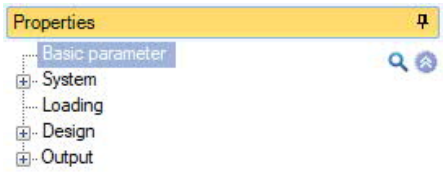
The definition of properties and control parameters is done in menu of the left screen section, also referred to as FDC section (Frilo.Data.Control). The user can check the effect of the entered values in the graphic screen on the right screen section.

Interactive graphic – Input options

The input options in the GUI window are described in the document Basic operating instructions-PLUS.

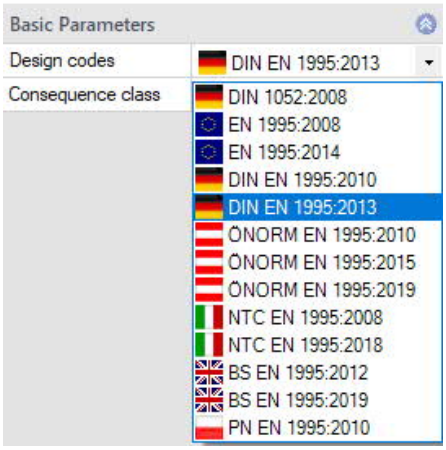
Note: *You can change some basic settings like assistant, color settings or units of measurement: ▸ File ▸ Settings.*

Basic parameters



Select the desired Design standard. The standard governing the combination of loads is selected automatically.

The Consequence class indicates the importance of the building.
Default is CC2/RC2.



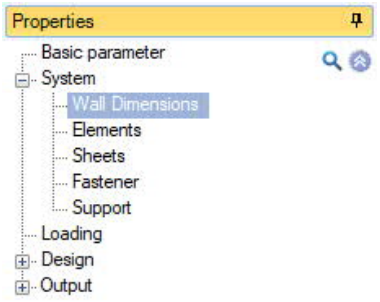
System

The System menu allows you to define the geometry and the material.

Note: *Glued laminated timber according to EN 14080:2013 for Germany and Italy is implemented.*
*The "former" term of glued laminated timber is marked with a * (e.g. GL24c*).*

Remarks

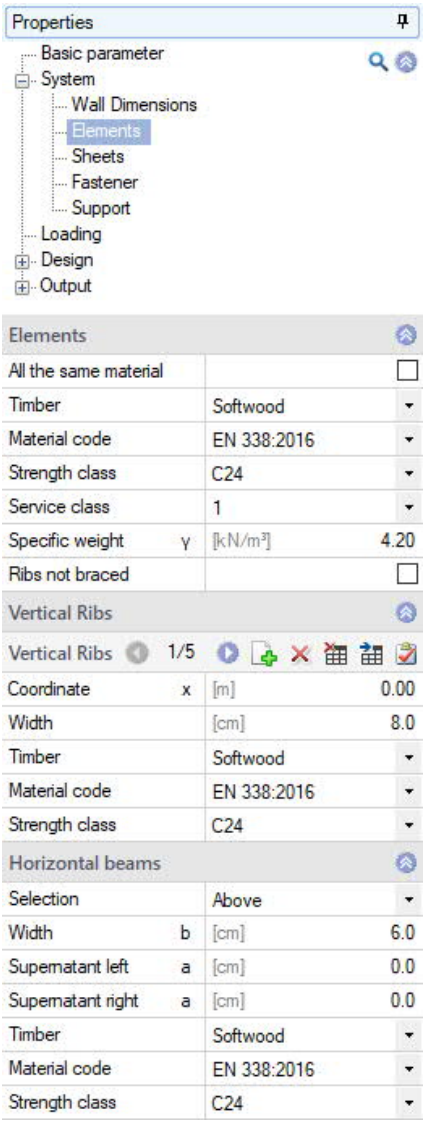
The user can enter remarks to the system and include them in the output scope, as desired.



Wall dimensions

Allows the specification of the wall dimensions. Additionally required elements/ribs and panels are generated dynamically by the software.

Elements / Ribs

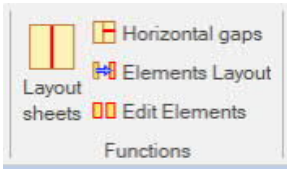


Allows the specification of parameters of the material of the vertical/horizontal elements and the strength/service classes. For different material, uncheck "All same Material". The specific weight is automatically applied for the selected strength class. The values for other rib materials are also determined automatically. You can also enter a different value, which will then be used for all rib materials.

Ribs NOT braced: If the option is checked, the ribs in the wall plane are not restrained by the planking. The stability verifications are carried out with the full buckling/tilting length (on the safe side). Otherwise the ribs are assumed to be restrained.

Vertical Ribs

Allows the definition of the properties of the vertical elements, such as cross-section width, position and material for individual elements (unless "All the same material" is unchecked). Adding and deleting ribs is done via the "Vertical Ribs" tab under the graphic - see also table input.



To edit or relocate several elements simultaneously, use the function buttons in the toolbar.

