THE LEADING TECHNOLOGY IN STANDARDIZED TIMBER CONNECTION SYSTEMS

SHERPA Manual

EFFICIENT, FLEXIBLE, SAFE

SHERPA CONNECTION SYSTEMS

SHERPA®

Ice Park Eilat Israel

Architecture:
Feigin Architects

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WIEHAG

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As of November 2013
A publication of SHERPA Connection Systems GmbH, prepared in association with holz.bau forschungs gmbh.

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Perceiving innovation as a challenge

Economic and efficient construction is the order of the day in modern timber construction. Efficient connection technology is indispensable in expanding the use of timber and hence timber construction. Screws, bonding agents and innovative connection technologies will acquire greater significance as the future unfolds.

Years of research and development in cooperation with holz.bau forschungs gmbh at Graz University of Technology have succeeded in expanding the SHERPA product family to include high-performance connectors. The world's largest connector family now services a load range of 5 to 300 kN. We pay particular attention to ensuring that all types function are based on the same physical principle and hence do not require users to adjust their thoughts. This does more than just save time. It prevents unnecessary mistakes in planning and implementation. The efficient wood connection system means we offer a connection concept that boosts the competitiveness of timber construction compared with steel and reinforced concrete frames.

Excellence delivers trust!

A qualified carpenter, Vinzenz Harrer worked for many years as a polisher and construction manager. Founding Vinzenz Harrer GmbH in 1994, he developed the company from a traditional timber construction firm to become a trade enterprise – the "leading specialist for solutions in timber construction". Among others, the company focuses on near-natural and sustainable construction products for energy-optimised building, and now operates in many areas of timber and prefab construction. Our sales channels in over 30 countries have helped establish outstanding expertise in a variety of building standards.

Vinzenz Harrer

Managing Director at
SHERPA Connection
Systems GmbH

The road to success

DI (FH) Josef Kowal has been part of the SHERPA team since March 2011, and is on hand to provide technical information for customers and partners. The SHERPA connectors deliver a high degree of standardisation, helping to introduce automatic procedures as quickly as possible to the practical field in planning and processing. Nevertheless, the system finds repeated use in individual solutions. This is only possible based on suitable planning documents. The new SHERPA Manual, its extensive technical data and explanations, also the calculation examples, is intended to provide for precisely this need.
In its design, a clear and conscious focus was placed on practical topics, including connections between wood and steel or reinforced concrete.

DI (FH) Josef Kowal

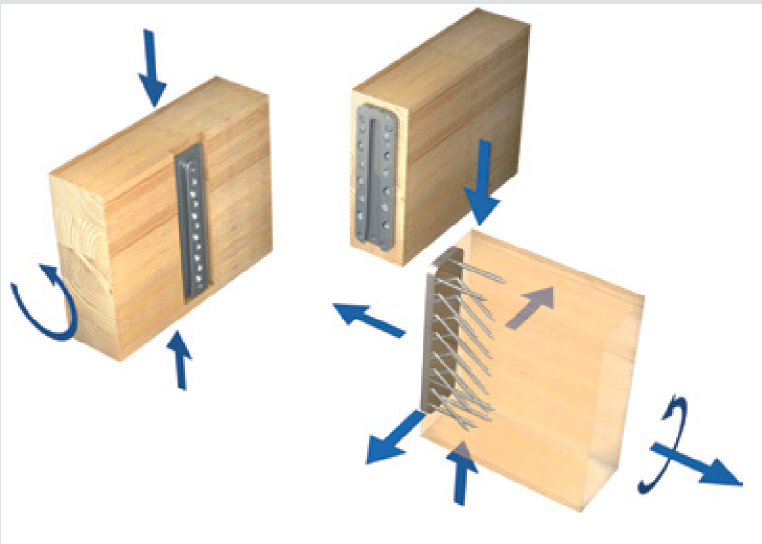
Technical Support
SHERPA Connection
Systems GmbH

SHERPA FOR WALLS, CEILINGS AND SUPPORTING FRAMEWORK

How it works

SHERPA connectors consist of two aluminium plates, joined friction-locked according to the principle of a classic dovetail connection.

This ingeniously simple system permits safe load absorption in, opposite and across the direction of insertion. Tensile and compressive forces are absorbed with equal ease, and the accommodation of momentary stress is also guaranteed.



Success in construction

The mature and tested SHERPA technology permits efficient & competitive planning and execution of demanding tasks throughout the construction industry.

The range of applications stretch from nodal points in timber engineering, connection situations to other building materials such as steel or concrete, through to conservatories, carports and stairs.

The broad product family delivers a tailored, secure and economic solution for any task. The high level of prefabrication and the rapid assembly of these standardised connectors guarantee economic implementation of the most varied projects.

TIMBER ENGINEERING

CARPORTS

STEEL-WOOD

CONCRETE-WOOD

CONSERVATORIES

STAIRS

FURNITURE CONSTRUCTION

THE BENEFITS ARE PERFECTLY EVIDENT:

SECURITY BASED ON A CERTIFIED SYSTEM

MULTIFUNCTIONAL IN STRENGTH AND APPLICATION

STANDARDISED AND SIMPLE CALCULATION

HIGH LEVEL OF PREFABRICATION

RAPID ASSEMBLY

PRELIMINARY RATING TOOL

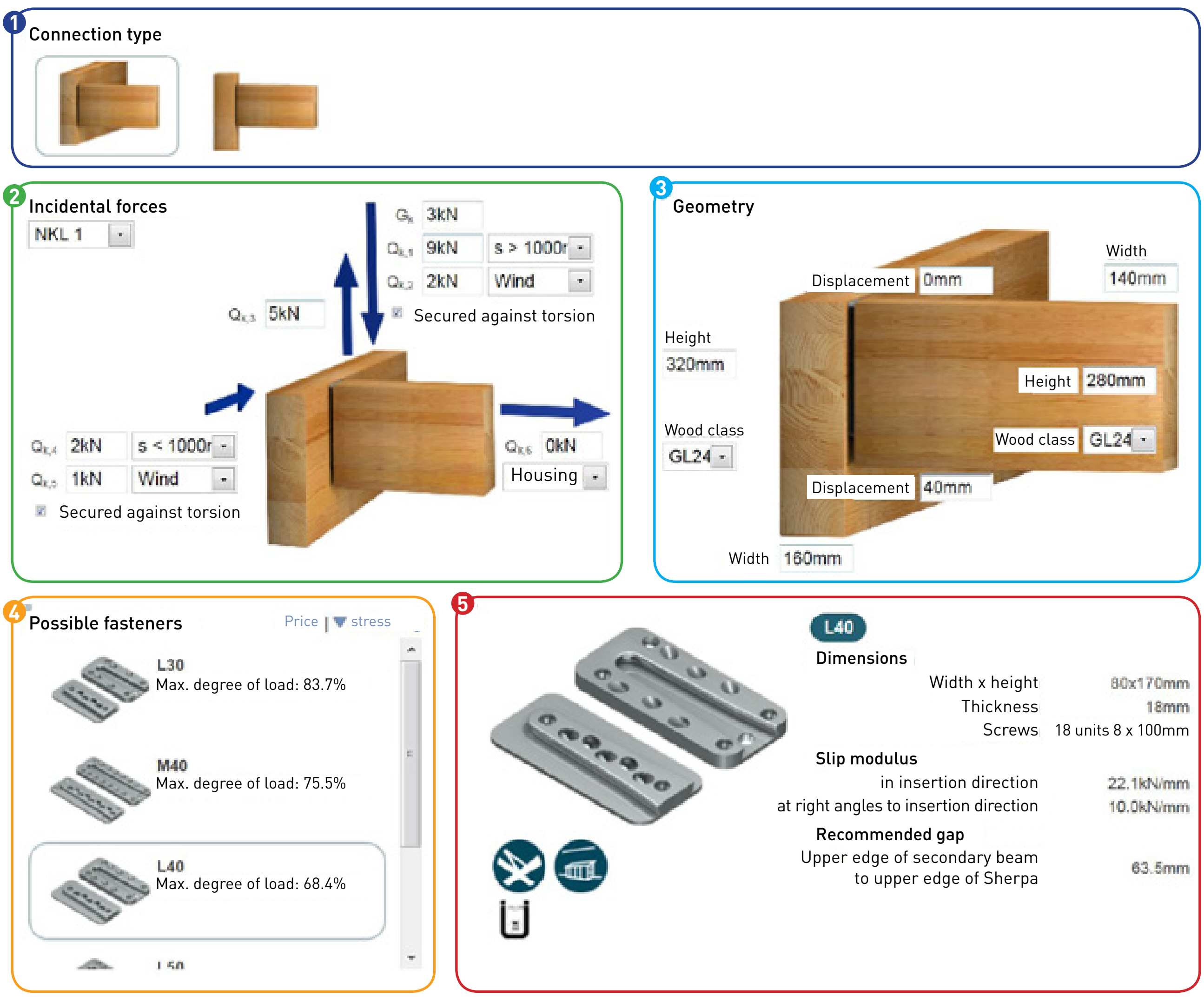
The fast track to the matching SHERPA connector

