Timber Joints HO3+ / HO13+ / HO14+

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.

Differences of HO3+ / HO13+ / HO14+

HO3+ / HO13+

HO3+ and HO13+ are suitable for the calculation of tensile splices in timber construction. The available fasteners are dowel pins, fit bolts/bolt, nails and special dowels. The tensile splice can be applied to multipart cross sections with butt straps of solid timber or steel.

HO13+

In addition to tensile splices, the HO13+ application is also suitable for the calculation of typical truss nodes in timber construction:

In such a joint, up to five outgoing members are connected in one centre point. If the members are all single-part, they are connected by means of steel plates that are either mounted to the surface or driven into slots to establish a steel-to-timber connection. Alternatively, a multi-part diagonal strut or multi-part chord can be connected in a timber-to-timber connection. The currently available fasteners are dowel pins/fit bolts/bolts as well as nails. For timber-to-timber connections and steel-to-timber connections with exterior metal plates, special dowels are additionally available. In timber-to-timber connections, combined arrangements of dowel pins and fit bolts are definable.

HO14+

The HO14+ application allows the calculation of the load -bearing capacity of a single fastener, typical in timber construction, while taking the given angle between the applying force and the grain into account.

Available standards

- DIN EN 1995:2010 / 2013
- ÖNORM EN 1995:2010 / 2015 / 2019
- BS EN 1995:2012
- NTC EN 1995:2008 / 2018
- PN EN 1995:2010

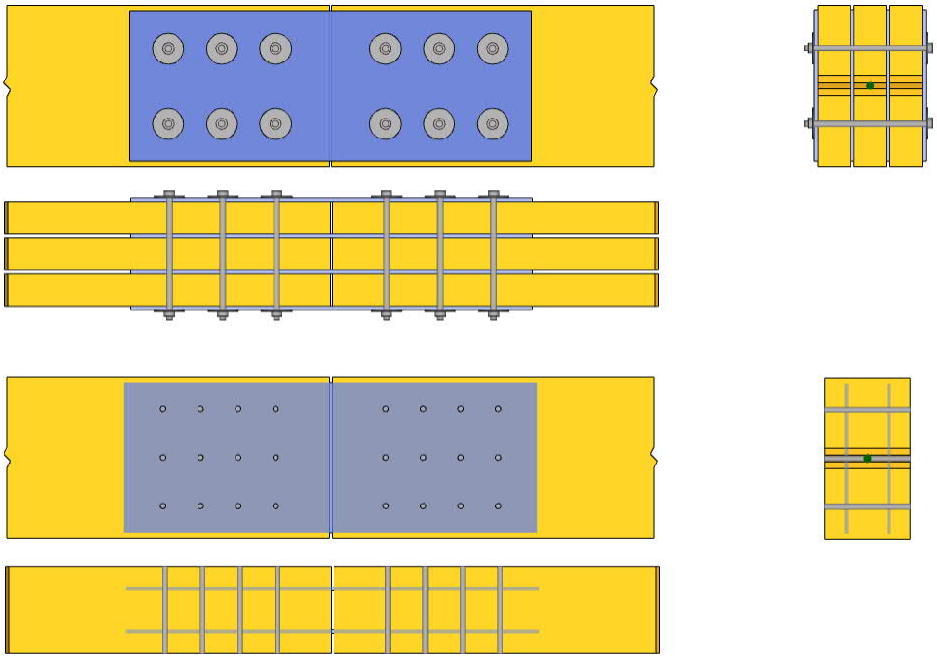
Additionally selectable: DIN 1052

HO3+: Tension Joint

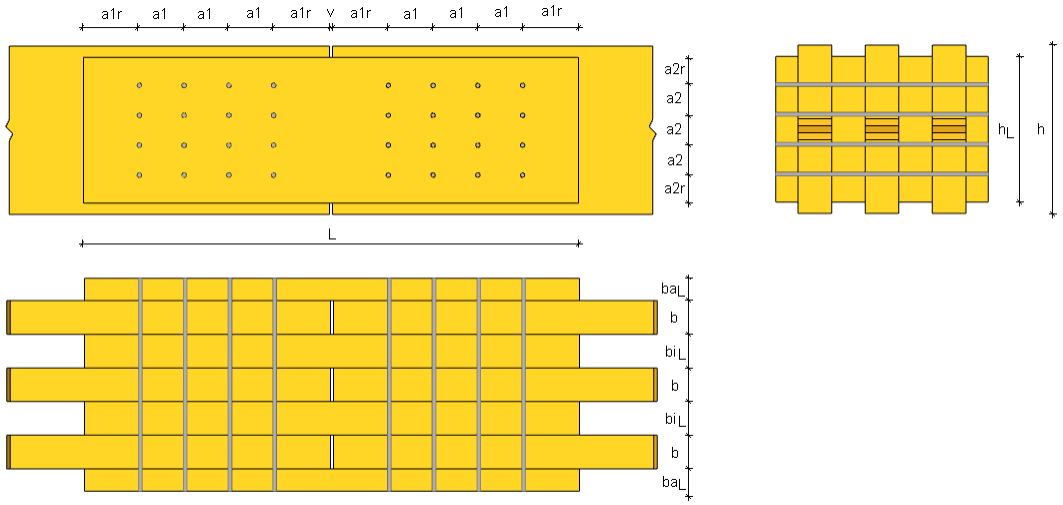
Application options

HO3+ allow the calculation of tensile splices in timber construction - also with HO13+ as a variant without posts / diagonals. The available fasteners are dowel pins, fit bolts/bolts, threaded rod, nails and special dowels. The tensile splice can be applied to multipart cross sections with butt straps of solid timber or steel.

The load-bearing capacity verifications of the fasteners are performed in accordance with Johansen's theory. Suspension effects can be taken into account, if applicable. On the basis of the load-bearing capacity, the software calculates the required number of fasteners, checks the minimum spacing to be complied with and performs the necessary verifications on the connected components in the area of the connection.



The loads are assumed applying symmetrically to the member axis. The loading should mainly apply in the central area of the member parts. A timber member can consist of three parts maximum.



The weakening of the cross section caused by the fasteners is taken into account in the verification of the connection area. The additional moment from distortion of the outer butt straps is considered in a simplified manner via a stress verification with reduced tensile strength.

Input HO3+

Wizard

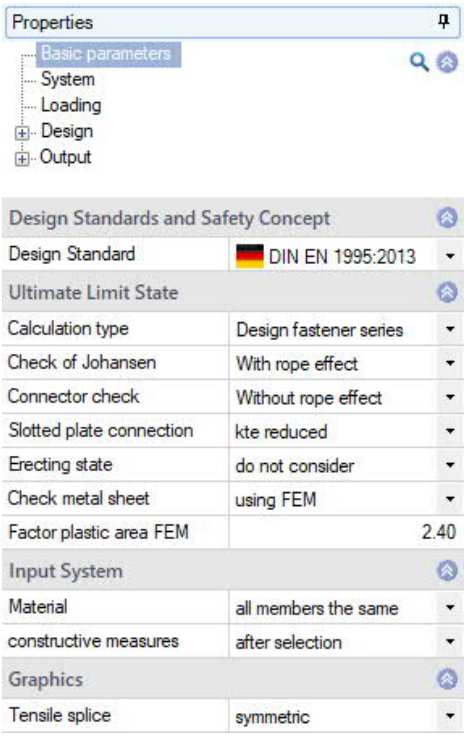
When the program starts, the Wizard window appears automatically, in which the "most important" entries for a new item can be made.

With the wizard you enter a system - quickly - and get a first impression of the results. You can then adjust the “secondary parameters” in a second step.

Note: You can disable the wizard in the settings menu.

Basic parameters

Selection of the desired design standard.



Ill.: HO3+

Ultimate limit state

Calculation type

Analysis

This type of calculation requires the exact input of rows and columns of the fasteners; exactly this one situation is calculated.

Dimensioning fasteners series

The calculation type "dimensioning fastener series" requires only the input of the number of rows of fasteners. The required number of fasteners per row is determined by the program.

Check of Johansen

This option allows you to include the rope effect of pullout-resistant fasteners in order to increase the load-bearing capacity in the verification in accordance with Johansen.

Connector check

Check of Johansen with / without rope effect for bolts for special types of dowels.

Slotted plate connection

For slot plate connections, the additional moment for eccentric load introduction in the outer part of the cross section is taken into account with a factor kte of 0.4 or 2/3. The user can disable this reduction for the modelling process and set kte to 1.0.