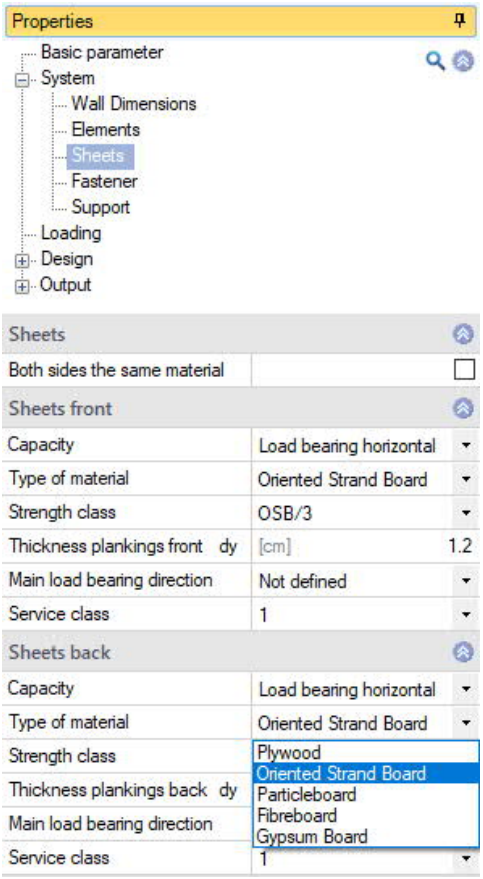
Horizontal ribs (beams)

Allows you to edit the properties of selected elements, such as cross-section width, projection or material. You can also right-click on the desired elemt in the interactive graphic and open the corresponding properties window.

Sheets

Both sides ... This option assigns the properties defined for the panelling on the front side to that on the rear of the wall. Any changes to the front panelling properties are also applied to the rear panelling. The service class can be specified separately for each side, however.

Sheets Front/Rear



Capacity If panelling is only applied to one side, the other is defined as "not existing". The option "Not load bearing" applies to panelling that has no static effect due to large cutouts for instance. In contrast to the "Not existing" option, dead load is taken into account if the option "dead load automatically" was activated in the Loads menu. The option "Load bearing horizontal" activates the shear field effect of the panelling.

Type of material The displayed selection of materials is determined by the material standards associated to the selected design standard.

Strenght class Selection of the appropriate strength class

Thickness... Allows you to specify the panelling thickness.

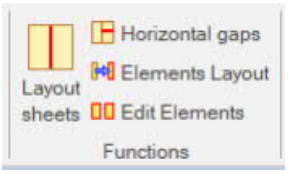
Main load bearing direction Depending on the type of timber material, it is the grain direction, the working direction or the direction of the skin grain. The option "Not defined" takes the most favourable values into account and is recommended.

Service class Allows you to select of the service class of the panelling.

Install panelling / Layout Sheets

Note: You should only install the panelling if all webs have been defined correctly, because a modification of the webs launches an automatic adjustment of the panels.

In order to reinstall the panelling or relocate vertical and horizontal joints, use the function buttons of the toolbar.

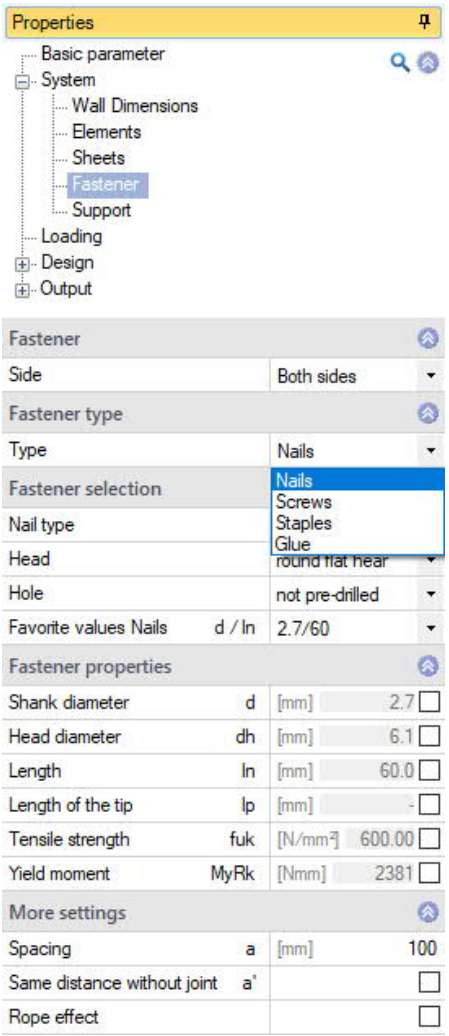


Fasteners

Allows you to define the desired fasteners and enter the appropriate parameters or select nails, screws, staples or glue via a selection dialog.

Optionally, fasteners can be defined for each side separately or both sides together.