Our system connectors deliver a whole ream of benefits, among them that all types function based on the same physical principle, irrespective of size. Despite this high level of standardisation, it will be necessary to consider fundamental aspects before initial project deployment. Today, though, we live in an age of quick-fire decisions. Delays must be avoided under all circumstances to ensure smooth procedures.

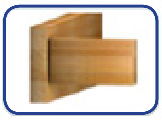
The SHERPA online rating tool was developed with just this in mind; it is accessible at any time and from anywhere by mobile devices such as smartphone, tablet computer or PC. It uses browser-based technology and therefore does not require any installation; the latest version is always available for you to calculate direct ratings.

Indemnification

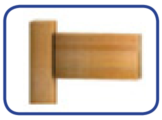
The preliminary rating tool permits rapid and efficient selection of connectors depending on a variety of exposures as defined in EN 1995-1-1 for different connection situations. It requires the entry of constant and changing loads and geometric data for the components involved.
We hereby provide notice that SHERPA Connections Systems is unable to accept any liability for the results of calculations produced using this free software.



1. Node type



Selection number 1:
Main and secondary
beam connection

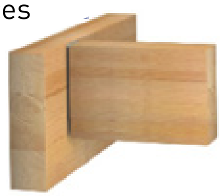


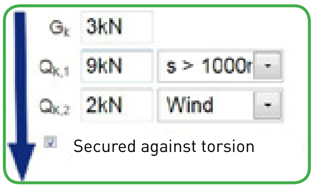
Selection number 2:
Support and secondary
beam connection

Currently there is a selection of two typical connection situations. The main and secondary beam connection found most frequently in practice is available alongside the version with support.

2. Prevailing forces

Enter lifting forces





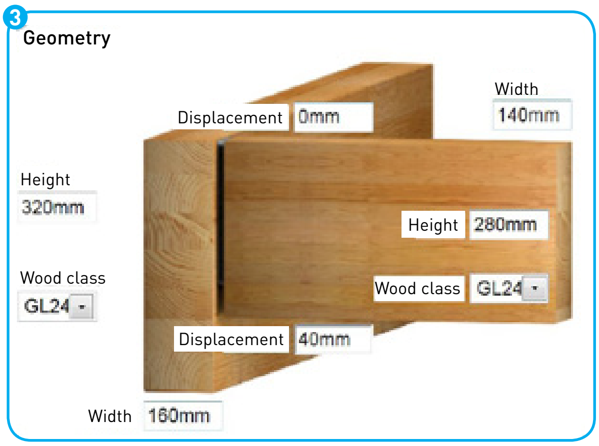
Constant and
changing forces
in the insert direction

Load at right angles
to the insert direction

Tension resistance

In box 2, please enter the characteristic load values. The partial safety factors in each case are based on the EuroCode.

3. Geometry

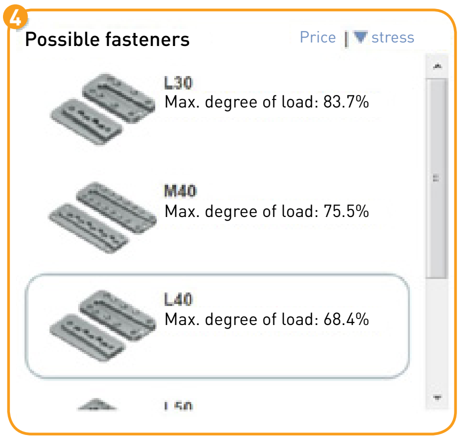


Details concerning the component dimensions and, if available, the corresponding height offset are crucial in the correct selection of connector. This information is the only way to make a comparison in terms of minimum gaps.

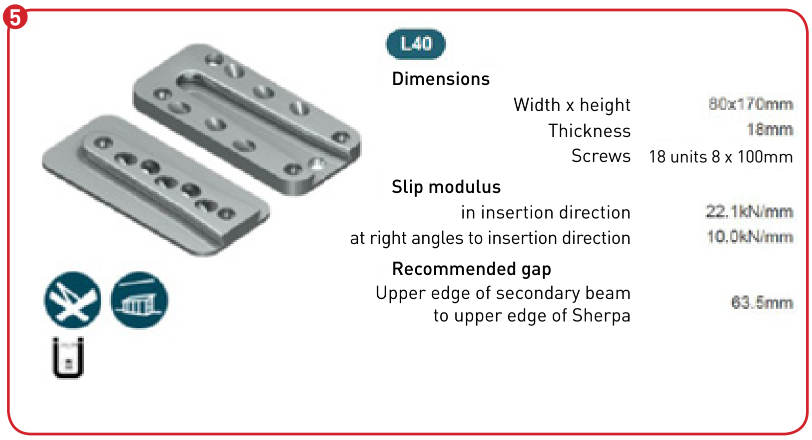
Based on its gross density, the timber material used directly influences the connector performance. A reliable and definite identification of possible connectors and their numbers can only be made after entry of these data.

At least one connector will usually be displayed for selection once the peripheral data are entered. Technical Support would be pleased to assist if you have not received a satisfactory result.

