HTC-P2P: HILTI CLT PANEL-TO-PANEL CONNECTOR

Technical guide to use and design

February 2025

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1. HTC-P2P: APPLICATIONS AND PRODUCT DESCRIPTION

1.1 Main features and intended use

The Hilti Timber Connector (HTC)-P2P (Panel-to-Panel) is HILTI's cutting-edge timber connector innovation. This point connector is specifically engineered to align and secure Cross Laminated Timber (CLT) panels subjected to in-plane loads, such as those typically acting in CLT floor systems. By effectively combining resistance to both tensile and shear loads, HTC-P2P helps to eliminate the need for traditional solutions such as nailed cover boards or inclined timber screws. The connector is not intended to transfer bending moments or out-of-plane shear loads between panels, so must not be utilized under those load conditions.

HTC-P2P has been rigorously tested, qualified and certified in accordance with European standards, as evidenced by the European Technical Assessment (ETA) 24/1199 [1]. The connector is approved for both static and seismic applications, for which it can be designed according to the EOTA Technical Report (TR) 085 [2]. The latter adheres to the Eurocode 5 design principles.

The connector is compatible with CLT panels of varying thickness, different layout configurations, joint geometries, and common moisture protection products.

Designing with HTC-P2P is streamlined through specialized Hilti design software. The connector is further supported by libraries in popular CAD software, helping to achieve a seamless transition from design to manufacturing to installation on the jobsite.

The HTC-P2P connector enhances the efficiency of joining CLT panels, allowing for alignment and fastening of the panels in a single step. When used in conjunction with HILTI's SIW 6AT-22 and offset adapter, the connector can be installed with minimal effort, eliminating the need for hammering, beam hoists, or special training. This helps to reduce risks on the jobsite. Moreover, the connector is fully releasable[1], facilitating onsite adjustments and promoting circularity in construction projects.

Fig 1.1 – HTC-P2P, Hilti's latest innovation for CLT panel-to-panel connections.

[1] Further information on adjustability and reuse can be found in Chapter 3.

1.2 Product description and installation parameters

The Hilti HTC-P2P connector consists of two dovetail-shaped wedges made of plywood, combined with steel components (see Fig 1.2). The plywood wedges are crafted from cross-laminated veneer lumber of beech, suitable for structural use as per EN 13986 [3] and EN 636 [4] standards. The steel components are manufactured following DIN 1052 (washer M12), DIN 933 [5] (hexagon head screw M12x100, steel grade 8.8), and AISI 1008 (sleeve M12) standards. The connector is shipped pre-assembled, ensuring that all its components are already connected when delivered. The ETA-24/1199 [1] only applies under the assumption that the connector and its individual parts have not been removed, replaced or modified.

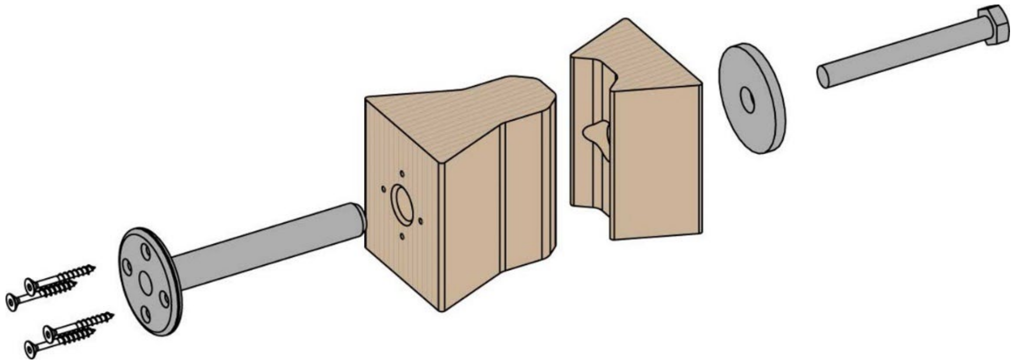


Fig 1.2 – HTC-P2P, exploded view of the product.

For installation, a predefined cutout must first be created in the CLT panel member, for example by using Computerized Numerical Control (CNC) machining. The geometry and main dimensions of the cutout required to accommodate the connector are detailed in the product ETA and product technical data sheet (which can be freely downloaded from our website). The specific cutout geometry can be found in CAD libraries of software such as CADworks, SEMA and Dietrich's, or downloaded from our website in stp, ifc, dxf and pdf formats.

The connector has a height of 90 mm. A cutout depth of at least 93 mm is recommended to ensure the connector is flush with the surface of the timber element. Deeper cut-out depths are possible, allowing for more recessed installation, but they must not exceed 105 mm.

HTC-P2P connectors are recommended for use in CLT panels with a minimum thickness of 120 mm, and a minimum of three crosswise layers. The connector is approved for use with single or double top layer configurations (see Fig 1.3). The lamellas should have a minimum strength class of C16, with an average strength class of C24, in accordance with EN 338 [6].