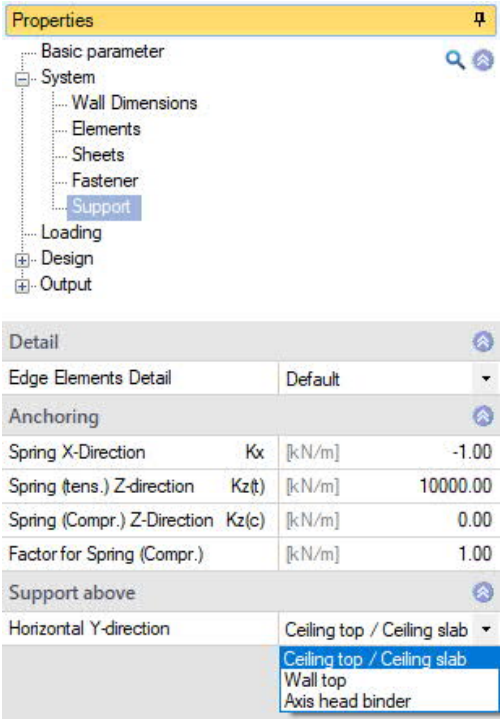
Additional information on the individual parameters is displayed in the info box below the input fields.



Supports

Edge elements detail

Shows the design of the end webs on top and bottom.



Default:
The detail corresponds to typical panelling structures in low buildings. The head and base webs run continuously over the total width. The end webs run between the head and base webs. A verification of the transverse compression strength of the end webs is required and often becomes decisive.

Vertical edge elements crossing
This version is used for walls under loading and/or in high buildings. The end webs of walls on top of each other are continuous over the total height and produce NO transverse compression. They must be connected with slot plates or dowel pins in a tension- and compression-resistant manner in each storey. This involves higher construction expenditure.

When selecting this variant, you can define projections on the end ribs. This setting has however no effect on the static conditions.

Depending on the selected detail, the support stiffness is defined as spring. Available are
-1 = high stiffness,
0 = automatic,
>0 = spring constant.
Enter the characteristic values because HTW applies automatically the required reduction for *kser* and *kdef* (end webs) by taking the considered combinations into account.

Spring in x-direction

Spring constant of the base web support. In connection with several storeys, it should be noted that a displacement of the top edge of the wall takes place in relation to the panel plane of the floor slab above. It can be simulated approximately by halving the value.

Spring (tension) in z-direction

Tension springs on the end webs. This value should approximately correspond to the value of the fastener stiffness *kser* of the tie-down. In this connection, the fasteners in the wall below should be taken into account additionally.

Spring (Compression) in z-direction

Compression springs on the end webs. This value corresponds approximately to the spring of the base web under transversal compression.
-1 = stiff
0 = the spring is calculated automatically with consideration to the geometry and the material.

Factor for compression spring

Values other than 1.0 are reasonable if the compression spring in z-direction was determined automatically by HTW based on the base frame.

1 = The compression spring is fully taken into account because the wall is located above a stiff basement wall, for instance.

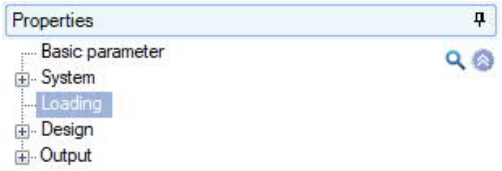
If the wall underneath the considered one is a timber-panelled wall, the elasticity of the head web should be taken into account. This means that only half of the spring value should be used (factor = 0.5). If an additional joist is fitted between the two walls, the factor could be further reduced from 0.4 to 0.2.

	If the vertical end webs run continuously over both walls, you need only specify a single value for the total connection stiffness.
Support above	Allows you to specify the height level of the wall support in y-direction (perpendicular to the wall plane).

Loading

Apply dead load automatically

Select this option to generate the dead load of the structure automatically. It is adjusted each time you edit and change the geometry.



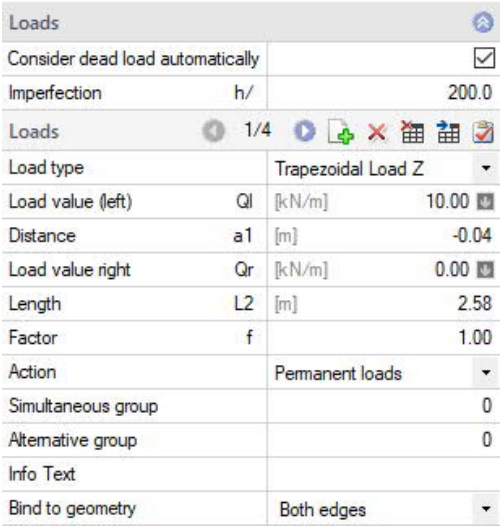
Imperfection/Plump line deviation

The specified plump line deviation is automatically included as equivalent horizontal load in all load cases and combinations. The action groups of the causing vertical load portion up to the creep portion are correctly taken into account. As no externally applying load is involved, no horizontal support reactions are produced.

The equivalent horizontal loads are applied in direction of the external horizontal loads. If a load case contains no external horizontal loads, the equivalent loads act to the right (+x).