4. Possible connectors



5. Selected connectors



1 Short presentation of the semi-probabilistic safety concept

2 Application

3 Technical data

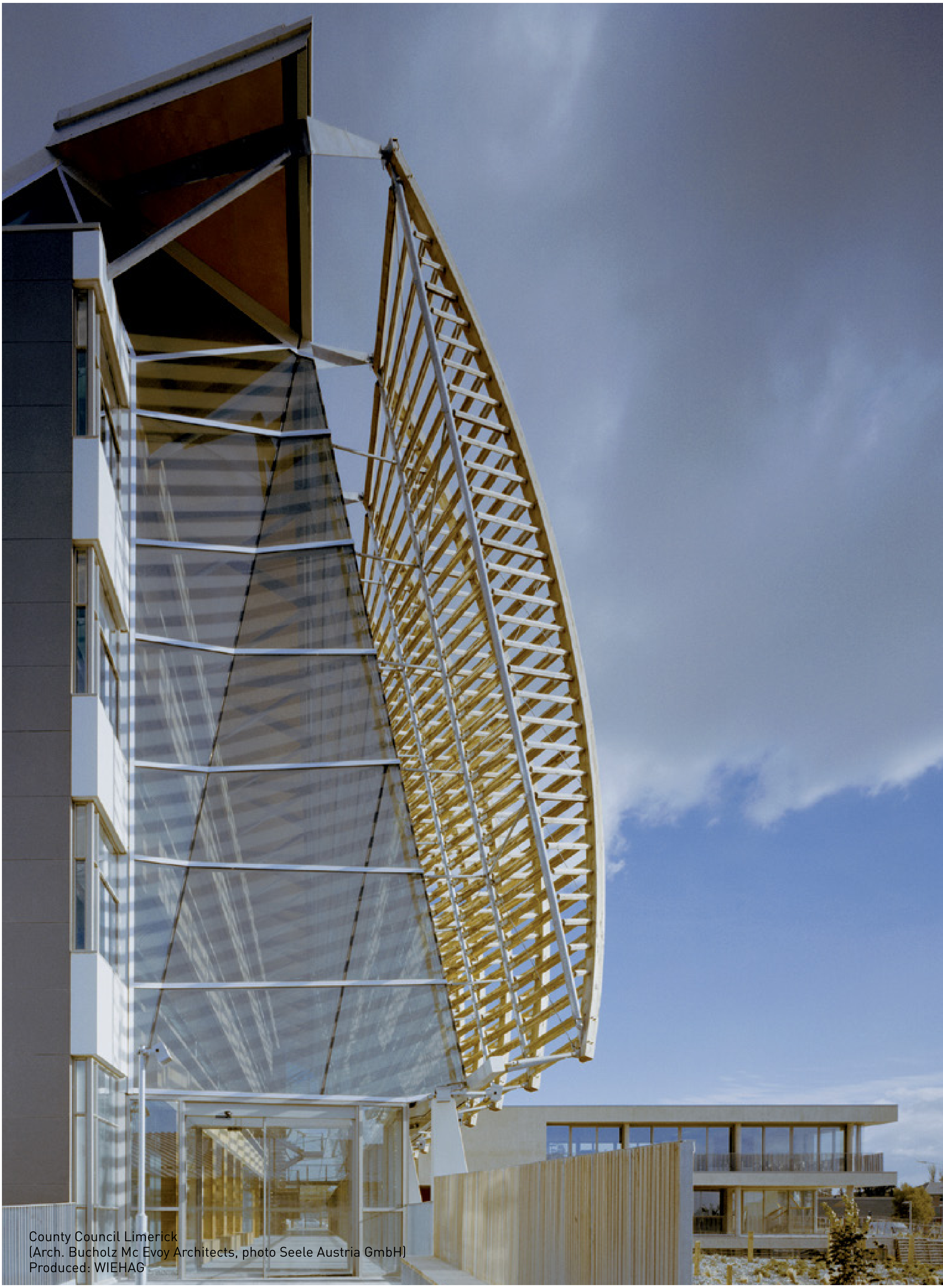
4 Modelling

5 Steel and steel reinforced concrete connection

6 Calculation examples XS to XXL Series

7 Product range

8 Literature and standards



County Council Limerick
(Arch. Bucholz Mc Evoy Architects, photo Seele Austria GmbH)
Produced: WIEHAG

1 Short presentation of the semi-probabilistic safety concept

1 Short presentation of semi-probabilistic safety concepts

Comments on Chapter 1:
This chapter contains a textual summary of the current valid European standards and of course makes no claim to be complete. It does not replace at any time the detailed definitions of the respective standards for practical applications, which must be consulted in every case, and must be considered binding.

1.1 Introduction

Wood construction has developed very differently around the world, influenced by each culture and the predominant types of wood. Since the nineteen-seventies, national regulations have attempted to eradicate trade barriers through a stage of cross-European harmonisation. There are now documents available within the standards family of Eurocodes which make it possible to uniformly measure wood structures on a European level.

The basic documents are extended through national appendices in order to take into account the various needs and requirements of the individual countries.
Well-founded knowledge is needed for secure handling of semi-probabilistic measurement concepts in order to apply EuroCode 5.

The methods to calculate wood structures using this safety concept are presented in the following sections. The presentation of some points is made from the national appendix for Austria.

The European standards to measure supporting structures can be found in Fig. 1.1.

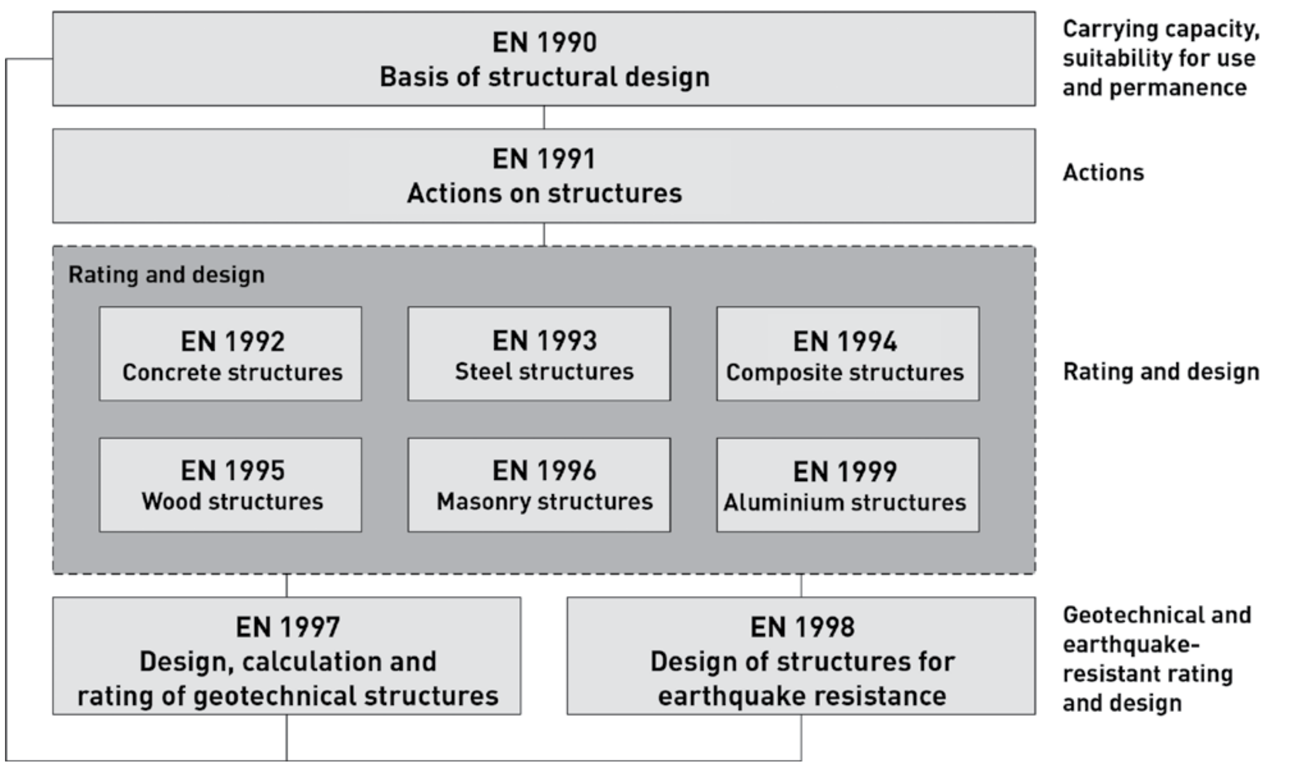


Fig. 1.1: An overview of European standards [1]

1.2 Basics on the measurement of limit states

1.2.1 General

The EuroCode standards family is based on semi-probabilistic safety concepts, and uses limit states to define structural reliability related to structural safety, serviceability and durability of structures. If the limit states are exceeded, the requirements which have been established for a structure can no longer be safely fulfilled.