Erecting state

The user can specify whether all minimum distances of the fasteners to the butt ends of members should be assumed under tension independently of the actually defined internal force for a particular available erecting state.

Check metal sheet

The cross-sectional load-bearing capacity of the metal sheet in a steel-wood connection is determined by means of FEM as standard. Alternatively, a simplified normal force check can be used, which is only carried out in the area of the joint centre patterns.

Factor plastic area FEM

This factor determines the plastic area around the joint centre holes for the metal sheet verification by means of FEM. Membrane stresses from this area are not used for the elastic stress verification.

It is to be entered as a factor to the hole diameter in the range 1.0 ... 3.0. (Standard 2.4)

Input System

Material / cross sections / fasteners

The user can define the material for each member individually or select "all members the same".

Note: with HO13+, this optional specification is also possible for cross-sections and connecting means.

Constructive measures

Here you select whether a selection of constructive measures, such as transverse tension reinforcement, should be visible, i.e. displayed in the left menu tree, or not. By default, the selection is displayed.

System

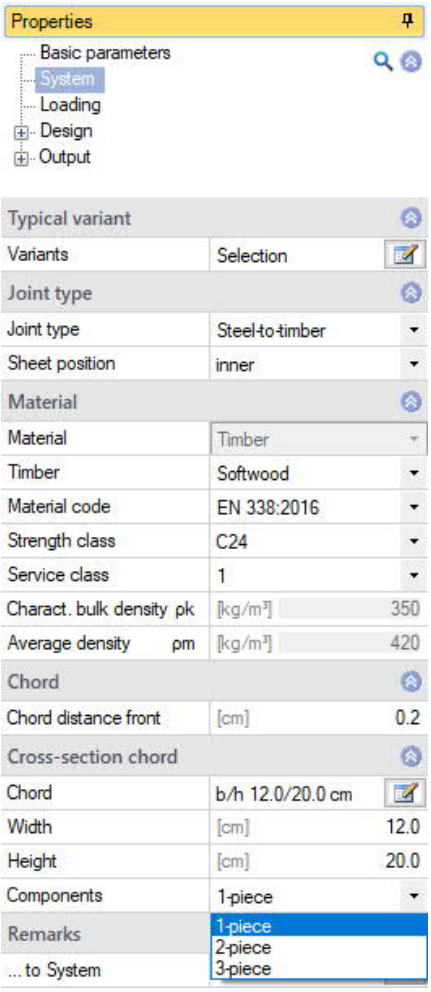
Variants

Selection of the node variant for

- timber – timber or

- steel – timber connection

click the  button for a graphical selection-window with schematic joint representations.



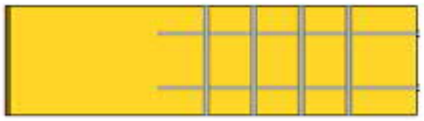
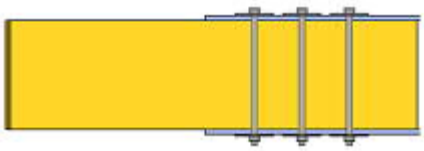
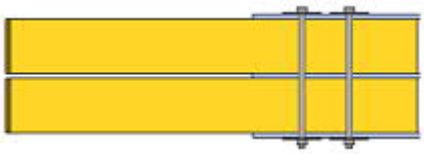
Joint type

For steel-timber connections, you can define the sheet position inner / outer metal sheet.

Material / Timber

Selection of the timber species (softwood, hardwood, glulam), strength- and service class (ambient climate).

Note: Depending on the setting of the basic parameters (same material for all members or individually for each member) the material parameters are set in the system section or during the definition of the individual component.

HO3+ / HO13+ Interior	Slot plates Single-part chord	
HO3+ / HO13+ Exterior	plates fitted to the outside Single-part chord	
Only HO3+: Interior + exterior	Interior and exterior plates Multipart chord	

Chord – cross-section

Allows the definition of the cross section of the chord. In connections with only interior or only exterior plates, the chord is always assumed single-part. In connections with both, interior and exterior plates, the chord must have two or three parts. In timber-to-timber connections, the chord can optionally be single-, two- or three-part

For multi-part chords, the user is prompted to specify the clearance *a* between the different cross-section parts. This clearance specification determines the width of the connected butt straps.

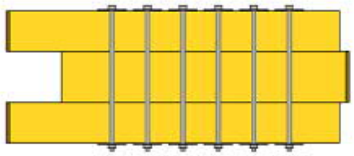
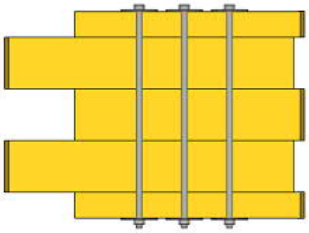
For symmetric representations of tensile splices, the clearance *v* between the butt ends of the joined chords can be specified. This specification has an effect on the total length of the butt straps.

Butt strap – cross-section

This option allows you to define the butt straps of a timber-to-timber connection. The width of the butt straps for multi-part chords is determined by the specification of the cross-section spacing in the chord, if any specification was made. The width is editable. Changing the value causes the automatic adjustment of the chord spacing. For multi-part chords, the location of the straps must be defined in detail.

Exterior butt straps can have another width than the interior ones.

Location (with multipart chords):

Interior	Butt straps are only fitted inside	
Interior + exterior	Butt straps are fitted inside and outside.	

Remarks

Optional input of comments about the system, which also appear in the output.

See also Remarks Editor.

Loads, actions

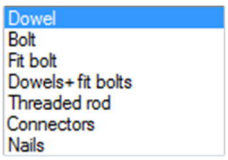
You can call up the table "Load case combinations" via the tab below the graphic.

Description	Enter your own description for the load combination.
Design situation	Selection of the design situation. P/T= permanent/transient, A= exceptional, AE = earthquake.
Ductility class	For design situation AE: L, M or H (DCL, DCM, DCH).
Load duration class	LDC. Relevant class of the load duration. Usually this is the shortest load duration of the effects involved in this design load case.
Nd	Design value of the axial force in the member, positive as tension force in grain direction away from the node.
Active	The load combinations can be switched to inactive if required.

Design / fasteners

Fasteners - selection

Allows the definition of the type of fastener. Available for selection are dowel pins, bolts, fit bolts, dowel pins combined with fit bolts, threaded rods, special dowels or nails.



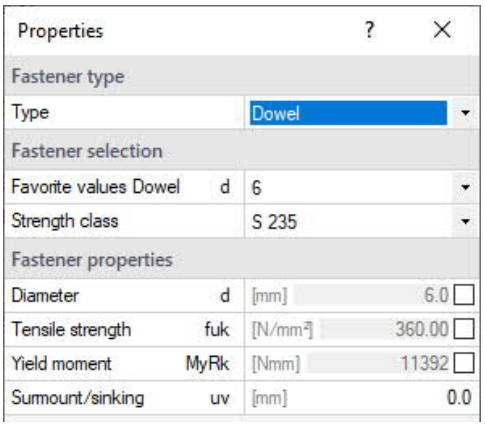
Depending on the selected topology, particular types of fastener may not be available. The combined arrangement of dowel pins and fit bolts is only available for timber-to-timber connections. Special dowels cannot be used to fasten slot plates.

Depending on the selected fastener, further specifications are required for the definition of the fastener geometry.

The selection of fasteners from preference values is activated by default. A list of default values is available. The dependent geometric values are displayed. They can be changed after marking the corresponding option - also the user-defined input of all values is possible.

Diameters are freely selectable in the range of 6 to 30 mm.

Dowel pins and fit bolts are fitted accurately to dimension, bolts are fitted with a gap of 1 mm.



Dowel pins

Preferred values	d	List of standard diameters (DIN 1052)
Strength class		List of steel grades or user defined
Dowel pin diameter	d	Selected diameter
Projecting/countersunk	uv	*Positive*, if projecting over the chord surface, *negative*, if countersunk

Bolts/fit bolts

Preferred values	M	List of standard values (DIN 7990)
Strength class		List of strength classes
Bolt diameter	d	Selected diameter
Washer		Standard selection for washers
Washer diameter	ds	Selected outer washer diameter
Inner washer diameter	dsi	Selected inner washer diameter
Projecting/countersunk	uv	Countersunk bolt *negative*

Special dowels

Toothing/spiking		Single-sided: two plate dowels are fitted back to back, type B1, C2, C4, C11 Two-sided: two-side spiked or toothed plate dowels A1, C1, C3, C5, C10 The selected option has an effect on the further definition of the dowel geometry and depends on the node topology.
Dowel type:		A1 joint ring C1 - C5 plate dowel C1 - C5 toothed plate C 10/11 spiked plate
Value	dc a1	dc diameterof A1, B1, C1, C2, C10, C11 a1 edge length of C3, C4, C5
Bolt geometry		All geometry values for bolts, see above.