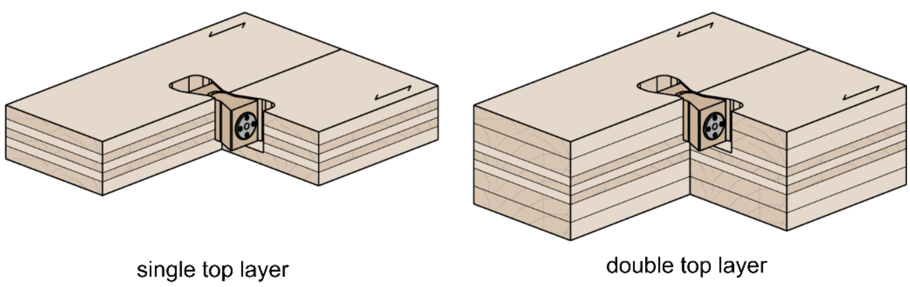


Fig 1.3 – HTC-P2P, single top layer vs double top layer CLT panels.

The connector is suitable for various butt joint configurations including flat or profiled butt joints, overlapping joints, and flat butt joints with a slot-key (see Fig 1.4). It is designed for use in timber structures under service class conditions 1 and 2, as specified in EN 1995-1-1 [7]. The intended service life of the connector is 50 years according to ETA 24/1199.

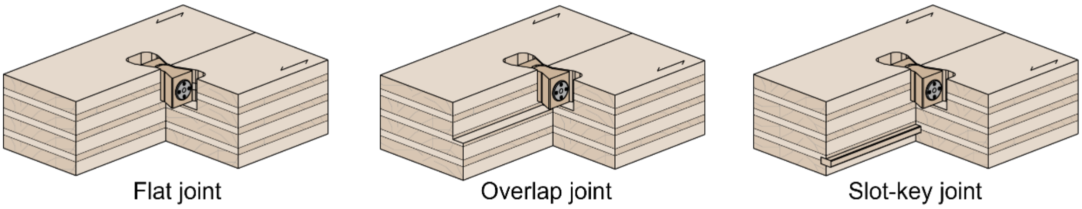


Fig 1.4 – Example of use of HTC-P2P with different joint geometries.

The selection of CLT panels size, CLT layer structure, distances from the panel edges and spacing between connectors should be based on the application structural requirements, following the provisions outlined in ETA-24/1199, and designed according to the TR 085. A summary of the main installation parameters is given in Table 1.1.

Table 1.1 – Geometric installation parameters for HTC-P2P

Installation parameters	
Minimum end distance (tension loads)	250 mm
Minimum end distance (shear loads)	300 mm
Minimum spacing (tension loads)	500 mm
Minimum spacing (shear loads)	300 mm
Minimum panel thickness	120 mm

2. DESIGN

2.1 HTC-P2P structural performance

The performance of the HTC-P2P connector is influenced by the load direction and by the layout of the CLT panels. The cutout depth also plays a significant role. In fact, the characteristic resistances in tension and shear, as well as the connector's stiffness, are defined in the ETA-24/1199 as a function of the "effective" ratio (see Fig 2.1):

$$\beta = \frac{\sum t_{p,i}}{d_e}$$

where:

- $t_{p,i}$ represent the thickness of the i-th individual layer of the CLT panel, oriented parallel to the load direction and engaged in the load transfer mechanism by the connector.
- d_e is the height of the HTC-P2P.

The ratio β describes the relative positioning of the connector, cutout and CLT layers. These parameters affect the connector's performance due to the variability of the timber mechanical properties with the grain orientation. In fact, the load transfer mechanism primarily occurs along the grains' direction. For this reason, the load transfer from the CLT panel to the connector depends on the thickness of only the layers with grains oriented parallel to the load. As a matter of fact, different values of the effective ratio must be determined for orthogonal directions (in the following indicated as $\beta_{II,t}$ and $\beta_{II,v}$ for tension and shear load directions, respectively).

Notice that similar values of the ratios β can be achieved with different CLT panels, even if they have different structures or are produced by different manufacturers. This implies that different configurations of layers and thicknesses can lead to similar performance.

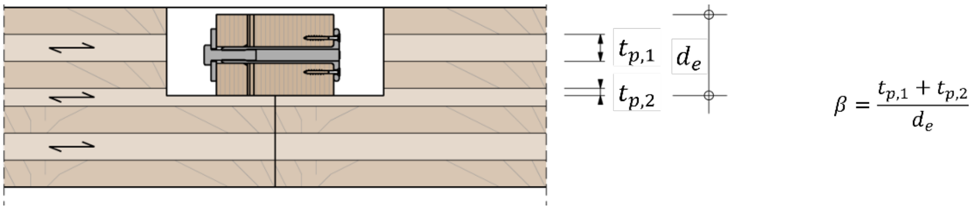


Fig 2.1 – Cross section of CLT panel and HTC-P2P to determine the connector effective ratio.

The formulae for determining the characteristic resistance and stiffness of the connector for tensile and shear loads are summarized in Table 2.1 and Table 2.2. The full, comprehensive set of technical data for HTC-P2P can be found in the ETA-24/1199 [1]. Notice that different formulae are provided for CLT panels with a single top layer and double top layer.