1.2.2 Limit states for structural carrying capacity [2]

Limit states for structural carrying capacity are those states which, when exceeded, can lead to the collapse of a structure or other form of failure.

Indications of the limit states for structural carrying capacity are:

» Loss of balance in the entire structure or individual strutural sections (consider assembly states)

» Loss of stability (especially in slender structural components)

» Introduction of failure mechanisms to the entire system or individual structural areas.

1.2.3 Limit states for serviceability [2]

Deformation or bowing of a structure with stress must be held within defined limits in order to prevent possible damage (e.g. crack formation) in components such as ceilings, floors, separating walls, installations, etc. This also applies to fulfilling requirements in regards to usability (bowing, vibration) and the appearance or comfort of the user.

1.2.4 Proof using partial safety coefficient methods

The safety concept anchored in EuroCode relates to
proving using a global safety coefficient - in contrast to deterministic
safety concepts ("procedures for reliable stresses" [3]) using so-called partial safety factor coefficients. These safety factors
are applied in order to keep the risk of failure of a supporting structure, and the associated model assumptions for calculation, as low as possible. One must therefore demonstrate that in all relevant design situations, the design values for actions or their effects will not exceed any relevant limit states. A benefit of this method is the clear separation of the most important influence factors to measure supporting structures.

Some of the most important influence factors include:

» Influences: Payloads, snow, wind, temperatures, . . .

» Construction material properties: Strength, stiffness, . . .

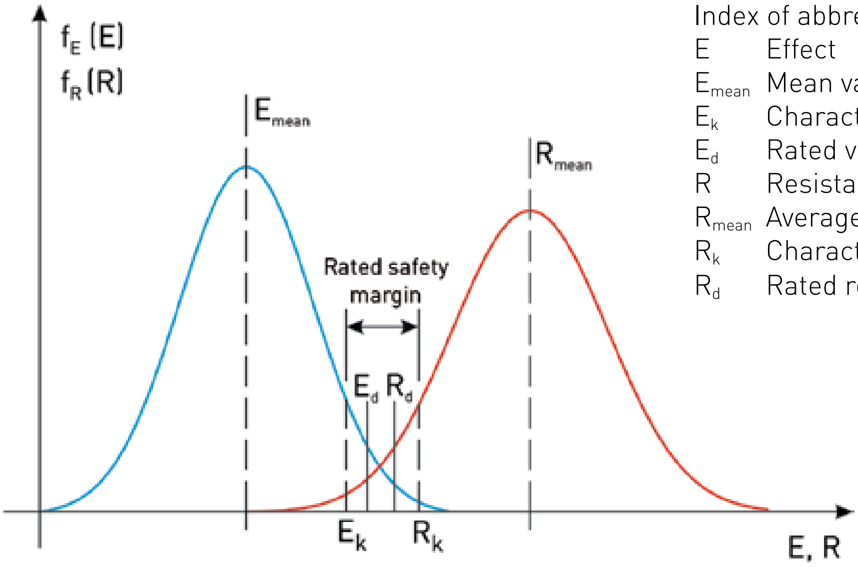
» Geometric dimensions: Measurements, geometries, . . .

All these influence factors are random variables which are subject to statistical variation.

This connection is shown in Fig. 1.2 in a graphical illustration using typical distribution functions for influence E and carrying capacity R of a construction component. Both random variables therefore show a distributive characteristic. Failure in this presentation can be shown for those points in which R - E < 0.

In the case of R - E = 0 [translator's note: original shows R - E - 0, this was changed here to make it correspond to the above]. Due to the fact that for both distribution functions – especially the ends of the distributions – insufficient empirical knowledge is generally available, the semi-probabilistic safety concept in this context is sufficient in order to ensure that the distribution functions continue to provide a sufficient safety margin between defined values (characteristic values or rated values).

The measurement of supporting structures can be carried out independent of construction materials through the uniform concept of Eurocodes with partial safety coefficients, and calculations for all materials can be based on the same concepts.



Index of abbreviations:

E	Effect
E_{mean}	Mean value of the effect
E_k	Characteristic value of the effect
E_d	Rated value of the effect
R	Resistance
R_{mean}	Average resistance value
R_k	Characteristic resistance value
R_d	Rated resistance value

Fig. 1.2: Semi-probabilistic safety concept

Due to the sometimes highly distributed properties of raw and construction wood materials in regards to mechanical properties, the othotropic (various properties in relation to the length, radial and tangential axes) material and moisture behaviour (shrinkage and swelling in these directions) and inhomogeneities in the building materials structure
are additionally applied to semi-probabilistic safety concepts for measurement and design of wood supporting structures.

This makes it possible, among other things, to consider various levels of moisture contents, the duration of the load effect, the reduction in cross-sectional surfaces due to cracks and/or timedependent deformation behaviour in wood construction.

1.3 Effects and effect combinations

1.3.1 Terms in connection with effects

Effects in the sense of the European standards concept are considered to mean in the following superordinate fashion:

» "a group of forces (loads) which effect a supporting structure (direct effects)" [N1],

as well as

» "a group of imposed deformations or acceleration which are caused, for example, by changes in temperature and humidity, uneven settlement or earthquakes (indirect effects)" [N1]

The following Fig. 1.3 shows an overview of the "effects standards" as per EN 1991 which may also require consideration.