In combination with dowels of a special design of a timber-timber connection, additional clamping means can be arranged which prevent the outer components from lifting off and thus enable a more favourable calculation of the load-bearing capacity in the connection area. The selected clamping means are adopted and verified with the existing pull-out force.

For dowels with diameter 130 mm and larger, an arrangement of additional clamping bolts should be made.

Nails

Arrangement		in parallel rows or offset on both sides
Arrangement along the back mark line		Along the back mark line without offset or Along the back mark line, offset by 1*d (might increase n_{eff})
Shaft		round and smooth or square and smooth
Hole		Predrilled or not pre-drilled (the length of the opposite nail is possibly restricted)
Preferred values		List of standard geometries
Nail diameter	d	Selected diameter
Head diameter	dk	Selected head diameter
Length	l	Selected nail length

Design of butt strap or chord

Calculation results and definition of the fastener distribution for the butt strap in a timber-to-timber connection or the chord in a steel-to-timber connection.

Constructive measures

Transverse tensile reinforcement: optional design with a transverse tensile reinforcement in the connection area, which is to be dimensioned for 30% of the transmission force per fastener and shear joint. This has a favourable effect on the calculable *n.eff* of the fastener row. See On/Off option under basic parameters.

Number of fasteners

Required [Johansen]:	specifies the number of required fasteners obtained from the bearing capacity of an individual set of fasteners (for one joint) independently of the arrangement.
n eff. [Total]:	specifies the number of required fasteners in relation to the effectiveness in the arrangement (n eff.), which is decisive for the design.
Existing:	number of existing fastener sets in the considered connection area.

Rows

max.:	maximum number of fastener rows in grain direction, that can be arranged on the component in parallel rows (perpendicular to the grain).
selected:	selected number of fastener rows in grain direction
Number per row:	number of fasteners in one row in grain direction. Depending on the basic parameter settings, the user can specify a user defined number (in the verification) or it is set automatically by the software (rows + design).

Distances

Output of the minimum fastener spacing and definition of:

a4	distance of the fastener rows to the edge perpendicular to the grain
a2	distance of the fastener rows from each other perpendicular to the grain
a3	distance of the fasteners to the face side in grain direction
a1	distance of the fasteners to each other in grain direction

Tip: If you enter "0" in a3 or a1, the software determines a value.

The distances are shown in the chapter Application options.

Design / metal plate

(Only available with steel-to-timber connections)

Location

The definition of the plate location corresponds exactly to the definition given in the chapter "System" , paragraph Nodes.

Thickness

Definition of the plate thickness

Number

Only in combination with slot plates: up to four slot plates can be set. Due to the equal distribution of the forces on the left and the right of the plate, the distances between the plates should be selected in such manner that the distance to the outer edge amounts to 35 to 50 % of the inner plate spacing.

Internal hole clearance

Allows the specification of the internal hole clearance *dl* on the plate.

Hole type

Drilled and punched holes are available for selection.

Material

Allows the specification of the steel grade for the plate.

Edge distance allowance

Allows to define the distance of the plate edge to the component edge. "0" means that the plate is inserted flush to the component surface. A value greater than "0" means that the plate is recessed in relation to the surface.

Distance of fastener from edge e1

Allows the definition of a minimum distance between the plate edge and the outer fastener *e1*. The value refers to the member axis and applies to all connection areas.

HO13+: Timber Joint

Application options

HO13+ is suitable for the calculation of typical truss nodes in timber construction. Tensile splices can be calculated too.

In such a joint, up to five outgoing bars are connected in a centre point. If the bars are all single-part, they are connected by means of steel plates that are either mounted to the surface or driven into slots to establish a steel-to-timber connection. Alternatively, a multi-part diagonal strut or multi-part chord can be connected in a timber-to-timber connection.

The currently available fasteners are dowel pins/fit bolts/bolts as well as nails. For timber-to-timber connections and steel-to-timber connections with surface-mounted plates, special dowels are additionally available.

In timber-to-timber connections, combined arrangements of dowel pins and fit bolts are definable.

The load-bearing capacity verifications of the fasteners are performed in accordance with Johansen's theory (verification method in accordance with Annex G of DIN 1052: 2004/2008). Suspension effects can be taken into account, if applicable.

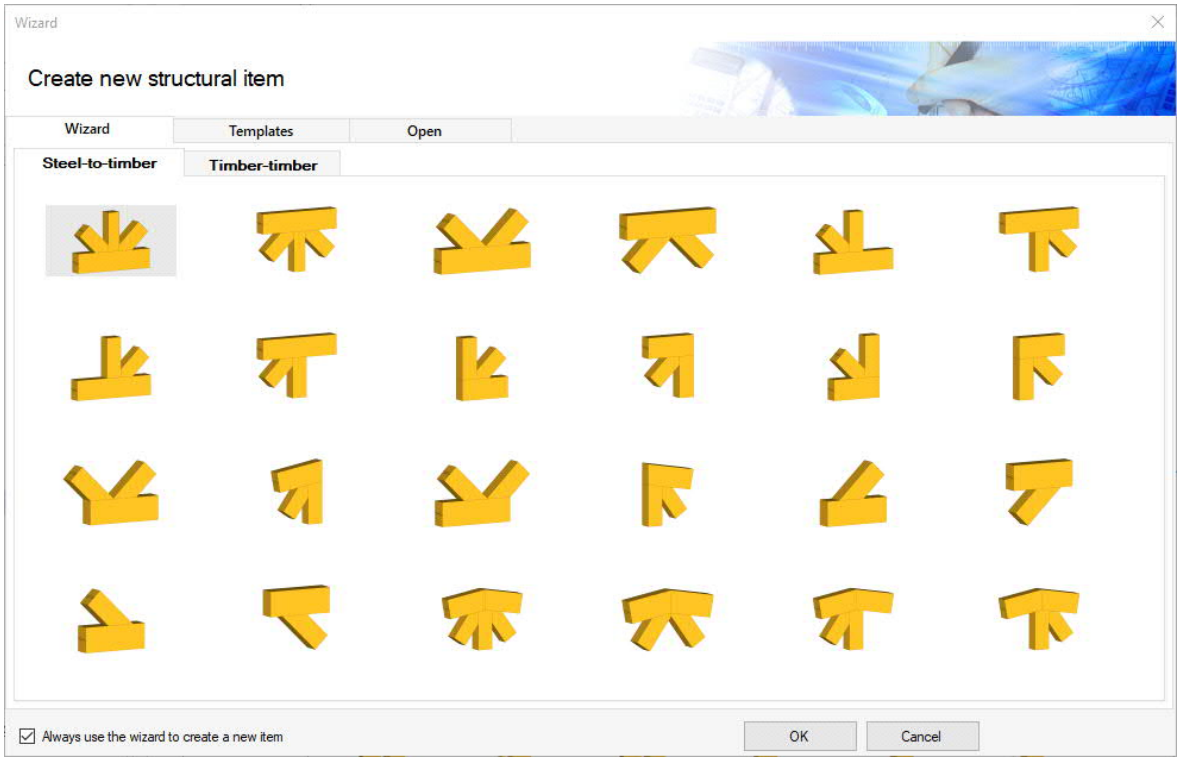
On the basis of the load-bearing capacity, the software calculates the required number of fasteners, checks the minimum spacing to be complied with and performs the necessary verifications on the connected components in the area of the joint.

Interface Trusses Timber: A node from FWH + can be transferred to HO13+ for the design.