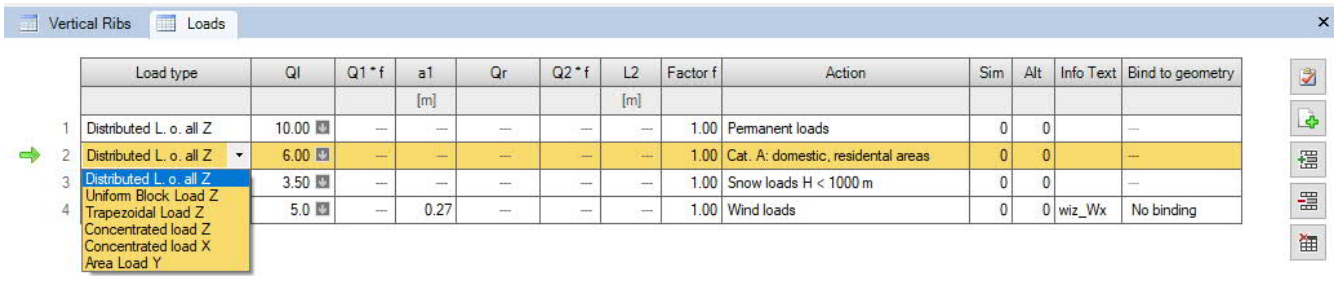
If a load combination contains no external horizontal loads, the axial web forces of both end webs are increased.

Note: The specification of a plump line deviation maps geometric and structural imperfections.



Loads (external loads)

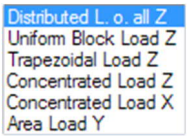
Alternatively to the definition of individual loads with the help of the left menu (FDC section), you can comfortably register your loads in a list below the graph, which you can display by activating the "Loads" button. All defined loads are shown in the list and you can check them at a glance.



Selecting loads in the FDC section:

The "Left/Right" buttons allow you to select a load for editing. The order number of the load and the total number of loads is displayed (see illustration: 2/3 means the second load of totally three loads).

Via additional buttons, you can add (+) or delete (x) loads.



Load type — Selection of the load type. All loads act in the wall plane on the web structure.

Uniformly distributed load over wall length z / Block load z / Trapezoidal load z (vertical)
Uniformly distributed loads and trapezoidal loads are assumed applying on top of the webs. The load portions between the vertical webs are distributed over the two adjacent webs, in order to maintain the load resultant of this portion. Load portions outside of the wall are assumed to apply in the axis of the end webs. The (internal) concentrated loads produced this way are combined in a load case.

Uniformly distributed load over the wall length
A uniformly distributed load always applies over the total wall width from the left to the right.

Trapezoidal load z
These load types apply at a distance a1 from the axis of the left web and have the length L2 in x-direction.

Concentrated load z (vertical)
The loads are applied to the top of the webs. Concentrated loads applying between the vertical webs are distributed over the two adjacent webs, in order to maintain the load resultant of this portion. Loads outside of the wall are applied in the axis of the end webs.

Concentrated load x (Horizontal direction of the wall)
This load type applies at a distance a1 above the axis of the top web.

Area load y (horizontal perpendicular to the wall plane)
This load type applies at a distance a1 from the axis of the left web and has the length L2 in x-direction.

Ordinate (left)	The total load is specified for concentrated loads. For uniformly distributed, trapezoidal and area loads, the left ordinate of the load at *a1* is specified. A load compilation can be called up via the "arrow symbol" .
Distance a1	Distance of the load or the left end of the load to the reference axis.
Ordinate (right)	The right ordinate for trapezoidal loads
Length L2	Length of the load in x-direction for distributed loads.
Factor	Multiplication factor of the load ordinates
Action group	The correct assignment is important to ensure that the safety and combination factors of the actions are applied appropriately. Only relevant to variable loads:
Sim	Loads assigned to the same simultaneous group always apply simultaneously, if the value is greater than zero. Example: load pair produced by a wall bracket of an appliance.
Alt	Loads assigned to the same alternative group never act simultaneously in any combination, if the value is greater than zero. Example: wind from the left and wind from the right.

Combination of concurrent group AND alternative group

Example: Four loads are assigned to alternative group 1, i. e. they do not apply simultaneously.

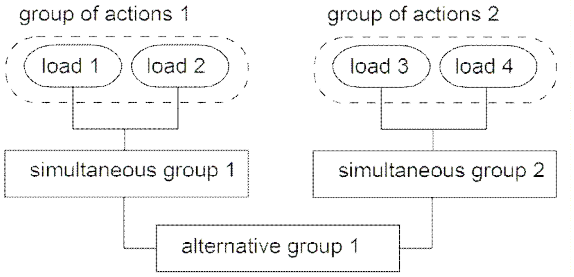
Loads 1 and 2 are assigned to concurrent group 1, load 3 and 4 to concurrent group 2.

Loads 1 and 2 apply simultaneously as a group.

Loads 3 and 4 apply simultaneously as a group.

The loads 1 and 2 do not apply simultaneously with the loads 3 and 4.

Loads belonging to the same concurrent group pass this feature on to their alternative group. A concurrent group only includes loads of the same action group and the same alternative group.



Infotext — Gives hints such as "From item 3" or similar information.