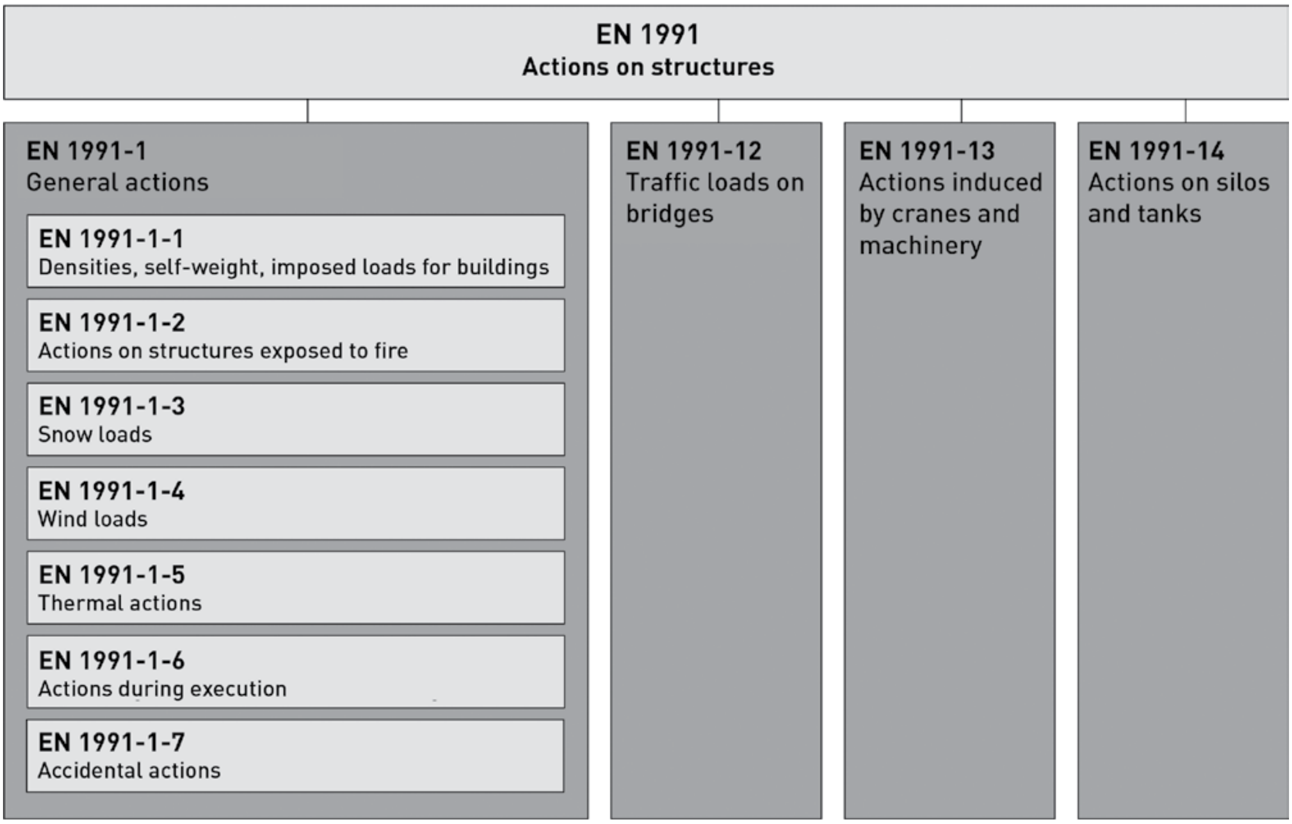


Fig. 1.3: EN standards for the consideration of effects

1.3.1.1 Effects of actions on a supporting structure

Stresses are placed on construction components through the effect on the supporting structure, for example cutting forces, stresses and strains or reactions in the global structure to bending and twisting.

1.3.1.2 Classification of the effects [N1]

Constant effects (G)
Effects (direct effects, such as the structure's own weight, building fixtures, etc., indirect effects such as shrinkage, unequal settling, etc.) from which one can assume that they will work in the same direction throughout the entire period that the structure is used,
and their temporal dimension changes may be neglected.

Changing effects (Q)
Effects (e.g. payloads on ceilings, snow loads, wind loads) which do not
always cause effects in the same direction, and whose temporal dimension changes cannot be neglected.

Extraordinary effects (A)
Effects (e.g. fire, explosion, earthquakes, vehicle impact, etc.) which are of short duration as a rule, but are of a meaningful dimension, and may not occur with any great probability during the planned useful life of the structure.

Characteristic value of an effect (G_k or Q_k)
Most important representative value of an effect.

Rated value of an effect (G_d or Q_d)
Value of an effect which can be determined by multiplying the representative values with a partial safety coefficient.

1.3.2 Combination of effects (without fatigue)

Because effects on supporting structures usually occur in combination with others, such as changing effects, various combinations must be applied with consideration of the probability of occurrence on the supporting structure.

A distinction is made between

» constant situations which correspond to the usual conditions under which the supporting structure is used;

» temporary situations which are related to temporally limited states of the supporting structure

» extraordinary situations which are related to extraordinary conditions for the supporting structure, such as fire, explosions, impact or consequences of local failure;

» situations with earthquakes, which include the conditions related to earthquake effects on the supporting structure [3]

"The chosen measurement situations must sufficiently and exactly capture all conditions which can be expected during the execution and use of a supporting structure. [N1].

The following general principle applies to combination rules:

Each effect combination should show a dominant changing effect (leading effect with a maximum) or an extraordinary effect (earthquake, vehicle impact, etc.).

The effects from other influences (concomitant effects) are also to be considered, as long as it makes sense to do so for physical or operating purposes. Thus changing effects can also occur as leading effects. Hence one can determine that the number of various payload combinations correspond to at least one of the differentiated, independent, changing effects. The result should be the combination with the least favourable effects on the supporting structure's behaviour. The integration of effects takes place using partial safety coefficients γ_G and γ_Q and combination coef ψ.

1.3.2.1 Combination rules for proving limit states for support capacity

Combination of effects with constant (normal situations) and temporary (construction situations) measurement situations (= basic combination) [N1]

$$E_d = \sum_{j \geq 1} \gamma_{G,j} \cdot G_{k,j} \oplus \gamma_{Q,1} \cdot Q_{k,1} \oplus \sum_{i > 1} \gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i} \tag{1.1}$$

with
E_d Measurement value with the effects combination
Σ "total effects of" (summation)
"are to be combined"
$G_{k,j}$ Characteristic value of constant effect j
$\gamma_{G,j}$ Partial safety coefficient for constant effect j
$Q_{k,1}$ Characteristic value for the dominant changing effect
$\gamma_{Q,1}$ Partial safety coefficient for the dominant changing effect
$Q_{k,i}$ Characteristic value of the concomitant changing effect i
$\gamma_{Q,i}$ Partial safety coefficient for the concomitant changing effect i
ψ Combination coefficient of a changing effect

Combination of effects with extraordinary measurement situations (fire, explosions, . . .) [N1]

$$E_d = \sum_{j \geq 1} G_{k,j} \oplus A_d \oplus (\psi_{1,1} \text{ oder } \psi_{2,1}) \cdot Q_{k,1} \oplus \sum_{i > 1} \psi_{2,i} \cdot Q_{k,i} \tag{1.2}$$

with
E_d Measurement value with an effects combination in an extraordinary measurement situation
A_d Measurement value of an extraordinary effect
$\psi_{1,1}$ Coefficient for frequent values of a dominant changing effect
$\psi_{2,1}$ Coefficient for a semi-constant value of the dominant changing effect
$\psi_{2,i}$ Coefficient for a semi-constant value of the concomitant changing effects

Combination of effects for measurement situations concerning earthquakes [N1]

$$E_{dAE} = \sum_{j \geq 1} G_{k,j} \oplus \gamma_I \cdot A_{Ek} \oplus \sum_{i \geq 1} \psi_{2,i} \cdot Q_{k,i} \tag{1.3}$$

with
E_{dAE} Measurement value for effects combinations for the measurement situation concerning earthquakes
A_{Ek} Characteristic value of an effect as a consequence of earthquakes
γ_I Weighting factor (see EN 1998)

1.3.2.2 Combination rules for proof of usability in limit states

Combinations of effects must be adjusted to the structural behaviour and the building's use and the associated usability requirements.

In general, the conditions of ÖNORM EN 1990:2013

$$E_d \leq C_d \tag{1.4}$$

must be fulfilled.

with
E_d Measurement value of effects on the level of usability
C_d Measurement value of the limit for the decisive usability criterion

Characteristic combination

Use for irreversible effects on a supporting structure

$$E_d = \sum_{j \geq 1} G_{k,j} \oplus Q_{k,1} \oplus \sum_{i > 1} \psi_{0,i} \cdot Q_{k,i} \tag{1.5}$$

Frequent combination

Use for reversible effects on a supporting structure

$$E_d = \sum_{j \geq 1} G_{k,j} \oplus \psi_{1,1} \cdot Q_{k,1} \oplus \sum_{i > 1} \psi_{2,i} \cdot Q_{k,i} \tag{1.6}$$

Semi-constant combination

Use for long-term effects (e.g. appearance) on a supporting structure

$$E_d = \sum_{j \geq 1} G_{k,j} \oplus \sum_{i \geq 1} \psi_{2,i} \cdot Q_{k,i} \tag{1.7}$$

1.3.3 Partial safety coefficients for effects

Using the partial safety coefficients, the model uncertainties and dimensional changes of the effects and their actions are considered.