Node topology

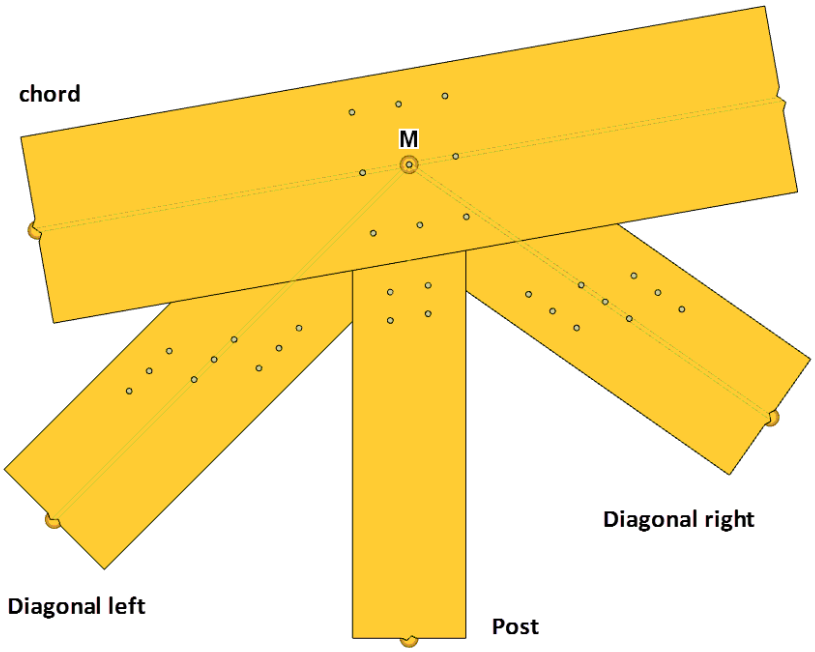
Definition of tensile splice: Select a chord with pinned support in the menu ▸ System ▸ Nodes and deselect the options "with posts" and "with diagonal...".
See also chapter HO3+: Tensile splice

Definition of truss node: ▸ System ▸ “Variants“ displays a window with schematic representations of node variants.



In principle, the definition of the nodes is based on the chord as the reference member. The node reference point M is located on the system axis of this chord. The system axes of all connected members intersect in M.

In the standard position, the chord is initially in the horizontal position, but can also have an inclination in relation to this.



Posts are always connected in the global vertical axis independently of the chord inclination.

The location of the struts to the left and right is determined by a given angle β referenced to the chord.

Struts and posts must be connected together on top or underneath the chord.

In the articulated version, the chord can have an inclination to the horizontal on the left and right in the sense of a ridge joint if it is located above posts or diagonals.

Input HO13+

Basic parameters

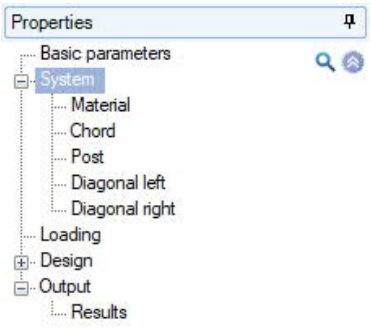
For the setting of the basic parameters for HO13+ see the chapter Input HO3+.

Detail graph

Displays a two-dimensional graph of the node and its members. The individual connected members are either shown in their actual position in the node or in a standardized position, i. e. the grain flows always in direction of the x-axis and the connected end of the represented member is on the left.

System

Variants



Selection of the node variant for

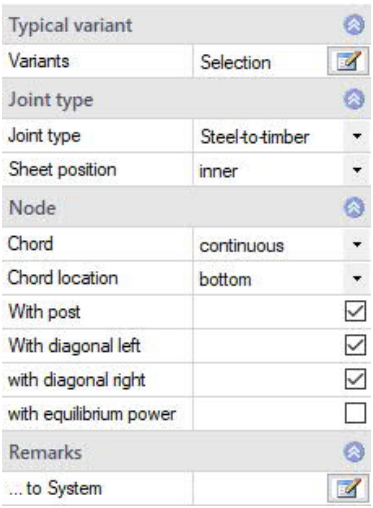
- timber – timber or

- steel – timber connection

click the button for a graphical selection-window with schematic joint representations.

The corresponding values are displayed in the input fields and the user can edit these values to adjust the standard model to the desired joint.

See also Node Topology.



Joint type

For steel-timber connections, you can define the sheet position inner / outer metal sheet.

Node

Chord:

The chord is usually continuous but can also have a pinned joint or end nodes to the left or right.

See the following illustrations/explanations.

Chord position:

The position of the chord at the bottom / top serves to determine the node geometry.

With post:

Optionally, a post may be connected to the truss node (always vertical in the system).

See the following illustrations/explanations.

With diagonal strut:

Diagonals on the left and right are possible. *See the following illustrations/explanations*.

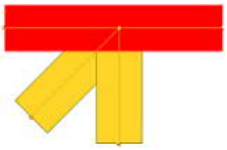
Equilibrium force:

When defining an equilibrium force , the user can enter horizontal and vertical internal force components (tab internal forces) in the centre, which map the total equilibrium in the node correctly. This may require additional verifications that are not kept by the programme. *See the following illustrations/explanations*.

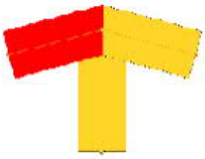
Depending on the selected node variant, the connection can be modelled by the following input fields:

Chord: definition of the type of chord.

- Continuous



- Pinned joint

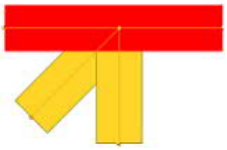


- Right-angle left

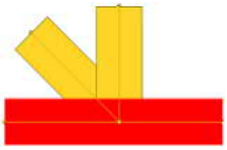
- Right-angle right

Chord position: Definition of the chord position in relation to the connected members.

- On top



- On bottom

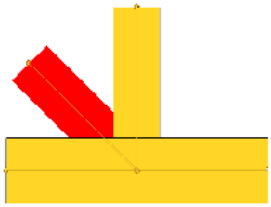


With post

Allows you to specify whether a post is connected to the chord. The post is always vertical in relation to the global system of coordinates. In a steel-to-timber joint, the post is connected with a metal plate; in a timber-to-timber joint, it is connected as a compression member via the contact surface. With the latter connection, additional measures are required to ensure position stability.

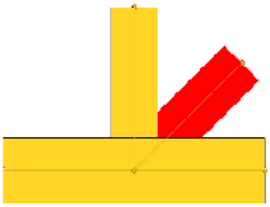
With diagonal strut on the left

Allows you to add a strut on the left node side. In a steel-to-timber joint, struts are combinable with all other members. In a timber-to-timber joint, only a single strut can be connected either on the left or right due to the condition of a point-centred node. Struts can also be used as posts in timber-to-timber joints if the connection of a multi-part member should be mapped.



With diagonal strut on the right

Allows you to add a strut on the right node side. (See also "With strut on the left").



Supported node

The option allows the mapping of models with nodes connected to a support or reinforced with constructive measures, for instance. When defining a supported node, the user can enter horizontal and vertical internal force components in the centre, which map the total equilibrium in the node correctly. This type of node requires additional verifications that are not available in this software application.

In the verifications of the contact joint of a compression post (timber-to-timber joint), the optional distinction between pressure on a single support and on a continuous support is available for supported nodes.

Material - Timber

Selection of the timber species (softwood, hardwood, glulam), strength- and service class (ambient climate).

Note: Depending on the setting of the basic parameters (same material for all members or individually for each member) the material parameters are set in the system section or during the definition of the individual component.

Material		
Material	Timber	
Timber	Softwood	
Material code	EN 338:2016	
Strength class	C24	
Service class	1	
Charact. density ρk	[kg/m³]	350
Average density ρm	[kg/m³]	420

Chord

Defines the cross section of a chord, either continuous or ending on the left or right of the node.

In connections with slot or exterior plates, the chord is always assumed single-part.

In timber-to-timber connections, the chord can optionally be single-, two- or three-part.

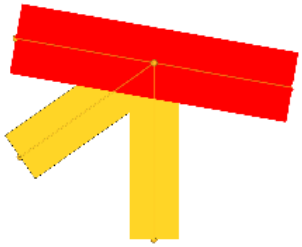
For multi-part chords, the user is prompted to specify the clearance *a* between the different cross-section parts. This clearance specification determines the width of the connected struts.

The inclination of the chord is referenced to the horizontal axis and defined positive if anti-clockwise. An inclination with an angle of 60° to -60° is allowed. The face of chords ending on the left or the right of the node intersects the vertical axis. With inclined chords, this produces a section that is not right-angled. Therefore, the chord inclination can be used for the indirect modelling of the member section.

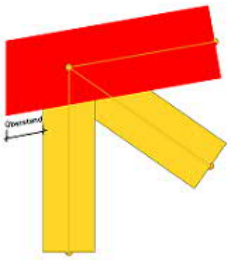
Chord		
Inclination	[°]	0.0
Material		
Material	Timber	
Material code	EN 338:2016	
Strength class	C24	
Cross-section		
Cross-section	b/h 12.0/20.0 cm	
Width	[cm]	12.0
Height	[cm]	20.0
Components	1-piece	
	1-piece 2-piece 3-piece	

Too small face distances in end chords can impede the appropriate arrangement of fasteners in the connection area. In these cases, a projection of the chord should be considered. The projection is defined with the help of the intersecting point with the member axis of the connected outer member.