Table 2.1 – HTC-P2P's product characteristic for tensile loads

Essential characteristics (tension)	Units	Single top layer	Double top layer
Minimum effective ratio $\beta_{II,t}$	-	0.22	0.14
Maximum effective ratio $\beta_{II,t}$	-	0.78	0.86
Characteristic resistance $R_{t,k}$	[kN]	39.3	16.5 $\beta_{II,t}$ + 21.1
Stiffness (slip modulus) $k_{ser,t}$	[kN/mm]	-1.6 $\beta_{II,t}$ + 7.4	-5.0 $\beta_{II,t}$ + 8.7

Table 2.2 – HTC-P2P's product characteristic for shear loads

Essential characteristics (shear)	Units	Single top layer	Double top layer
Minimum effective ratio $\beta_{II,v}$	-	0.22	0.14
Maximum effective ratio $\beta_{II,v}$	-	0.78	0.86
Characteristic resistance $R_{v,k}$	[kN]	30.7 $\beta_{II,v}$ + 24.6	31.6 $\beta_{II,v}$ + 21.0
Stiffness (slip modulus) $k_{ser,v}$	[kN/mm]	5.4 $\beta_{II,v}$ + 5.4	9.6 $\beta_{II,v}$ + 3.7

2.2 Design recommendations

The design of HCT-P2P should adhere to the EOTA TR085 – *Design of Point Connectors – Dovetails made of plywood for cross laminated timber* [2]. This document applies to the design of point connectors having an ETA in accordance with EAD 130036-01-0603 [8]. It covers the design of connectors in service classes 1 and 2, as defined in EN1995-1-1 [7], and follows design principles from EN1995-1-1 and prEN1995-1-2 [9] (for fire design).

As a general rule, at the ultimate limit state and for all load conditions (static and quasi-static, and seismic), each design action on the connector, F_d, must be not greater than the design resistance of the connector R_d:

$$F_d \leq R_d$$

2.2.1 Static and quasi-static loading conditions

For static loads (tension and shear), the design resistance of the connector is determined by:

$$R_d = k_{mod} \frac{R_k}{\gamma_M}$$

Where:

- R_k is the characteristic resistance to static and quasi-static loads of HTC-P2P, and it is determined based on the effective ratios $\beta_{II,t}$ or $\beta_{II,v}$ (for tension or shear respectively) as defined in the ETA-24/1199 and indicated in Table 2.1 and Table 2.2 in this document.

- k_{mod} is taken from EN1995-1-1 Clause 3.2 for plywood and service classes 1 and 2, according to the relevant load-duration class, as shown in Table 2.3 in this document.

- $\gamma_M = 1.3$ is the partial factor for the material property, as indicated in EN1995-1-1 Clause 2.4 for plywood.

For combined tension and shear loads (i.e. tension and shear loads applied simultaneously), the design verification for the HTC-P2P must satisfy the following relationship:

$$\left(\frac{F_{t,d}}{R_{t,d}}\right) + \left(\frac{F_{v,d}}{R_{v,d}}\right) \leq 1.0$$

where $F_{t,d}$ and $F_{v,d}$ are the tensile and shear loads, and $R_{t,d}$ and $R_{v,d}$ are the tensile and shear design resistances, respectively.

Table 2.3 – k_{mod} values for plywood according to the relevant load-duration class (service classes 1 and 2)

Load-duration class (plywood, service classes 1 and 2)				
Permanent	Long term	Medium term	Short term	Instantaneous
0.6	0.7	0.8	0.9	1.1

2.2.2 Seismic loading conditions

The design resistance of the connector for seismic loads is determined similarly to static loads, using the formula:

$$R_{Ed} = k_{mod} \frac{R_k}{\gamma_M}$$

where:

- R_k is the characteristic resistance to static and quasi-static loads of HTC-P2P, and it is determined based on the effective ratios $\beta_{II,t}$ or $\beta_{II,v}$ (for tension or shear respectively) as defined in the ETA-

24/1199 and indicated in Table 2.1 and Table 2.2 in this document.

- k_{mod} is taken from EN1995-1-1, Clause 3.2, for plywood and service classes 1 and 2, according to the relevant load-duration class.

- γ_M is the partial factor for the material property, as indicated in EN1995-1-1 Clause 2.4 for plywood. In accordance with EN1998-1-1 [10], Clause 8.6(3).
  - $\gamma_M = 1.3$ for tensile loads, since the HTC-P2P is approved for Ductility Class L (DCL)
  - $\gamma_M = 1.0$ for shear loads, since the HTC-P2P is approved for Ductility Class M (DCM).

As with static and quasi-static loads, for combined tension and shear loads, the design verification for the HTC-P2P must satisfy the following relationship:

$$\left(\frac{F_{t,Ed}}{R_{t,Ed}}\right) + \left(\frac{F_{v,Ed}}{R_{v,Ed}}\right) \leq 1.0$$

where $F_{t,Ed}$ and $F_{v,Ed}$ are the tensile and shear seismic loads, and $R_{t,Ed}$ and $R_{v,Ed}$ are the tensile and shear seismic design resistances, respectively.

2.2.3 Fire-loading conditions

The design resistance under fire exposure from below the panel follows the charring rate method presented in prEN1995-1-2 [9] and the requirements of prEN1995-1-2 Clause 10.4. The load-bearing capacity of the connector can be verified for a standard fire exposure up to 120 minutes (R120).

Char-line position:
It must be verified that the residual cross-section covering the connector is at least 20 mm thick, after the fire exposure time. This means that, for a floor panel application, the char-line is at least 20 mm below the connector face. The term “char-line” here refers to the borderline between the char-layer and the residual cross-section, assumed to be the 300 °C isotherm.

The position of the char-line can be determined following the prescription of prEN1995-1-2. The progress of the char-line is determined based on alternating phases where the charring occurs at varying rates. In the most general case of an initially unprotected CLT panel, the position of the char-line can be determined by considering the following charring phases:

- For the first exposed layer in the CLT panel, a *normal charring phase*, during which the entire first layer of the CLT panel chars at constant rate β_1.