Tab. 1.1: Rated value of the effects, and recommended partial safety coefficient as a summary [N1]

Limit state of the carrying capacity for evidence of storage safety (EQU) and carrying capacity (STR) of components without geotechnical effects					
Combination	Constant effects		Changing effects		
	Unfavourable	Favourable	Leading effect	Concomitant effect	
Basic combination	$\gamma_{G,j,sup} \cdot G_{k,j,sup}$	$\gamma_{G,j,inf} \cdot G_{k,j,inf}$	$\gamma_{Q,1} \cdot Q_{k,1}$	$\gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i}$	
$\gamma_{G,j,sup} = 1{,}35$	STR evidence				
$\gamma_{G,j,inf} = 1{,}00$	STR evidence				
$\gamma_{G,j,sup} = 1{,}10$	EQU evidence (e.g. lifting forces following wind suction; supporting structure is considered as a stiff body)				
$\gamma_{G,j,inf} = 0{,}90$	EQU evidence (e.g. lifting forces following wind suction; supporting structure is considered as a stiff body)				
$\gamma_{G,j,sup} = 1{,}35$	EQU evidence (resistance on the component side is considered along with it; for combined EQU/STR evidence)				
$\gamma_{G,j,inf} = 1{,}15$	EQU evidence (resistance on the component side is considered along with it; for combined EQU/STR evidence)				
$\gamma_{Q,1} = 1{,}50$	STR and EQU evidence with unfavourable effect (0 for favourable effect)				
$\gamma_{Q,i} = 1{,}50$	STR and EQU evidence with unfavourable effect (0 for favourable effect)				
$\gamma_{G,j,sup} / \gamma_{G,j,inf}$	Partial safety coefficients for calculation with upper/lower measurement values				
$G_{k,j,sup} / G_{k,j,inf}$	Upper/lower characteristic value of a constant effect				
ψ	Combination coefficient				
A_d	Measured value of an extraordinary effect				
A_{Ed}	Measurement value of an effect following an earthquake, $A_{Ed} = \gamma_I \cdot A_{Ek}$ (γ_I ... weighting factor)				
				Main	Further
Extraordinary	$G_{k,j,sup}$	$G_{k,j,inf}$	A_d	$(\psi_{1,1}$ or $\psi_{2,1}) \cdot Q_{k,1}$	$\psi_{2,i} \cdot Q_{k,i}$
Earthquake	$G_{k,j,sup}$	$G_{k,j,inf}$	$\gamma_I \cdot A_{Ek}$ or A_{Ed}		$\psi_{2,i} \cdot Q_{k,i}$

Limit states of usability				
Combination	Constant effects		Changing effects	
	Unfavourable	Favourable	dominant	Further
Characteristic	$G_{k,j,sup}$	$G_{k,j,inf}$	$Q_{k,1}$	$\psi_{0,i} \cdot Q_{k,i}$
Frequent	$G_{k,j,sup}$	$G_{k,j,inf}$	$\psi_{1,1} \cdot Q_{k,1}$	$\psi_{2,i} \cdot Q_{k,i}$
Semi-constant	$G_{k,j,sup}$	$G_{k,j,inf}$	$\psi_{2,1} \cdot Q_{k,1}$	$\psi_{2,i} \cdot Q_{k,i}$

Comment:
For extraordinary measurement situations and earthquakes at the limit state of carrying capacity as well as evidence at the limit state of usability, the partial safety factor 1.0 is used.

1.3.4 Combination coefficients $\psi 0$, $\psi 1$ and $\psi 2$

Using combination coefficients ψ_0, ψ_1 and ψ_2, the reduced probability of concomitant occurrence of unfavourable effects can be considered on several independent, changing effects.

The effects are divided into:

» **Characteristic value of an effect [N1]**
The characteristic value of an effect is chosen in such a way that it is not exceeded during the time period under consideration.

» **Rare value [N1]**
The combination value of a rarely occurring, changing effect is used in combination with a changing effect.

» **Frequent value of a changing effect [N1]**
The combination value of a frequently occurring, changing effect is chosen in such a way that the frequency of exceeding the value within the useful life is limited to a specific value.

» **Semi-constant value of a changing effect [N1]**
The combination effect of a semi-constant occurring, changing effect is chosen in such a way that the frequency of exceeding the value occurs over a significant part of the time period considered.

Tab. 1.2: Recommended combination coefficient as per ÖNORM EN 1990:2013

Effects	ψ_0	ψ_1	ψ_2
Payload in a building [a]			
Category A: Residential buildings	0.7	0.5	0.3
Category B: Office buildings	0.7	0.5	0.3
Category C: Communal areas	0.7	0.7	0.6
Category D: Sales areas	0.7	0.7	0.6
Category E: Storage areas	1.0	0.9	0.8
Category F: Vehicle traffic in the building, vehicle weight ≤ 30 kN	0.7	0.7	0.6
Category G: Vehicle traffic in the building, 30 kN < vehicle weight ≤ 160 kN	0.7	0.5	0.3
Category H: Roofs	0	0	0
Snow load on buildings (see EN 1991-1-3) [b]			
Finland, Iceland, Norway, Sweden	0.7	0.5	0.2
Areas in CEN Member States with an altitude greater than 1000 metres above sea level NN	0.7	0.5	0.2
Areas in CEN Member States with an altitude less than 1000 metres above sea level NN	0.5	0.2	0
Wind loads in buildings (see EN 1991-1-4) [c]	0.6	0.2	0
Temperature applications (without fire) in buildings, see EN 1991-1-5 [d]	0.6	0.5	0

Remarks:
Determining the combination coefficients is shown in the national appendices
[a] For payloads in buildings, see EN 1991-1-1
[b] For snow loads, see EN 1991-1-3. ,The significant local conditions must be considered in countries which are not explicitly named.
[c] For wind loads, see EN 1991-1-4
[d] For temperature variations, see EN 1991-1-5

1.4 Variable basis

1.4.1 Measurement values for load capability (load capacity)

The measurement value for load capacity of a cross-section, component or a combination is calculated for wooden structures using formula (1.8).

$$X_d = \frac{k_{mod} \cdot X_k}{\gamma_M} \quad \text{or} \quad R_d = \frac{k_{mod} \cdot R_k}{\gamma_M} \tag{1.8}$$

with

X_k or R_k	Characteristic value of a strength characteristic or load capability
k_{mod}	Modification coefficient to consider the load efficiency duration and the use class; see Table 1.6
γ_M	Partial safety coefficient of a construction material's properties, see Table 1.5

The modification coefficient k_{mod} is a safety factor which takes into account the influence of supporting behaviour with various moisture contents and the duration of the load effects. The safety factor γ_M is a partial safety coefficient which considers the most unfavourable distribution of construction material properties, model uncertainty and dimensional variations.

1.4.2 Effects and environmental influences

1.4.2.1 Load effect duration classes (KLED)

The classification of the duration of an effect on a building/supporting structure can be found in Table 1.3.

Tab. 1.3: Classification of supporting structures in KLED as per ÖNORM EN 1995-1-1:2009 [N2] and ÖNORM B 1995-1-1:2010 [N3]

KLED	Magnitude of the accumulated load effect duration	Examples
constant	longer than 10 years	Own load of supporting structures, fixtures, fixed installations and building equipment
long	6 months to 10 years	Storage materials
average	1 week to 6 months	Payloads, snow loads at terrain height greater than 1000 metres above sea level NN
short	shorter than one week	Snow loads at terrain height to 1000 metres above sea level NN, wind loads
very short	shorter than 1 minute	Unusual loads, impact loads Earthquake loads

1.4.2.2 Use classes (NKL)

The hygroscopic characteristics of wood change with the wood's moisture increasing and decreasing due to the environmental humidity. Adjusting to wood's equilibrium moisture content influences the technical properties of the wood (with increasing moisture, the strength of the E modulus decreases). It is necessary to divide the supporting structures into use classes due to environmental influences on wooden components.