Chord inclination (negative)

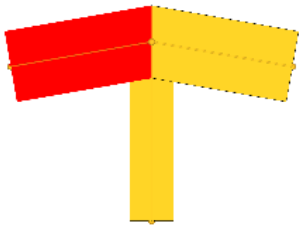


Chord inclination (positive) with vertical section on the face side of the projecting chord



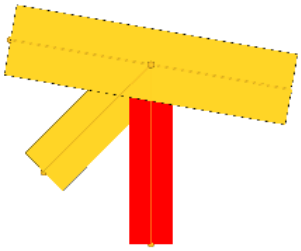
Chord left / right

This option allows you to define the single-part cross section of the chord in pinned steel-to-timber joints. Bottom chords are always horizontal (chord inclination = 0). Top chords can have an inclination. Inclinations that are positive on the left and negative on the right produce a downward inclination on both sides.



Post

Allows you to define the cross section of the post, which is always single-part. The post has always a vertical position independently of the chord inclination. In timber-to-timber joints, the post is always connected to a single-part chord as compression member via a contact joint. Constructive safeguarding measures are required in this case.



Diagonal Strut left / right

Defines the cross section of a strut. In a timber-to-timber joint with single-part chord, the struts are designed as collar ties. The distance between the outer cross-section parts is determined by the width of the chord. In combination with multi-part chords, the struts are in-between the chord parts and their width corresponds to the spacing of the latters.

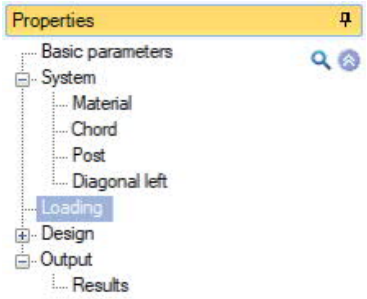
Diagonal left		
Inclination	[°]	-45.0
Material		
Material	Timber	
Material code	EN 338:2016	
Strength class	C24	
Cross-section		
Cross-section	b/h 12.0/14.0 cm	
Width	[cm]	12.0
Height	[cm]	14.0

Note: *Member inclinations should be defined positive and anti-clockwise. The angle between two adjacent members must have 15° minimum. Otherwise, the software adjusts the value automatically.*

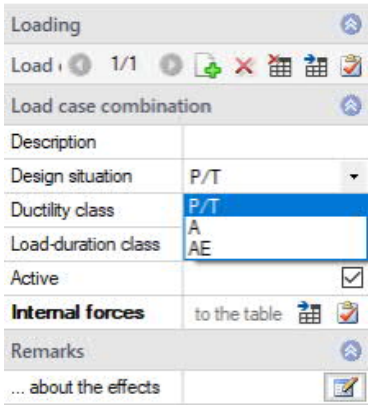
Loads, actions

The loading should mainly apply in the central area of the member parts.

	Place	Nd [kN]	Vzd [kN]	Myd [kNm]
1	Chord left, load-bearing	5.0	0.0	0.00
2	Chord right, load-bearing	0.0	0.0	0.00
3	Post	0.0	---	---

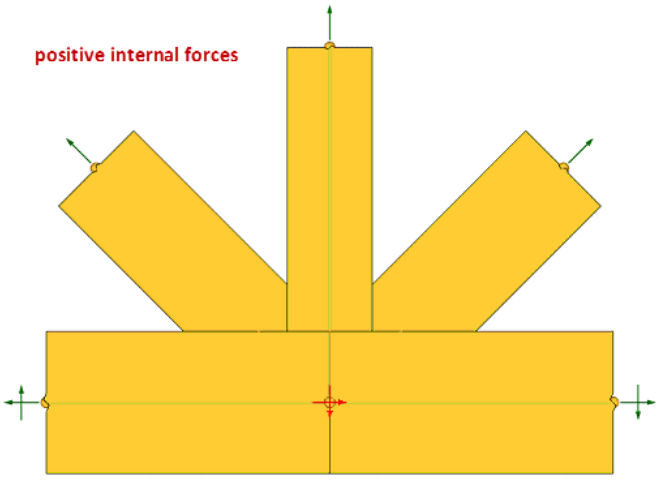


For the input of “Load case combinations” and “Internal forces” click the tabs below the graphic.



Description	Enter your own description for the load combination.
Design situation	Selection of the design situation. P/T= permanent/transient, A= exceptional, AE = earthquake.
Ductility class	For design situation AE: L, M or H (DCL, DCM, DCH).
Load duration class	LDC. This option allows you to define the load duration class (permanent, middle, short ...).
Active	The load combinations can be switched to inactive if required.

Nd	Axial force, positive as tensile force acting in direction of the grain outgoing from the node, used as design value. Should be entered with its γ_F-fold value.
Vzd	Design value of the shear force, positive if acting upwards on the left face and downwards on the right face. This value allows the user to take transversal loads on the chord into account, which produce an angle between the resultant and the grain direction in the joint.
Myd	Design value of the moment for cross-section design of a continuous chord, e.g. in the case of a collar beam connection to a rafter.



Note: The equilibrium of the forces applying to the node must be balanced!
Otherwise, the software does not put out any results. The sum of the horizontal and vertical forces is displayed for review.

Support Nd and Vzd

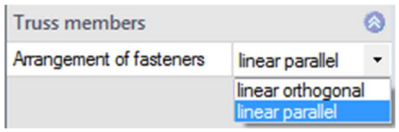
The user should only make a specification if a supported node was defined. The values are used to model the topologies of additionally supported nodes.

The design values *Nd* for a horizontal supporting force and *Vzd* for a vertical force apply in the centre point of the node. The horizontal force is positive if it applies from the left to the right. The vertical force is positive if it applies from top to bottom.

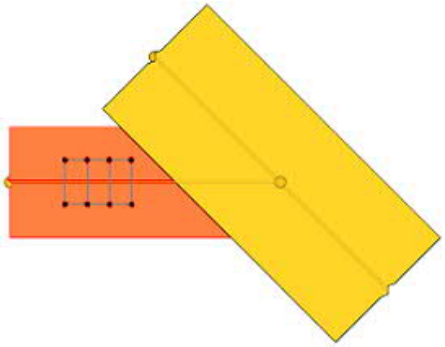
A supported node might require verifications that have not been implemented in the software yet.

Design / settings

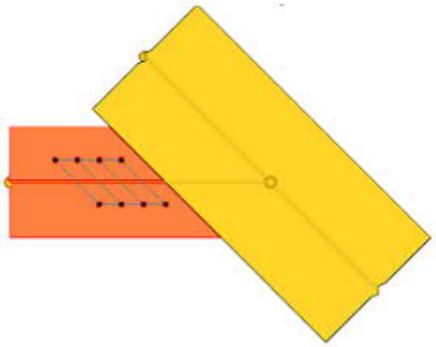
Truss members



Only steel-to-timber joints: allows the specification of the arrangement of the fasteners in the member section.



linearly orthogonal
(pairs of two parallel rows perpendicular to the grain)



linearly parallel
(pairs of two parallel row in parallel to the axis of the connected member)

The layout is defined separately for the truss members (posts, struts) and the chord with pinned joints and is only available for steel-to-timber joints.

Design / metal sheet

Only available with steel-to-timber connections.

Sheet position

Specification of the sheet location (interior, exterior).
See also graphs in the chapter HO3+

Thickness

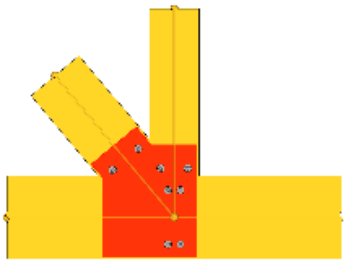
Allows the definition of the plate thickness.

Quantity

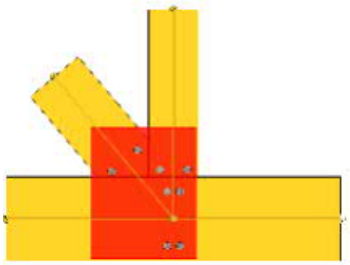
Only in combination with slot plates: up to four slot plates can be set. Due to the equal distribution of the forces on the left and the right of the plate, the distances between the plates should be selected in such manner that the distance to the outer edge amounts to 35 to 50 % of the inner plate spacing.