- For each subsequent layer of the CLT panel, until the total fire exposure time is reached:
  - A *post-protected charring phase*, characterized by a higher charring rate β_2, throughout a thickness of 25 mm.
  - A *consolidated charring phase*, during which the remaining thickness of the CLT layer chars at the initial, constant rate β_1.

More in general, the prEN1995-1-2 indicates how different levels of protection should be considered in the design, if needed.

Calculation of the design resistance:
The design resistance of the connector under fire exposure is determined using the formula:

$$R_{d,fi} = k_\theta k_{mod} k_{fi} \frac{R_k}{\gamma_{M,fi}}$$

where:

- R_k is the characteristic resistance to static and quasi-static loads of HTC-P2P, and it is determined based on the effective ratios $\beta_{II,t}$ or $\beta_{II,v}$ (for tension or shear respectively) as defined in the ETA-24/1199 [1] and indicated in Table 2.1 and Table 2.2 in this document.

- k_θ is the temperature-dependent reduction factor for the strength of the point connector, taken as 1.0 under the assumption that the residual cross-section covering the connector is at least 20 mm.

- k_{mod} is taken as 1.0, according to prEN1995-1-2, Clause 4.5.

- k_{fi} is the modification factor for the strength property for the fire situation, taken as 1.10 for LVL, as indicated in prEN1995-1-2, Clause 4.5.

- $\gamma_{M,fi}$ is the partial factor for the relevant mechanical material property for the fire situation, taken as 1.0 unless otherwise specified in the National Annex (as addressed in EN1995-1-2 Clause 4.5).

For combined tension and shear loads the design verification for the HTC-P2P must satisfy the following relationship:

$$\left(\frac{F_{t,d,fi}}{R_{t,d,fi}}\right) + \left(\frac{F_{v,d,fi}}{R_{v,d,fi}}\right) \leq 1.0$$

Where $F_{t,d,fi}$ and $F_{v,d,fi}$ are the tensile and shear fire loads, and $R_{t,d,fi}$ and $R_{v,d,fi}$ are the tensile and shear fire design resistances, respectively.

2.3 Design example

The following design example is presented to further clarify the design process described in the previous sections. For illustrative purposes, the design of a single connector (see Fig 2.2) subjected to static loads, seismic loads, and exposed to fire for 90 minutes (R90) is considered. The approach can be easily extended to other cases with multiple connectors.

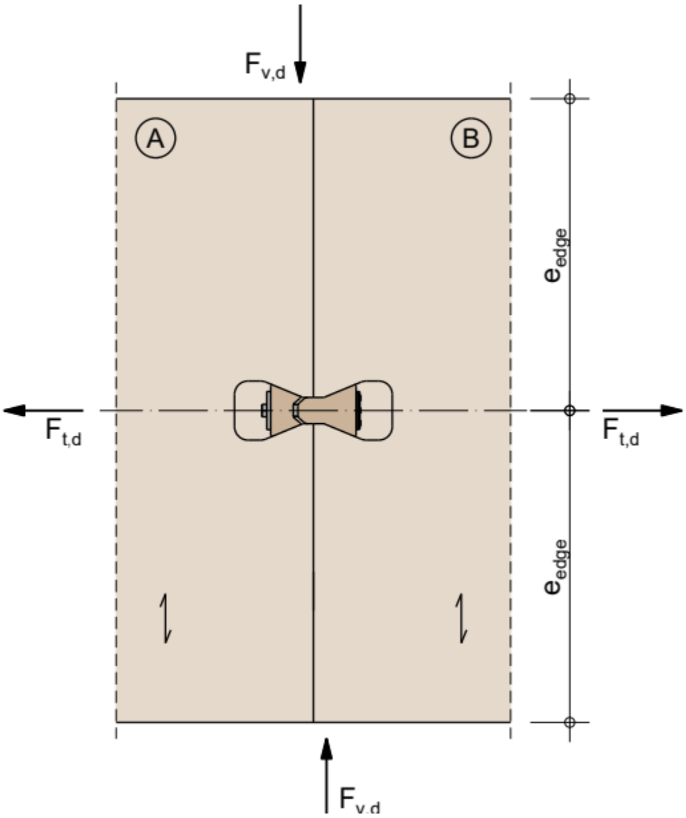


Fig 2.2 – Design example: top view of CLT panels and connector.

In the following it is assumed that the joined CLT panels have the same structure (i.e. the same thickness same lamella structure with the same orientation). If different CLT panels (or different orientations) are considered, the same verification should be done separately for each panel.

2.3.1 Geometric data

CLT panel thickness:	200 mm
Number of layers in each CLT panel:	5
Lamella structure (layers thicknesses):	40-40-40-40-40 mm, single top layer
Distance from panel edge (e_{edge}):	500 mm
Cutout depth:	100 mm
Connector height (d_{conn}):	90 mm