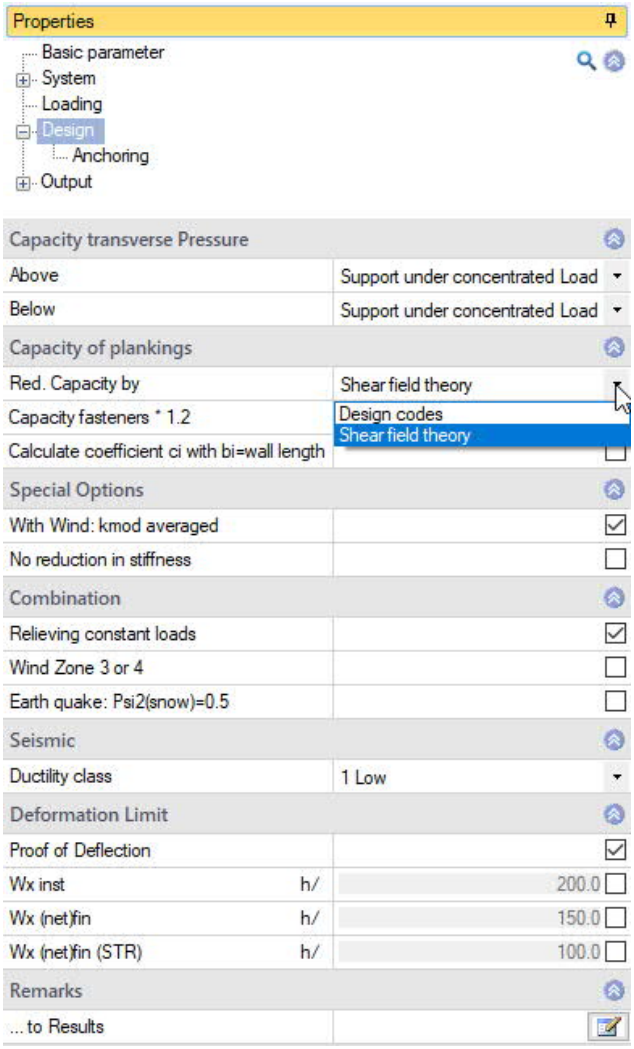
Adjust to changes in geometry — The values specified for *a1* in the load definition always refer to the axis of the left web. They are not adjusted when the geometry is changed. The length value *L2* is not adjusted either. In many cases, an adjustment is reasonable, however.

Example 1: You have defined a uniformly distributed load with projections of half the grid spacing (=door opening width). If you change the wall length, you must adjust the load length *L2* manually to maintain the projection on the right. If you had selected the adjustment opinion Axes of end webs, the adjustment would have been done automatically.

Example 2: If you define a concentrated load at a distance of 62.5 cm from the right end web (on web n-1) and select the adjustment option Axis of right end web, the distance to the right end web is maintained even if you move the left end web (via the x-coordinate) to the left, i. e. change the wall length.

Design

This section allows you to adjust various settings for the verifications.



Capacity transverse Pressure

The user can influence the *kc90* value of transverse compression on the upper and lower web in accordance with the actual conditions.

Depending on the material and the selected options, HTW+ determines automatically the appropriate *kc90* coefficient. The fibre suspension effect is considered too, by increasing the effective contact areas *Aef*.

If the vertical webs are close to each other (overlapping contact areas *Aef*), the posts are assumed as a SINGLE web for the selection of the *kc90* value. The contact area *Aef* is reduced in the calculation of the compression is such a manner that overlapping does not occur. The verifications of the transversal compression of the concerned webs are performed individually for each web with these values.

Support under concentrated load, kc90=1

This option is appropriate if the vertical webs stand upright on the base web and a joist perpendicular to the wall is underneath. These conditions can analogously be applied to the head web.

The option is "on the safe side".

Base frame compression, continuously supported, kc90 >=1

If the base frame rests on an unyielding solid component, the conditions for a calculation as base frame compression are satisfied. These conditions apply only in exceptional cases to the head web.

Support under uniformly distributed linear load, kc90=1

This option should only be used in justified exceptional cases.

Load-bearing capacity of the panelling

In the verification of the panelling of walls with identical panelling on both sides, the resistances of the individual panellings are added up. With different panellings on either side, the reductions must be taken into account. Distinctions such as "different" and "similar" are made in this context.

The "Similarity" of the panellings on either side can be detected by calculating the deformations based on the stiffness. If the stiffness of the "softer side" is greater than 99 %, both panellings are assumed "identical". If the percentage is between 75 % and 99 %, the panellings are considered as "similar" and below 75 % as "different".

The required reduction factor is determined in accordance with the classification in "identical", "similar" and "different".

Shear field theory	Reduction according to shear field theory, taking into account stiffness and achievable resistance sv,0,Rd. This method ensures that the load-bearing

	capacities used in the verification can actually be activated. This recommended method gives more accurate and realistic results.
Design codes:	Reduction with the factors of the standard. If the load-bearing capacity and/or stiffness varies greatly, the load-bearing capacity of the wall panel can be overestimated! Identical: 1.00; similar: 0.75; different: 0.5
Stiffness:	Min (portion of total stiffness / 0.5 ; 1.0)
stiffness / min code:	The more favourable value of both models
Capacity fasteners *1.2	Optional faktor 1.2 according to EN 1995-1-1:2004/A1:2008 § 9.2.4.2(5) + NA

Special Options

With wind: According to EN 1995, $k_{mod,short}$ is used for wind. According to a few NAs, the mean value from short and very short can be used: kmod = kmod ($k_{mod,short}$ + $k_{mod,very\ short}$)/2
Check the option to calculate with the mean value according to NA.

G share. Here it is defined how the proportion of permanent loads for stability is determined in each combination (no G-part / permanent loads / permanent and quasi-permanent loads).

Combination

In wind zones 3 and 4, snow does not have to be considered as an accompanying action if wind is the leading action.