Sheet shape

A variety of options is available to tailor the outline of the plates to the requirements. The plate can have a rectangular shape or an outline matched to the joint.



matched to the joint (contoured)

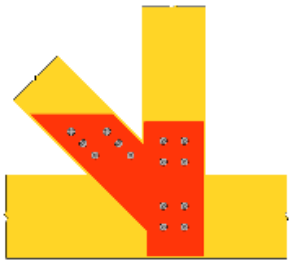


rectangular

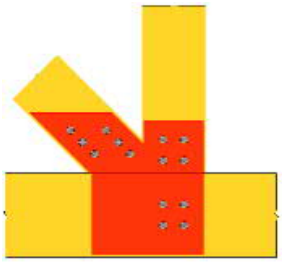
Shape in the area of the chord

The connection area of a continuous chord constitutes a special case. The plate matched to the node shape is either concave, i. e. cut at a minimum distance to the fasteners or orthogonal, i. e. extends to the outer edge of the connected members.

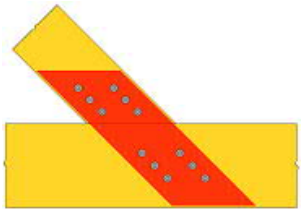
If only a single strut or post is connected, the plate can have a trapezoidal shape, extending from the connected member into the chord.



Concave



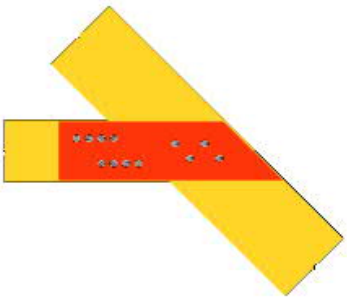
Orthogonal



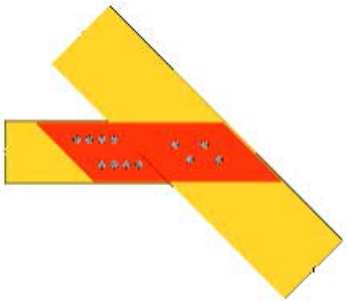
Slanted

Section in truss member

With plates matched to the joint, the section in the truss member can be adjusted to the arrangement of the fasteners. By defining the distance to the longitudinal edge e1, the default minimum spacing can be changed.



Orthogonal



Parallel

Internal hole clearance dl

Allows the specification of the internal hole clearance dl on the plate.

Hole type

Drilled and punched holes are available for selection.

Material

Allows the specification of the steel grade for the plate.

Edge distance tolerance

Allows to define the distance of the plate edge to the component edge. "0" means that the plate is inserted flush to the component surface. A value greater than "0" means that the plate is recessed in relation to the surface.

Distance of fastener from edge e1

Allows the definition of a minimum distance between the inserted plate edge and the outer fastener. The value refers to the direction of the member axis and applies to all connection areas.

Design / fasteners

See chapter Design / Fasteners in a tensile splice

Design / Fastener patterns for the individual bars

Metal plate joint

The geometry of the section on the connected member and the permissible distances of the fasteners to the edges determine the area inside which the fasteners can be arranged in rows. The back mark in grain direction is parallel to the component edge and symmetrical to the member axis. The back mark cross to the force direction can optionally be set orthogonal to the component edge or parallel to the section in the member connection.

The continuous chord constitutes a particular case, because the back marks are always orthogonal to the edge: if only a single strut or post is connected with a plate, the back marks may also be parallel to the inclination of the connected member. The metal plate normally adopts the shape of a parallelogram in this case.

Timber-to-timber connection

The allowable area for the arrangement of the fasteners is determined by the intersecting connected members and the minimum edge distances of the fasteners.

The back marks in force direction are parallel to the edge of the load-applying component and symmetrical to its member axis. The back marks cross to the force direction are parallel to the edge of the load-bearing component.

Constructive measures

Transverse tensile reinforcement: optional design with a transverse tensile reinforcement in the connection area, which is to be dimensioned for 30% of the transmission force per fastener and shear joint. This has a favourable effect on the calculable *n.eff* of the fastener row. See On/Off option under basic parameters.

Number of fasteners

Required [Johansen]:	specifies the number of required fasteners obtained from the bearing capacity of an individual fastener set (for one joint) independently of the arrangement.
n eff. [Total]:	specifies the number of required fasteners in relation to the effectiveness in the arrangement (n eff.), which is decisive for the design.
Existing:	number of existing fastener sets in the considered connection area.

At least two fasteners are assumed in the connection area. In the area of the continuous chord, at least four fasteners are required. By selecting the basic setting option "Verification", only a single fasteners could be provided in the connecting area. At least, four shear areas must be effective in this case. For nails and screws, a minimum quantity of two applies as a rule.

Rows

Max.:	maximum number of fastener rows in grain direction, that can be arranged on the component in parallel rows (perpendicular to the grain).
Selected:	selected number of fastener rows in grain direction
Number per row:	number of fasteners in one row in grain direction. Depending on the basic parameter settings, the user can specify a user-defined number (in the verification) or it is set automatically by the software (rows + design).

Distances

Output of the minimum fastener spacing to comply with and definition of:

a4	distance of the fastener rows to the edge perpendicular to the grain
a2	distance of the fastener rows from each other perpendicular to the grain
a3	distance of the fasteners to the face side in grain direction
a1	distance of the fasteners to each other in grain direction

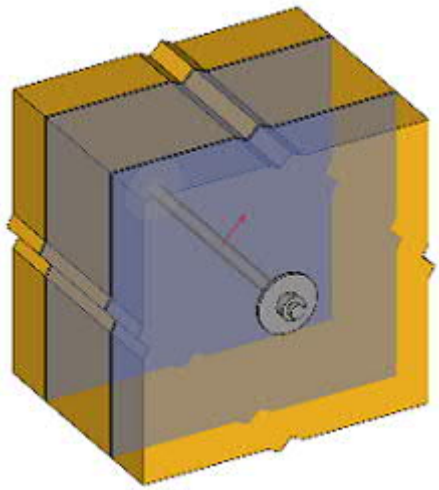
Tip: If you enter "0" in a3 or a1, the software determines a value.

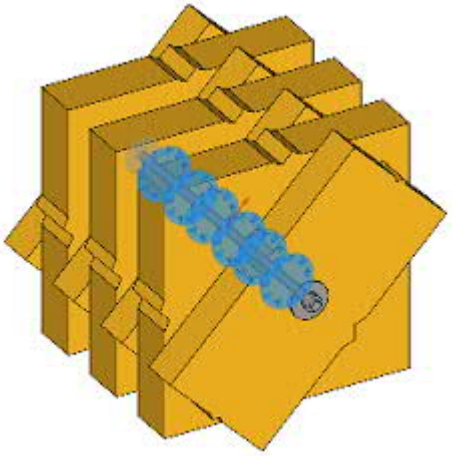
HO14+: Single-fastener Timber Joint

Application options

The HO14+ application allows the calculation of the load -bearing capacity of a single fastener, typical in timber construction while taking the given angle between the applying force and the grain into account.

The available fasteners are dowel pins, fit bolts/bolt, threaded rod, special dowels (connectors, timber-timber) and nails. The joint can be modelled for multi-part cross sections with butt straps of solid timber or steel. In a single-part cross section, you can calculate joints with up to four slot plates.





The load-bearing capacity verification of the fastener is performed in accordance with Johansen's theory. Suspension effects can be taken into account, if applicable.

In addition, constructions can be calculated in which there is a non-load-bearing intermediate layer, such as in timber panel construction, where a beam shoe connects to a timber component through a planking. For such three-layer systems, the Blaß/Laskewitz method derived from the Johansen theory is used.

In order to calculate the bearing capacity of an individual fastener, all required minimum distances must be adhered to. The effectiveness of a fastener in a particular fastener arrangement must be examined separately, which cannot be done with this software. A verification of the component in the connecting area is neither available. The HO13+ application is suitable for the modelling of a node with consideration to the necessary verifications.

Input HO14+

Basic parameters

Standard

Selection of the desired design standard.

Verification in accordance with Johansen

This option allows you to include the rope effect of pullout-resistant fasteners in order to increase the load-bearing capacity in the verification in accordance with Johansen.

Material

Optionally, the materials are defined for each component separately or for all components together.

Definition of fasteners

Standardized fasteners are available for selection in a list. The user can also specify user-defined dimensions or edit the values of standard fasteners.

How to define fasteners is described in the chapter HO3+ Design - Fasteners. (Without the fastener types "dowel pin" and "dowel pin with fit bolt").