Tab. 1.4: Classification of supporting structures in use classes [N3]

Use class	Environmental weather		Wood moisture for most conifers	Supporting structure or building type
	Temperature	Relative humidity [a]		
1	20° C	≤ 65 %	≤ 12 %	Inside of residential, school and administrative buildings
2	20° C	≤ 85 %	≤ 20 %	Inside of commercial buildings such as warehouses, riding halls and industrial buildings as well as roofed structures outside, whose components are not exposed to the elements (30° rainfall angle)
3	-	-	> 20%	Components outside with structural wood protection

[a] Relative humidity may not exceed the given values over several weeks for use classes 1 and 2

1.5 Construction material properties

1.5.1 Partial safety coefficients for construction material properties and resistances

Tab. 1.5: Recommended partial safety coefficients for construction material properties as per ÖNORM EN 1995-1-1;2009.

Limit state of supporting capacity	γ_M
Basic combination	
Solid wood Glulam LVL, plywood, OSB compounds nail panels (steel properties)	1.30 1.25 1.20 1.30 1.25
extraordinary combination	
General	1.00
Limit state for usability	γ_M
General	1.00

1.5.2 Modification coefficients for strength with consideration of the user class and load effect duration

Remarks from EN 1995-1-1;2009: Assumes a load combination with various load effects durations; as a rule, use the value for k_{mod} with a short duration. Consists of a compound of wood parts with various time-dependent behaviour, so one should determine $k_{mod} = \sqrt{k_{mod,1} \cdot k_{mod,2}}$ k_{mod} with $k_{mod,1}$ and $k_{mod,2}$ for both wood parts.

Tab. 1.6: Recommended modification coefficient k_{mod} [N2]

Construction material (reference standard)	Use class		
Solid wood (EN 14081-1) Glulam (EN 14080) Glued laminated timber (EN 14374, EN 14279) Plywood (EN 636-1, EN 636-2, EN 636-3)			
Load effect duration	1	2	3
constant	0.60	0.60	0.50
long	0.70	0.70	0.55
average	0.80	0.80	0.65
short	0.90	0.90	0.70
very short	1.10	1.10	0.90

Tab. 1.7: Recommended deformation coefficient k_{def} [N2]

Material	Use class		
	1	2	3
Solid wood Glulam Laminated veneer timber Glued laminated timber Plywood boards	0.60	0.80	2.00

Comments on EN 1995-1-1;2009:
This consists of a compound of wood construction parts with the same time-dependent behaviour, so the k_{def} value should be doubled. If a compound of wood and/or wood materials with various time-dependent behaviour is used, as a rule, the value for k_{def} with deformation coefficients $k_{def,1}$ and $k_{def,2}$ should be applied for the wood construction materials used.

If there is a compound made of wood construction materials with various k_{def} values, use the arithmetic mean. The deformation coefficient for wood should be used for steel sheet/wood compounds.

1.5.3 Construction material parameters

Construction material properties are given characteristic values which correspond to a given quantile value of a statistical distribution. As a rule, the

» 5% quantile value is to be used for strength and gross density, and

» 5% quantile value or mean value for stiffness

1.5.3.1 Solid wood

Tab. 1.8: Characteristic strength values for coniferous wood as per ÖNORM EN 338:2009 and ÖNORM B 1995-1-1:2010

		Coniferous											
		C14	C16	C18	C20	C22	C24	C27	C30	C35	C40	C45[3]	C50[3]
Strength properties [N/mm²]													
Bending	$f_{m,k}$	14	16	18	20	22	24	27	30	35	40	45	50
Parallel tensile[1]	$f_{t,0,k}$	8	10	11	12	13	14	16	18	21	24	27	30
Right-angle tensile[1]	$f_{t,90,k}$	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Parallel pressure[1]	$f_{c,0,k}$	16	17	18	19	20	21	22	23	25	26	27	29
Right-angle pressure[1]	$f_{c,90,k}$	2.0	2.2	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.1	3.2
Shear[1,4,a]	$f_{v,k}$	3.0	3.2	3.4	3.6	3.8	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Stiffness properties [kN/mm²]													
Average value of the elasticity modulus, parallel	$E_{0,mean}$	7	8	9	9.5	10	11	11.5	12	13	14	15	16
5% quantile of the elasticity modulus, parallel[1]	$E_{0,05}$	4.7	5.4	6.0	6.4	6.7	7.4	7.7	8.0	8.7	9.4	10.0	10.7
Mean value of the elasticity modulus right-angle[1]	$E_{90,mean}$	0.23	0.27	0.30	0.32	0.33	0.37	0.38	0.40	0.43	0.47	0.50	0.53
Mean value of the shear modulus[1]	G_{mean}	0.44	0.50	0.56	0.59	0.63	0.69	0.72	0.75	0.81	0.88	0.94	1.00
Gross density [kg/m³]													
Gross density	ρ_k	290	310	320	330	340	350	370	380	400	420	440	460
Mean value of the gross density	$\rho_{k,mean}$	350	370	380	390	410	420	450	460	480	500	520	550

Remarks about EN 338:2009 [N4]:

[1] The above given values for tensile, pressure and shear resistance which are the 5% quantile of the elasticity modulus. the average value of the elasticity modulus, right angle, for the fibre direction and the mean value of the shear modulus are calculated in Appendix A of EN 338-2009's formulae.

[2] The characteristics in the table apply for wood at 20° C and 65% relative humidity, usual moisture.

[3] It is possible that class C45 and C50 construction wood are no longer available.

[4] The characteristic values for push resistance are given in EN 408 for wood without cracks. The effects of cracks must be treated in the design standards.

Remarks:

[a] In ÖNORM B 1995-1-1:2010, the characteristic value for shear resistance for all strength classes is given, deviating from EN 338:2009 determined by $f_{v,k}$ = 3,1 N/mm² (is currently under scientific investigation, and is is in discussion).

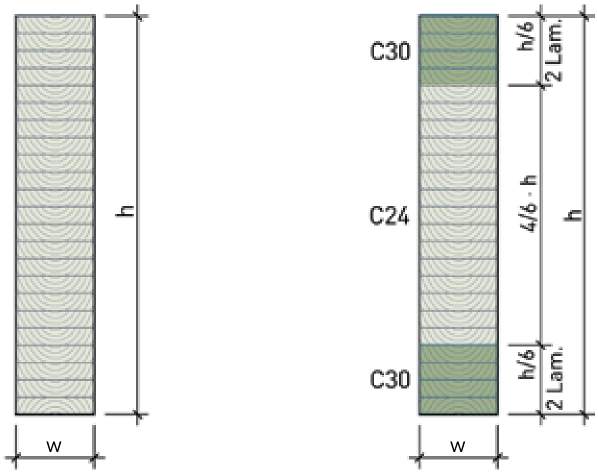
1.5.3.2 Glulam

Glulam (BSH) consists of machine-dried wood laminates glued together. The rigid planar bonding of the lamellae does not require consideration when determining proof of supportability. There are cross-sections with homogeneous (h) and combined (c) construction
(see Fig. 1.4) available.