In some countries, Psi2 for snow in Earthquake combinations must be set to 0.5.

Seismic

Ductility class	Only effective for earthquakes. Design rules for classification into a ductility class according to EN 1998 must be observed. The setting must be coordinated with the behavior coefficient of the seismic load determination.

Deformation limits

In accordance with Eurocode 5, tab. 7.2, two deformations limits should be observed:

Wx,inst: Elastic portion of the deformation for the serviceability verification.

Wx(net),fin: Elastic portion including creep for the serviceability verification.

You can define the limits individually.

The deformation in the design combination might additionally be limited by the relevant National Annex (e. g. NA for Germany).

Wx(net),fin (STR): Elastic portion including creep for the serviceability verification.

Note: The verifications of the deformation refer to the storey height.

Ill.:

ux1: displacement by deformation of the horizontal anchors

ux2: displacement by deformation of the vertical anchors

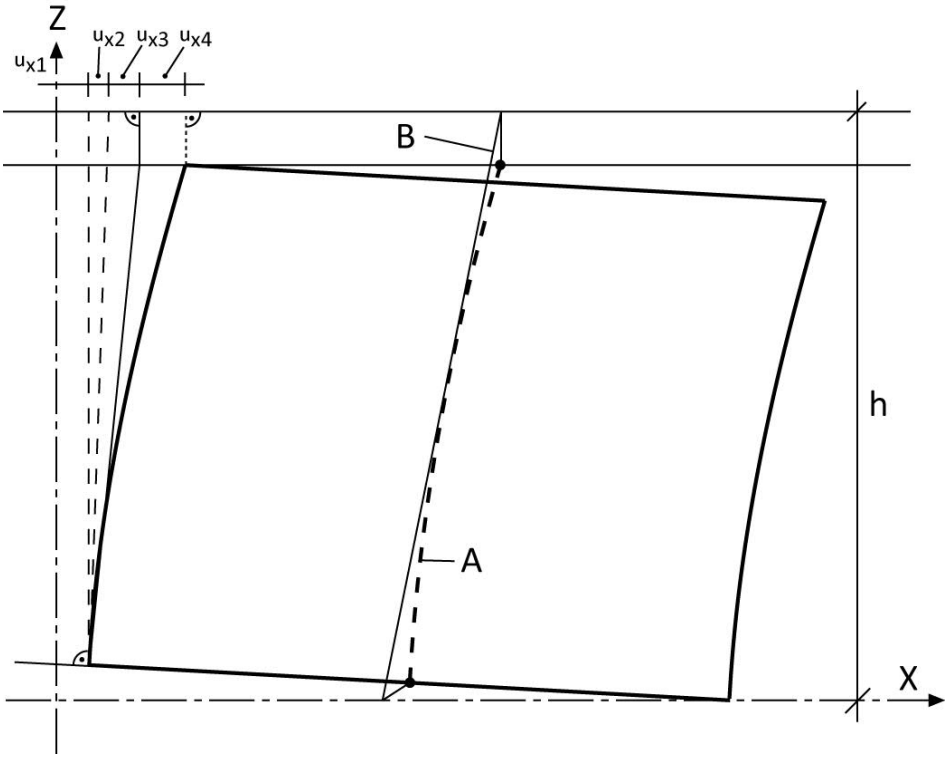
ux3: displacement by shear and fastener deformation of the panelling

ux4: displacement by bending deformation of the wall

A : deformation line

B: verification line

h: storey height = verification height



Anchoring

For anchoring the end ribs, the program supports the design of two-part Würth panel anchors according to approval ETA-14/0274 of 2020/11/30 - Würth Hold Downs.

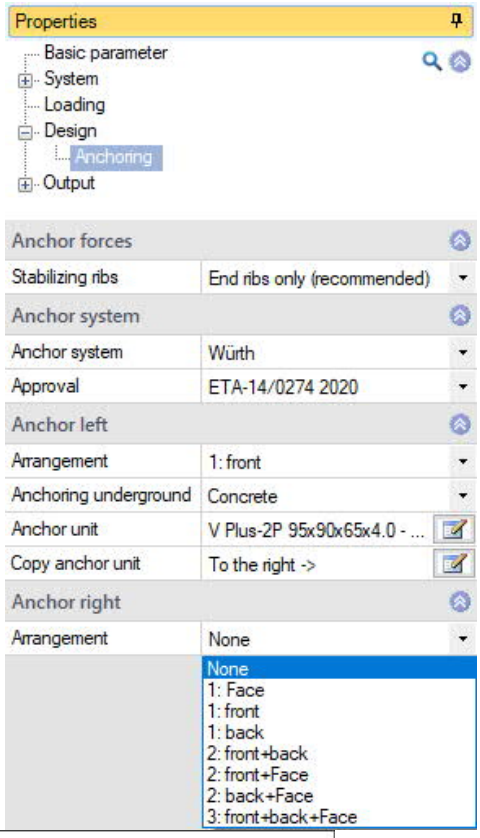
After selecting the Würth anchor system, all combinations of anchors, flanges and fasteners can be selected. The selection is limited to the allowable choices.

The design results are displayed immediately after each change.

Please ensure that the system is calculated as the anchoring force of the end rib needs to be known. Otherwise only the anchor capacity is shown.