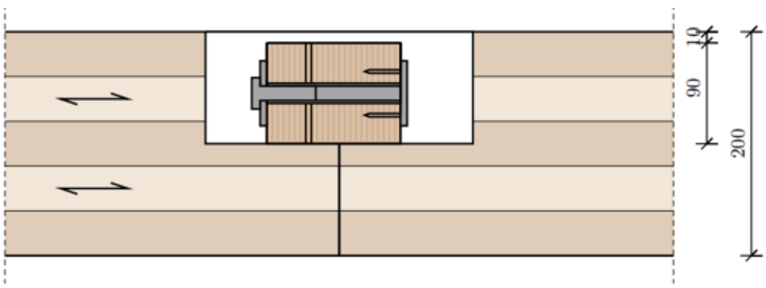
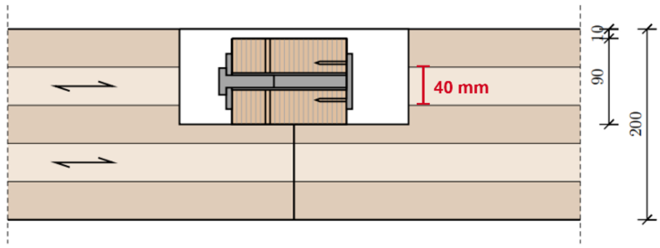


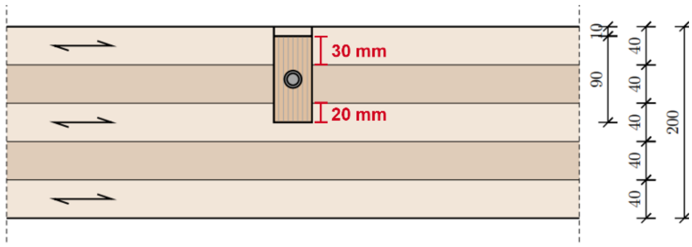
Fig 2.3 – Design example: cross section of CLT panels and connector.

Based on the provided geometric data for the CLT panels and the connector, the effective ratios $\beta_{II,t}$ and $\beta_{II,v}$ relative to the directions parallel to tension and shear loads respectively, can be determined as:

$$\beta_{II,t} = \frac{\sum t_p}{d_{conn}} = \frac{40}{90} = 0.44$$



$$\beta_{II,v} = \frac{\sum t_p}{d_{conn}} = \frac{30 + 20}{90} = 0.56$$



2.3.2 Static load conditions

It is assumed that the connector is subjected to the following static (or quasi-static) loads, acting simultaneously:

Static tensile load:	$F_{t,d} = 5.0\ kN$
Static shear load:	$F_{v,d} = 20.0\ kN$
Load duration:	short, $k_{mod} = 0.9$

The verification to tension, shear and combined loads follows the steps discussed in Section 2.2.1.

Tensile load verification:

The characteristic resistance to tensile loads is defined in the ETA-24/1199 [1] as a function of the effective ratio $\beta_{II,t}$. For a single top layer configuration, the characteristic resistance in tension is constant (Table 2.1):

$$R_{t,k} = 39.3\ kN$$

The design resistance in tension can be determined according to:

$$R_{t,d} = k_{mod}\frac{R_{t,k}}{\gamma_M} = 0.9 \times \frac{39.3}{1.3} = 27.21\ kN$$

Finally, the verification with respect to tensile loads leads to:

$$\frac{F_{t,d}}{R_{t,d}} = \frac{5.0}{27.21} = 0.18 \leq 1.0 \quad \text{(Verified)}$$

Shear load verification:

The characteristic resistance to shear loads is defined in the ETA-24/1199 [1] as a function of the effective ratio $\beta_{II,v}$. For a single top layer configuration, it is determined as the following linear function (Table 2.2):

$$R_{v,k} = 30.7\,\beta_{II,v} + 24.6 = 30.7 \times 0.56 + 24.6 = 41.66\,kN$$

The design resistance in shear can be determined according to:

$$R_{v,d} = k_{mod}\frac{R_{v,k}}{\gamma_M} = 0.9 \times \frac{41.66}{1.3} = 28.64\,kN$$

Finally, the verification with respect to shear loads leads to:

$$\frac{F_{v,d}}{R_{v,d}} = \frac{20.0}{28.64} = 0.69 \leq 1.0 \quad \text{(Verified)}$$

Combined tensile and shear load verification:

Combined tensile and shear loads must be verified considering the linear combination of the connector utilizations in tension and shear:

$$\left(\frac{F_{t,d}}{R_{t,d}}\right) + \left(\frac{F_{v,d}}{R_{v,d}}\right) = 0.18 + 0.69 = 0.88 \leq 1.0 \quad \text{(Verified)}$$

2.3.3 Seismic load conditions

In this section, it is assumed that the connector is subjected to the following seismic loads:

Seismic tensile load:	$F_{t,Ed} = 10.0\,kN$
Seismic shear load:	$F_{v,Ed} = 25.0\,kN$
Load duration (static):	instantaneous, $k_{mod} = 1.1$

The verification to tension, shear and combined loads follows the steps discussed in Section 2.2.2.

Tensile load verification:

The characteristic resistance to tensile loads is defined in the ETA-24/1199 [1] as a function of the effective ratio $\beta_{II,t}$. For a single top layer configuration, the characteristic resistance in tension is constant (Table 2.1):

$$R_{t,k} = 39.3\,kN$$

Considering that the connector is approved for ductility class DCL in tension ($\gamma_M = 1.3$), the design resistance in tension can be determined according to:

$$R_{t,Ed} = k_{mod}\frac{R_{t,k}}{\gamma_M} = 1.1 \times \frac{39.3}{1.3} = 33.25\,kN$$

Finally, the verification with respect to tensile loads leads to:

$$\frac{F_{t,Ed}}{R_{t,Ed}} = \frac{10.0}{33.25} = 0.30 \leq 1.0 \quad \text{(Verified)}$$

Shear load verification:

The characteristic resistance to shear loads is defined in the ETA-24/1199 as a function of the effective ratio $\beta_{II,v}$. For a single top layer configuration, it is determined as the following linear function (Table 2.2):

$$R_{v,k} = 30.7\,\beta_{II,v} + 24.6 = 30.7 \times 0.56 + 24.6 = 41.79\,kN$$

The design resistance in shear can be determined according to:

$$R_{v,Ed} = k_{mod}\frac{R_{v,k}}{\gamma_M} = 1.1 \times \frac{41.79}{1.0} = 45.97\,kN$$

Finally, the verification with respect to shear loads leads to:

$$\frac{F_{v,Ed}}{R_{v,Ed}} = \frac{25.0}{45.97} = 0.54 \leq 1.0 \quad \text{(Verified)}$$

Combined tensile and shear load verification:

Combined tensile and shear loads must be verified considering the linear combination of the connector utilizations in tension and shear:

$$\left(\frac{F_{t,d}}{R_{t,d}}\right) + \left(\frac{F_{v,d}}{R_{v,d}}\right) = 0.30 + 0.54 = 0.84 \leq 1.0 \quad \text{(Verified)}$$

2.3.4 Fire load conditions

In this section, it is assumed that the connector has to be designed for fire exposure of under 90 minutes, and it is subject to the following fire load conditions:

Fire tensile load:	$F_{t,Ed} = 3.5\,kN$
Fire shear load:	$F_{v,Ed} = 14.0\,kN$
Fire exposure:	$R90$
Charring rates:	$\beta_1 = 0.65\,mm/min$, $\beta_2 = 1.30\,mm/min$

The verifications of the position of the char-line (at least 20 mm below the connector face), and of tension, shear and combined loads follow the steps discussed in Section 2.2.3.

Position of the char-line:

In this example, the position of the char-line is determined considering the following three charring phases (see Fig 2.4).

1) In the first charring phase, the first layer of the CLT panel entirely chars at constant rate β_1. Since the layer is 40 mm thick, the first phase will have a duration $t_{f,1}$:

$$t_{fi,1} = \frac{40}{\beta_1} = \frac{40}{0.65} = 61.54\,min$$

After the first phase of charring, the remaining time to take into consideration is $90 - 61.54 = 28.46\,min$.

2) In the second phase, the char-line progresses at constant char rate β_2 through a thickness of 25 mm. The duration $t_{f,2}$ of this phase can be determined as:

$$t_{fi,2} = \frac{25}{\beta_2} = \frac{25}{1.30} = 19.23\,min$$

After the second phase of charring, the remaining time to be considered is $28.46 - 19.23 = 9.23\,min$.

3) In the third phase, the char-line progresses again at a constant charring rate β_1 through the remaining 15 mm from the second layer. In the remaining 9.23 minutes, only a portion of this layer is charred. In fact, the 90 minutes fire exposure is reached after the char-line has advanced for only 6 mm:

$$t_{fi,3} = \frac{6.0}{\beta_1} = \frac{6.0}{0.65} = 9.23\,min$$

$$t_{fi} = \sum t_{fi,i} = 61.54 + 19.23 + 9.23 = 90\,min$$

Based on the above, the position of the charred line below the connector, d, can be determined as the difference of the total CLT panel thickness, minus the connector embedment and the total thickness of the charred layer:

$$d = 200 - 100 - (40 + 25 + 6) = 29\,mm \geq 20\,mm \quad \text{(Verified)}$$

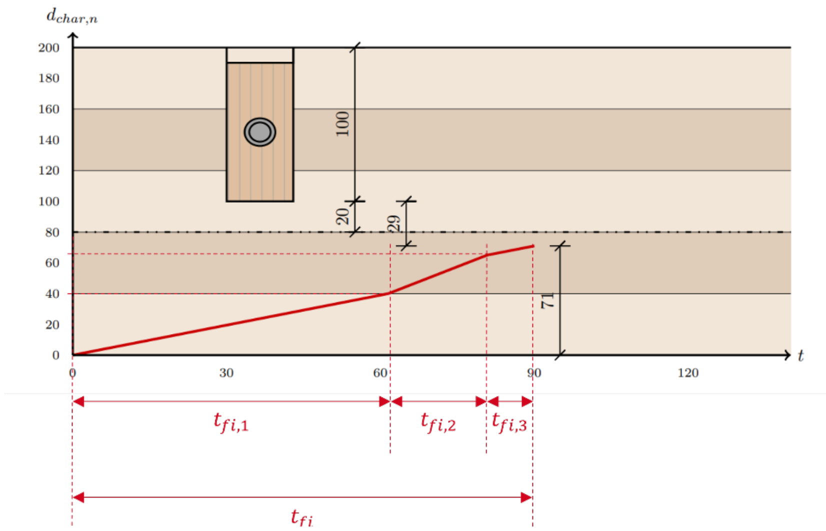


Fig 2.4 – Design example: calculation of the position of the char-line.