System

Joint type

Selection of

a timber-to-timber or

a steel-to-timber connection.

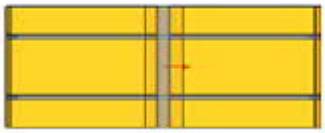
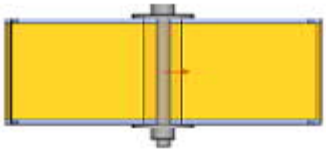
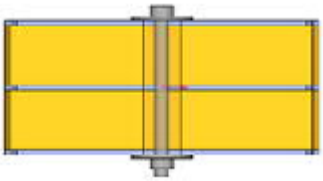
Specification whether the joint is single-shear or multi-shear.

Intermediate layer

For connections with pin-shaped fasteners, the assumption of direct contact of the components to be connected applies. Deviating from this, it can be specified here whether there is a non-load-bearing intermediate layer in the construction. A three-part layer structure is always assumed. Layer 1 as a load-bearing component made of steel or timber, layer 2 as an intermediate layer and layer 3 as a load-bearing layer, each made of timber or timber-based material. The verification of such a construction is carried out according to "Blaß, H.J. and Laskewitz, B.: Tragfähigkeit von Verbindungen mit stiftförmigen Verbindungsmitteln und Zwischenschichten, Bauen mit Holz, 2003".

Metal plate / Sheet position

For steel-to-timber connections, further specifications about the location of the metal plate are required.

Interior	slot plates single-part component	
Exterior	plates fitted to the outside single-part component	
Interior + exterior	interior and exterior plates multi-part component	

Member 1

Defines the cross section of the load-bearing component. In connections with only interior or only exterior plates, the component is always assumed single-part. In connections with both, interior and exterior plates, the component must have two or three parts. In timber-to-timber connections, the component can optionally be single-, two- or three-part.

For multi-part components, the user is prompted to specify the clearance *a* between the different cross-section parts. This clearance specification determines the width of the connected butt straps or the load-applying component.

The grain in component 1 runs always in direction of the global horizontal axis of the defined system.

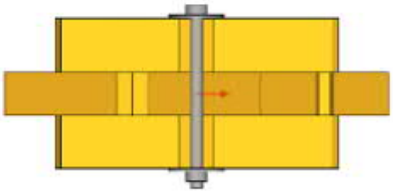
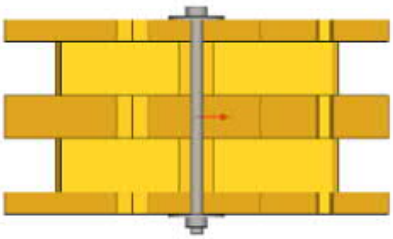
Material: as described in the chapter System of the HO3+ manual.

Member 2 (butt straps)

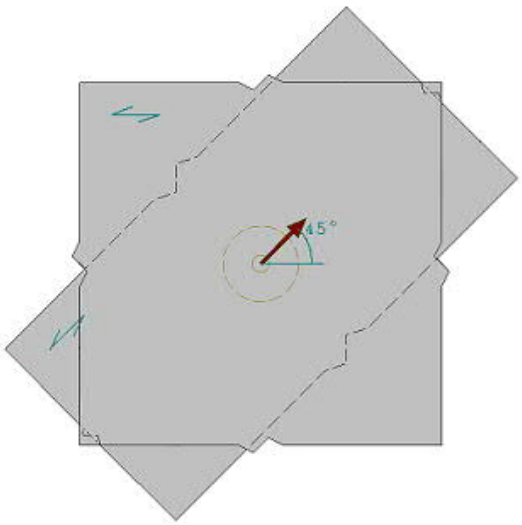
This option allows you to define the load-applying component in a timber-to-timber connection. The width of the butt straps for multi-part components is determined by the specification of the cross-section spacing in component 1, if any. The width is editable. When the user changes the value, the spacing in component 1 is automatically adjusted.

For multi-part components, the location of the straps must be defined in detail.

Exterior butt straps can have another width than the interior ones.

Inside	Butt straps are only fitted inside	
Interior + exterior	Butt straps are fitted inside and outside.	

The grain direction of component 2 is defined in the input field "Inclination". Inclinations in the range of -360° to 360° are definable. If the user specifies "0°", the grains flow in direction of the global horizontal axis.



Special case

For the verification of nails in the connection of coupling purlins, different rules apply if, due to a roof pitch of 30° or less, the nails are permanently stressed to pull out. Under "Connection structure" it can be specified whether this is such a special case.

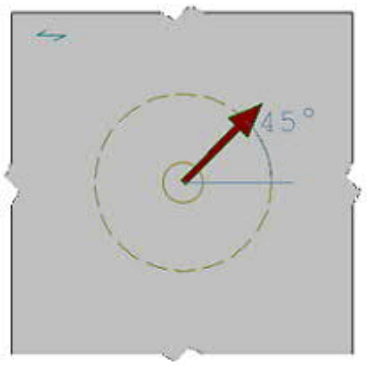
Remarks

Optional input of comments about the system, which also appear in the output.

See also Remarks Editor.

Loading, actions

Design situation	Selection of the design situation. P/T= permanent/transient, A= exceptional, AE = earthquake.
Ductility class	For design situation AE: L, M or H (DCL, DCM, DCH).
Load duration class	LDC. This option allows you to define the load duration class (permanent, middle, short ...).
$F_{v,Ed}$ angle α	Introduced shear force (resultant). Angle α between the resultant force $F_{v,Ed}$ in the fastener and the grain direction, selectable range between -360° and 360°. An angle of "0°" defines a force acting in horizontal direction to the right. The magnitude of the force f is not decisive for the calculation of the fastener's load-bearing capacity in the ULS and, therefore, no specification is required.



Ill.: A resultant force F applying at an angle of 45°

Design / fasteners

Fasteners

The definition of the fastener is described in the chapter HO3+ Design - Fastener.
(Without the fastener types "dowel pin" and "dowel pin with fit bolt").

Metal sheet

Only available with steel-to-timber connections.

Sheet position

See chapter HO14+ - System

Thickness

Allows the definition of the sheet thickness

Quantity

Sheet fitted inside, single-part cross section. Only in combination with slot sheets: up to four slot sheets can be set. Due to the equal distribution of forces on the left and right of the sheet, the distances between the sheets should be selected in such a manner that the distance to the outer edge corresponds to a portion of 35 to 50 % of the inner sheet spacing.

Internal hole clearance dl

Allows the specification of the internal hole clearance dl on the sheet.

Hole type

Drilled and punched holes are available for selection.

Steel grade

Allows the specification of the steel grade for the sheet.