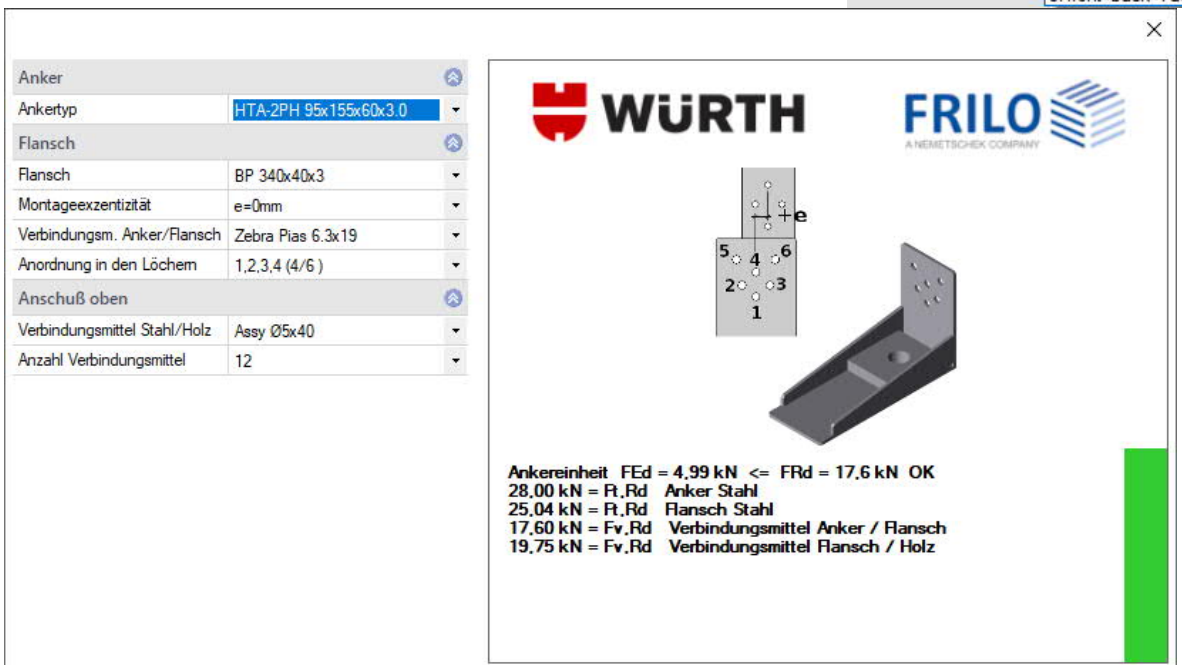
The characteristic load-carrying capacities (Rk) of the anchors are determined after approval. Depending on the verification, the design load-bearing capacities result from the consideration of $\gamma_{M,steel}$ or $\gamma_{M,timber}$ and k_{mod}.

Anchoring elements in the subsoil are not measured. However, you get the tensile forces to be absorbed in the output.



Anchor unit:

Use the edit button to open the Würth selection dialog

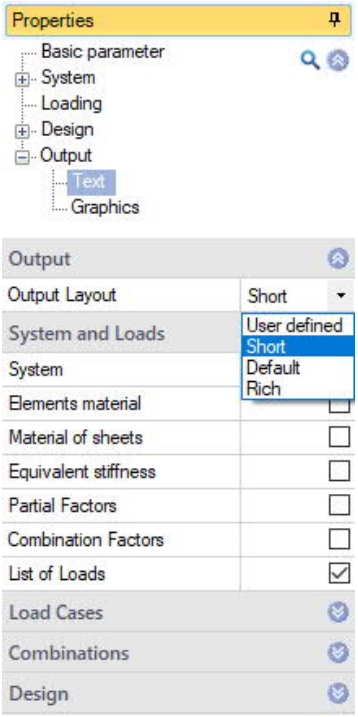


You can either define the right anchor separately or simply adopt the already defined left anchor (copy anchor unit).

Output

The scope of the output for text and graphics can be defined via the output profile by checking the output options.