Tensile load verification:

The characteristic resistance to tensile loads is defined in the ETA-24/1199 as a function of the effective ratio $\beta_{II,t}$. For a single top layer configuration, the characteristic resistance in tension is constant (Table 2.1):

$$R_{t,k} = 39.3\,kN$$

The design resistance in tension can be determined according to:

$$R_{t,d,fi} = k_\theta k_{mod} k_{fi} \frac{R_{t,k}}{\gamma_{M,fi}} = 1.0 \times 1.0 \times 1.10 \times \frac{39.3}{1.0} = 43.23\,kN$$

Finally, the verification with respect to tensile loads leads to:

$$\frac{F_{t,d,fi}}{R_{t,d,fi}} = \frac{3.5}{43.23} = 0.08 \leq 1.0 \quad (Verified)$$

Shear load verification:

The characteristic resistance to shear loads is defined in the ETA-24/1199 as a function of the effective ratios $\beta_{II,v}$. For a single top layer configuration, it is determined as the following linear function (Table 2.2):

$$R_{v,k} = 30.7\,\beta_{II,v} + 24.6 = 30.7 \times 0.56 + 24.6 = 41.66\,kN$$

The design resistance in shear can be determined according to:

$$R_{v,Ed} = k_{\theta} k_{mod} k_{fi} \frac{R_{v,k}}{\gamma_{M,fi}} = 1.0 \times 1.0 \times 1.10 \times \frac{41.66}{1.0} = 45.83\,kN$$

Finally, the verification with respect to shear loads leads to:

$$\frac{F_{v,Ed}}{R_{v,Ed}} = \frac{14.0}{45.83} = 0.31 \leq 1.0 \quad (Verified)$$

Combined tensile and shear load verification:

Combined tensile and shear loads must be verified considering the linear combination of the connector utilizations in tension and shear:

$$\left(\frac{F_{t,d}}{R_{t,d}}\right) + \left(\frac{F_{v,d}}{R_{v,d}}\right) = 0.08 + 0.31 = 0.39 \leq 1.0 \quad (Verified)$$

2.4 Introduction to the Hilti HTC-P2P design software

To optimize the design of the HTC-P2P connector while ensuring compliance with the latest international codes and standards such as EOTA TR 085 and ETA-24/1199, a free-to-access, cloud-based Hilti design software is available.

The design module features a user-friendly interface supported by detailed drawings and three-dimensional visualizations, making the design process intuitive. It minimizes necessary inputs while allowing for full design flexibility of the connector. As a cloud-based solution, it can be accessed through any web browser on a PC, Mac, tablet or smartphone. No installation or updates are required.

The design module supports multiple load scenarios including static, quasi-static, seismic and fire design. It also generates a comprehensive design report referencing the state-of-the-art design method and approval documents. Whether your project is small or large, this tool helps you achieve optimal results in the shortest time.

To get you started, a streamlined design flow is given below, offering an overview for new or inexperienced users on how to use the software module and its main inputs.

1. **Select the Hilti P2P design module:** an editable interface will open, divided into multiple sections guiding you through the overall design process.

2. **Project management:** create a new project or refer to an existing one. For each project, multiple connector "positions" can be defined, each being a separate design case. This feature allows the saving of multiple design configurations for a single project. Projects and positions can be retrieved from the Project Management tile's main interface.

3. **Connection type:** customize the configuration of the panels by defining the orientation of the lamellas, selecting equal or different CLT panels, and specifying fire exposure requirements.

4. **Material & geometry:** define the service class (based on EN1995-1-1 definition), detail the structure of the CLT panels, and define the number and position of the connectors. For the CLT panels, you can define the number, layout and thickness of the layers either by selecting a specific panel from a predefined library, or by inputting a customized panel configuration. A connector's position is determined by the number of connectors, cutout depth, distance from the edge of the panel, and spacing between connectors.

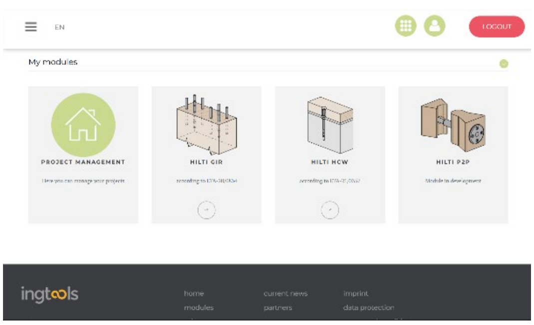
5. **Loads:** input the magnitudes of the acting loads (static, seismic and fire) and define the load-duration classes.

6. **Design and report:** this section displays the main design output, visualizing the verifications for the individual failure modes. It also allows generating a comprehensive design report detailing all the design calculations and verifications performed by the software. The report is generated in PDF format, making it easy to export and save.

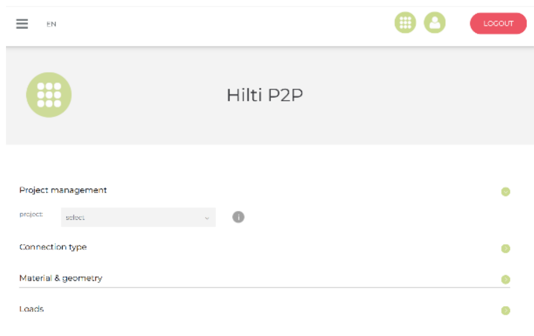
Remarks

Any and all information and data contained in the software concerns solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. The results of the calculations carried out by means of the software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you.