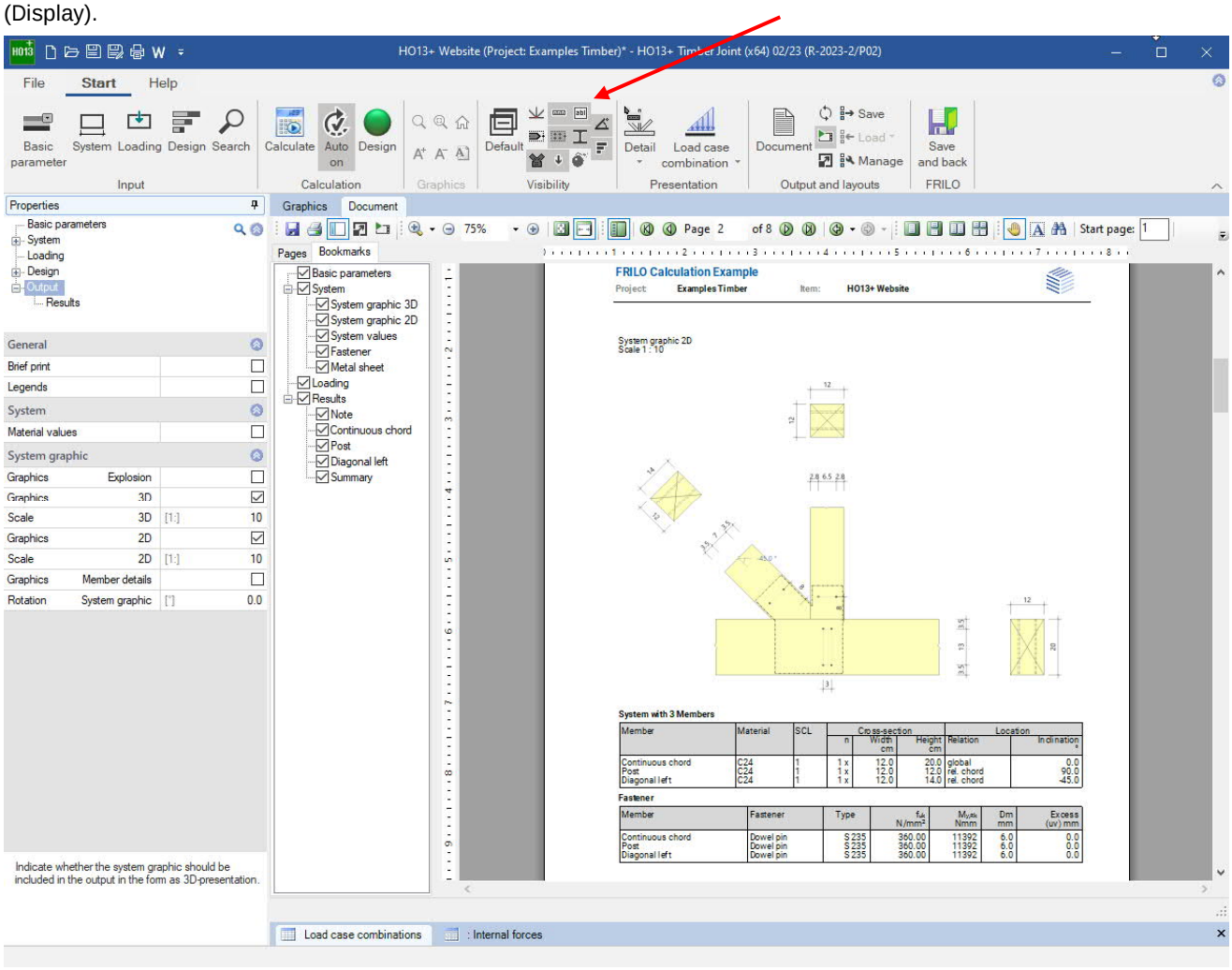
Output

Activating the Document tab allows you to display the document in PDF format.

→ See also the document Output and Printing
and output in the Document Designer

The output options (brief print, legends, etc.) define the scope of the output. Tick the options as desired.

You have various display options for the graphic in the graphic window via symbols in the ribbon at the top (Display).



Connection to framework programs

In various framework programmes such as RSX or FWH+ it is possible to transfer a node as a detail to the HO13+ programme and to model it as a truss node connection.

Node selection and start of transfer

- FWH+ Start transfer: right click on the node, “”see FWH+ Design
- RSX: Here the calculation is started first. In the displayed result graphic switch on the visibility of the nodes (see icon on the right). Then click with the right mouse button on the corresponding node and select "Transfer connection to HO13+" in the context menu.

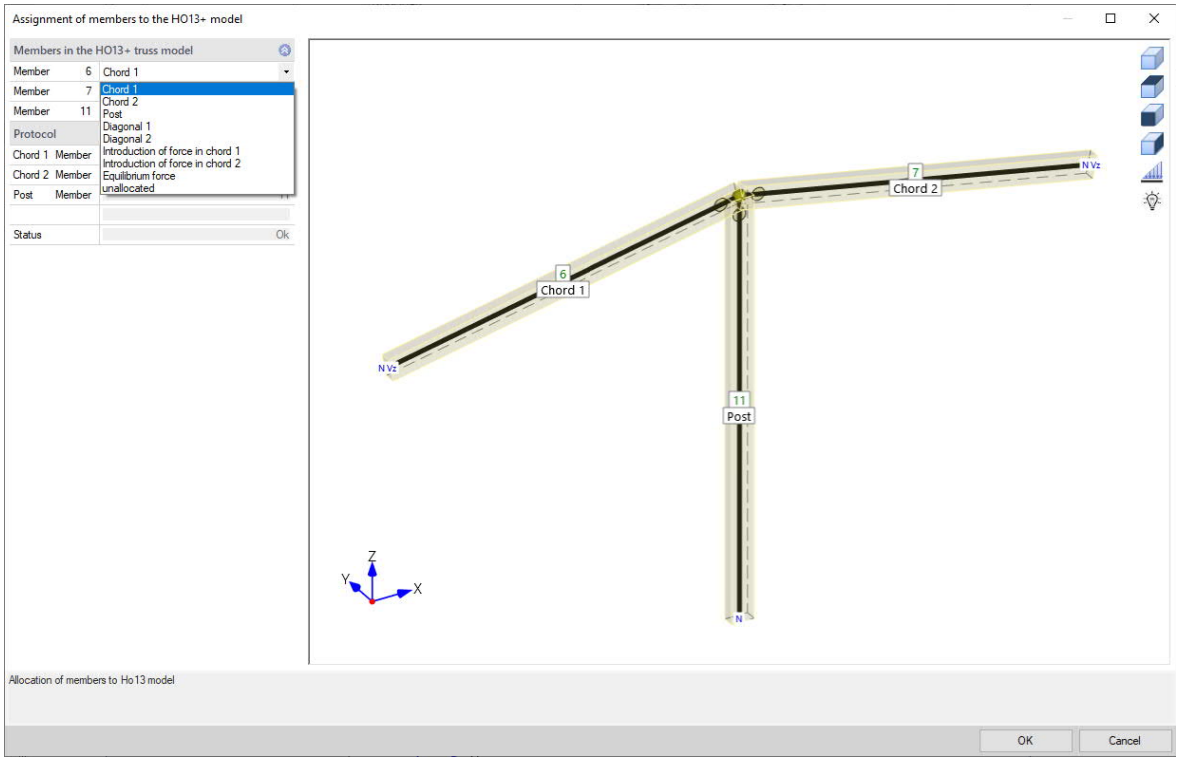
Member assignment individual/automatic

The interface is designed in such a way that, if possible, it automatically assigns the members of the framework programme to the possible HO13 connection types. For control or for a deviating modelling or in all cases where no clear assignment is possible, a dialogue is displayed.

This is structured in such a way that on the one hand an individual or on the other hand an assignment of the members to the HO13 connection type supported by sets of rules and automatisms is possible.

The individual assignment is preset as default.

To start the automated assignment, click on the light symbol  . If necessary, assignments that trigger conflicts are cancelled.



Entries are made either in the menu on the left or - more intuitively - directly in the interactive graphic (via right-click and context menu).

The designation of the possible assignments is based on the terms introduced in HO13+ for the system description:

- "Chord 1" or "Diagonal 1" correspond to the members "Chord left" or "Diagonal left" in the HO13 type.
- "Chord 2" or "Diagonal 2" correspond to the members "Chord right" or "Diagonal right" in the HO13 type.
- "Post" corresponds to the member with the same name in the HO13 type.
- "Equilibriumforce" corresponds to an equilibrium-resolving force application in the HO13 type, which represents a member connection that does not appear in the design of the connections.
- "Force introduction in chord 1/2" corresponds to an addition of the internal forces of this member, converted to the modelling plane of the truss node, to the selected intersection bank of the chord.

Allocations are only possible to the extent that they correspond to a system that can be modelled in HO13+. The limitations that apply there are checked for each entry and a status is displayed within the log area. Only when all members have been assigned and there are no contradictions to the modellability of an HO13 type, the dialogue can be confirmed with Ok and HO13+ can be started.

Limitations result from material, cross-section, stress or position of the members in relation to each other:

- Basic components (chord, post, diagonal) must be made of timber.
- Basic components must (currently) consist of a one-piece cross-section.
- Posts and diagonals must be hinged.
- Posts and diagonals can only absorb subordinate transverse forces.
- An angle between two bars must be at least 15°.

In addition, further limitations apply due to the variety of possible topologies.

For easier assessment, the internal forces at the respective member edge are displayed categorically in the graphic, provided they are decisive in a load case combination. They can be switched to invisible using the controls in the graphic area.

All listed member numbers correspond to those from the original model and are transferred to the structural analysis document for the identification of the individual verifications.

Internal force components that result from a spatial design or from biaxial loading and are not considered in the planar model of HO13+ can be classified as negligible by the user in the dialogue, provided they have no or only a minor effect on the model. This simplistic approach may require a separate consideration of their influence.

Within the HO13+ modelling layer, the orientation of the node may differ from the orientation in the original system. Posts are always displayed vertically in HO13+, continuous chords may be displayed horizontally. The orientation of the system graphics in the structural analysis document can be adjusted subsequently. To do this, define an appropriate rotation angle in the left menu area of HO13+ under Output (Rotation system graphics). If HO13+ is called from the FWH+ programme, the value for this rotation is automatically preset.