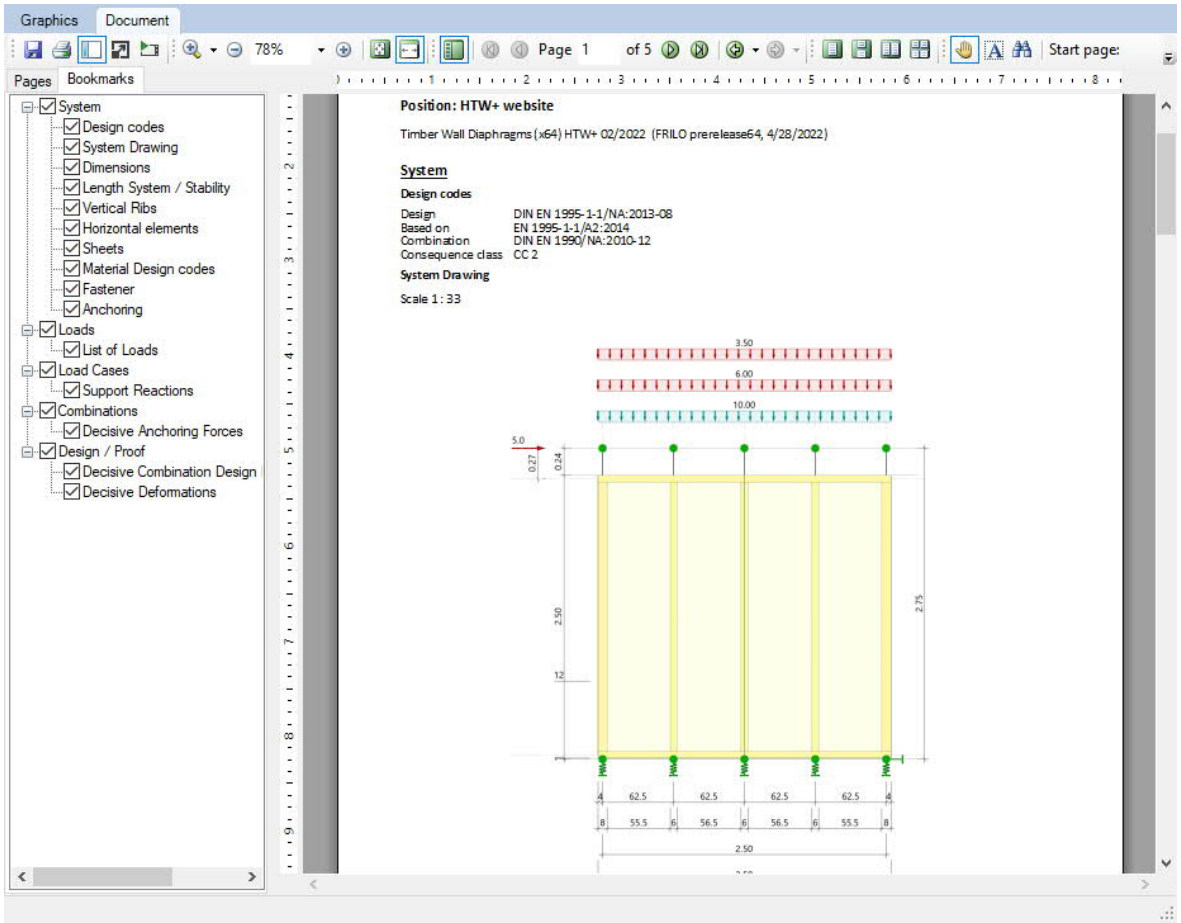
Selecting a profile (Short...) activates a predefined set of options. You can immediately add and/or deselect further options. If the selected options do not correspond to a predefined profile, "User-defined" appears for the output profile. The selected options are saved with the position. The output profile itself can be saved/loaded/managed via "Output and layouts" in the top menu bar.



Output as PDF

The Document tab displays the document in PDF format.

See also Output and Printing.



Calculation and results

The following specialities should be noted in connection with the fasteners:

The data entered for the fasteners are checked for plausibility. This check does not restrict or exclude the use of any types of fasteners, because Frilo cannot know all available types. The bearing capacities put out, are always calculated with the equations specified in the selected design standard.

Minimum spacing of 0 mm might result, if a too high timber density was specified in combination with nails that are fixed without pre-drilling. Another reason for this might be that the software failed in calculating the minimum spacing.

If it was possible to calculate a bearing capacity, it will be put out even if the minimum spacing and distances are not adhered to!

Document

The Document tab displays the document in PDF format.

The manipulation options of this tab correspond to those of common PDF readers such as Adobe Acrobat Reader©.

You can define the output scope in the Text/graphic output menu.

A summary of the results is always given on the last pages.

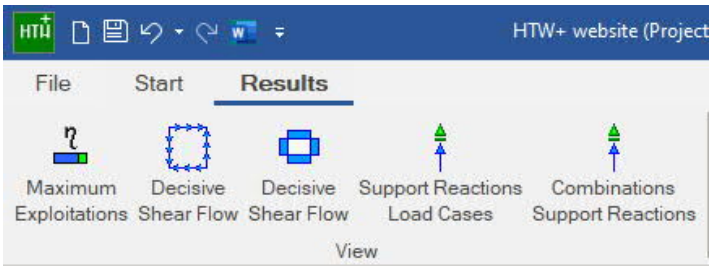
Note: The rotation and zooming of result graphs has no influence on the output of the corresponding graph.

Special notification marks

In the document, decisive and/or maximum utilizations are marked with an asterisk (*), exceeded limits with exclamation marks (!!). Table columns with the title error contain notes concerning non-permissible values such as too low cross-sectional dimensions.

Results and result graph

▸ Accessible via the Results tab in the toolbar.



For the graphical representation of the results, the user must switch from the Document tab over to the Graphic tab.

Maximum utilizations: The maximum utilizations of all verifications are shown.

Decisive shear flow: The decisive shear flow in the front and rear panelling is shown and the decisive value is displayed.

Support reaction load cases: The support reactions of all load cases are displayed with their 1.0-fold value.

Support reaction combinations: The smallest and greatest support reactions of all combinations are displayed. The values are determined against three comparison conditions:

Fd ; Fd · γ_M ; extremal value · γ_M / k_{mod}

Successful verifications button

By activating this button, meaningful notes to the verifications are displayed - see toolbar.