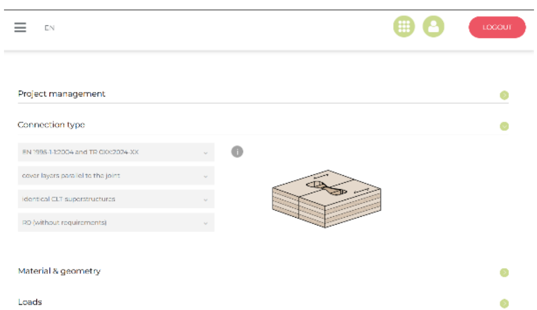
Table 2.4 – Hilti design software for HTC-P2P – main design steps



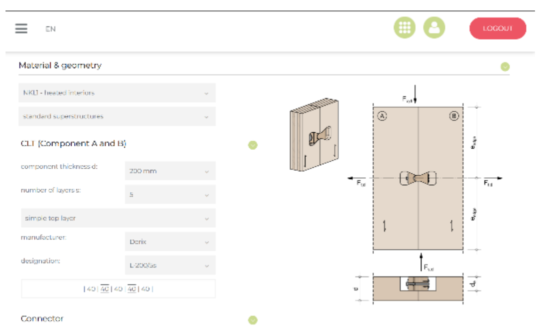
Step 1 – Select the Hilti P2P design module



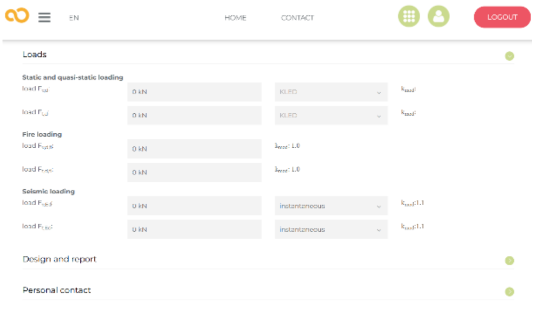
Step 2 – Project management



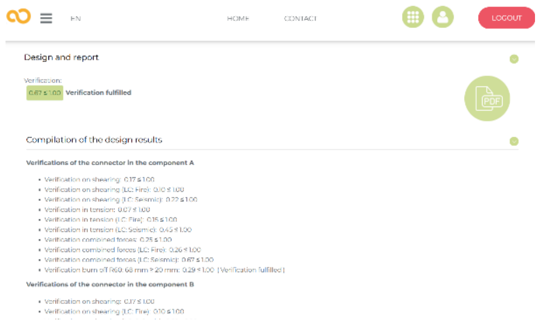
Step 3 – Connection type



Step 4 – Material & geometry



Step 5 – Loads



Step 6 – Design and report

3. GENERAL RECOMMENDATIONS

Panel Alignment. The HTC-P2P connector enables the alignment of CLT panels by pulling the panels together during installation. Prior to installing the connector, ensure that the panels are placed with a gap of less than 20 mm according to the HTC-P2P IFU. Misalignments of up to 5 mm along the joint are also permissible. The connector does not assist with aligning panels in the out-of-plane direction (e.g., vertical alignment for CLT floors); such alignment should be achieved using traditional methods like shimming or screwing.

CLT Panel Joints. The HTC-P2P connector can be utilized with various joint geometries, provided the overlap between joints does not interfere with the geometry of the cutout. Specifically, the overlap should occur on a plane outside the cutout depth. Under these conditions, the connector's performance remains unaffected by the joint configuration. Typical applications with different joint configurations for the HTC-P2P connector are shown in Fig 1.4.

Water and Moisture Management. Connectors should be stored and used in environmental conditions that comply with the moisture requirements prescribed in EN1995-1-1 for Service Classes 1 and 2. Store connectors in a dry location (e.g., indoors) and avoid exposure to stagnant water or rain, even when they are in their original storage box.

Before installation, ensure that the cutout is free of water, dust and chipped wood. Protect the cutout during the transportation phase of the CLT panels, and until the connector installation, by using waterproofing membranes. These membranes should be completely removed from the cutout before inserting the connector (e.g., by cutting the membrane along the cutout profile).

At installation, the connector should have a moisture content below 18%. If the connector absorbs water at the jobsite (up to 60 minutes), swelling of the plug width by up to about 1.0 mm can be observed. This is compatible with the cutout geometry and should not cause issues during installation. After installation, protect the connector from moisture and standing water by covering it with a waterproof membrane. If the connector becomes wet, allow it to dry until the moisture content falls below 18% before covering it. This practice helps prevent mold formation during the connector's service life.

Wet/Dry Cycles. Wet/dry cycles, resulting in the swelling and shrinking of the connector, do not affect its performance. The connector's performance has been assessed without pre-tensioning, so there are no risks related to parts loosening due to swelling or shrinking of the wedges. The connector's stiffness may temporarily increase if wet after installation. This is due to additional pre-tensioning between the connector and the CLT panels. Potential losses of pre-stress during the connector’s service life have already been considered in the product performance assessment which constituted the basis for ETA-24/1199.

Releasability and Reusability. The connector is fully releasable using the reverse mode of the impact wrench SIW 6AT-22 along with the offset adapter. This feature allows for complete removal of the connector or adjustments during the initial installation on the jobsite. The connector is not qualified or approved for reuse, neither in the same nor in different structures.

Airtightness and Smoke Tightness: The HTC-P2P connector does not affect the airtightness and smoke tightness of the joint. The connector helps aligning the CLT panels during its installation. The connector is compatible with traditional approaches for ensuring the airtightness and smoke tightness of CLT panel joints, such as using selected joint shapes (e.g., continuous slot-key joints) or applying protective adhesive tape across the joint between panels. The design of the joint's airtightness and smoke tightness can be carried out according to existing guidelines for CLT panel-to-panel connections, with no special provisions needed for HTC-P2P.

4. REFERENCES

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