Tab. 1.9: Characteristic strength values as per ÖNORM EN 1194:1999

		strength class for glulam							
		for homogeneous glulam				for combined glulam			
		GL 24h	GL 28h	GL 32h	GL 36h	GL 24c	GL28c	GL 32c	GL 36c
Strength properties [N/mm²]									
Bending	$f_{m,g,k}$	24	28	32	36	24	28	32	36
Tensile, parallel	$f_{t,0,g,k}$	16.5	19.5	22.5	26	14	16.5	19.5	22.5
Tensile, right-angle[a]	$f_{t,90,g,k}$	0.4	0.45	0.5	0.6	0.35	0.4	0.45	0.5
Pressure, parallel	$f_{c,0,g,k}$	24	26.5	29	31	21	24	26.5	29
Pressure, right-angle	$f_{c,90,g,k}$	2.7	3.0	3.3	3.6	2.4	2.7	3.0	3.3
Shear[1,b]	$f_{v,g,k}$	2.7	3.2	3.8	4.3	2.2	2.7	3.2	3.8
Stiffness properties [N/mm²]									
Average value of the elasticity modulus, parallel	$E_{0,g,mean}$	11,600	12,600	13,700	14,700	11,600	12,600	13,700	14,700
5% quantile of the elasticity modulus, parallel	$E_{0,g,05}$	9,400	10,200	11,100	11,900	9,400	10,200	11,100	11,900
Mean value of the elasticity modulus, right-angle	$E_{90,g,mean}$	390	420	460	490	320	390	420	460
Mean value of the shear modulus	$G_{g,mean}$	720	780	850	910	590	720	780	850
Gross density [kg/m³]									
Gross density	$\rho_{g,k}$	380	410	430	450	350	380	410	430

Remarks on ÖNORM B 1995-1-1:2010:
[1] A strength value for tensile resistance is given for all glulam strength classes, in deviation from the information in EN 1194:1999, which is $f_{v,g,k}$ = 3,0 N/mm². The influence of cracks is to be considered with shear evidence with a factor of k_{cr}.



Homogeneous structure

Combined structure GL 28 c

Fig. 1.4: Examples of cross-section construction of upright rectangular sections subjected to bending stress.

2 Information for use

2 Application

2.1 Planning instructions

2.1.1 European technical approval

The European technical approval, ETA-12/0067 ensures a high degree of performance capability, quality and safety for SHERPA connectors. It contains all relevant conditions for quality assurance, for application areas and material characteristics.

ETA-12/0067 13
1359-CPD-0552 065_0001

2.1.2 Purpose of use and measurement principles

SHERPA connectors are used to erect supporting connections in wood-wood, wood-steel-reinforced concrete or wood-steel structures. These common joints can be executed with end-grain-cross-cut, end-grain-end-grain, cross-cut-cross-cut or end-grain-steel/steel-reinforced concrete combinations.

The following wood or wood materials are allowed as per ETA-12/0067:

» Solid wood as softwood with a minimum strength class of C24 or higher as per EN 338 or EN 14081-1

» Glulam in strength class GL 24 hours or higher as per EN1194 and EN14080.

» Laminated veneer lumber as per EN 14374

» Glulam-similar components such as: double- and triple beams as per prEN 14080

» Plywood as per European technical approvals

» Laminated veneer lumber such as Intrallam or Parallam as per European technical approvals

The following rules are to be observed for the support beams to be joined:

» the primary components are either secured against torsion or, if not sufficient secured against torsion and are not sufficiently stiff against torsion or are positioned according to plan in a freely rotating way, the relative value of the carrying capability must be reduced.

» A wane behind the connection plate is not permitted.

» The wood components must show an open surface in the area of the connection.

» No gap may occur between the connector backside and the wood surfaces.

The connectors may only be exposed to static and quasi-static effects. The measurement of carrying capability and usability of connections must adhere to EN 1995-1-1. The connectors must be capable of taking loads in all three spatial axes, whereby additional stresses from torsion and warping must also be considered, and it must be capable of bearing those stresses. Use is only permitted in use classes 1 and 2 as per EN 1995-1-1. Wood moisture must be therefore limited to a **maximum of 18 %.** Condensate formation must always be prevented.

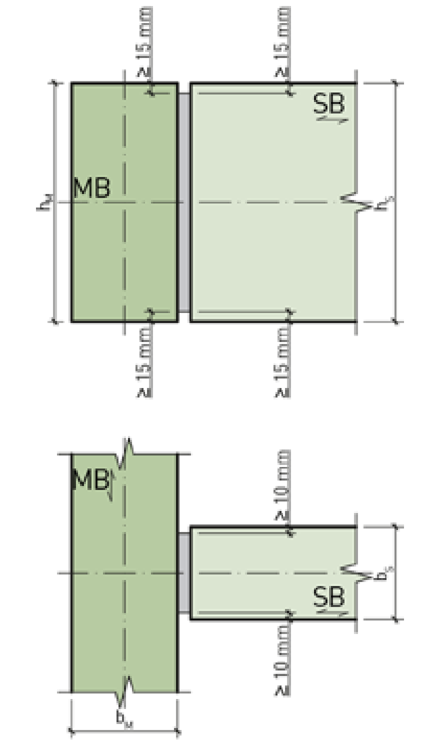
2.1.3 Execution planning and work preparation

Right-angle, oblique and tilted connections can be executed using SHERPA connectors. A combination of a oblique line and a tilt can also be executed. The minimum edge distance for all connector types and series is 15 mm for the upper and lower edge, and 10 mm for the right and left sides.

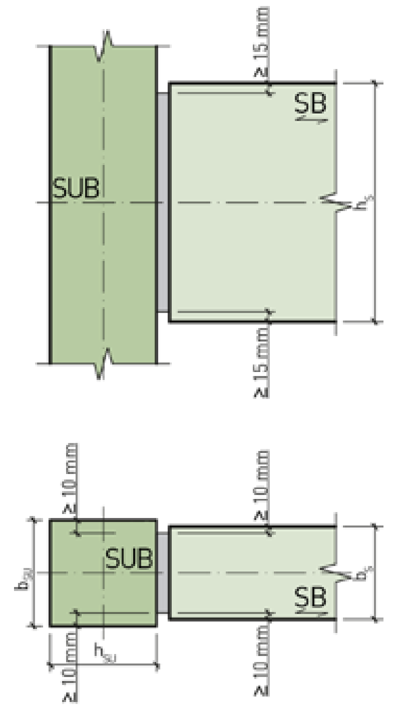
In particular, in connector situations with a oblique and/or a tilted secondary beam, it is recommended to check adherence to the minimum edge distance using 3D geometrical data from the technical download area on the SHERPA website. In addition, technical support is available for advice.

2.1.4 Minimum edge distances

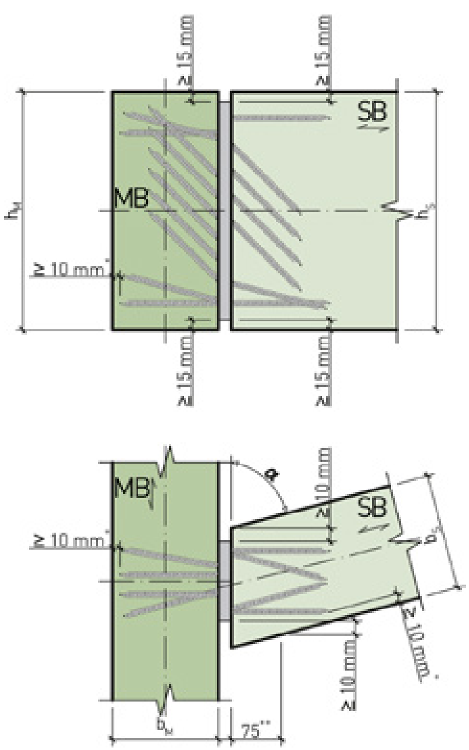
Right-angled connection for main and secondary beams



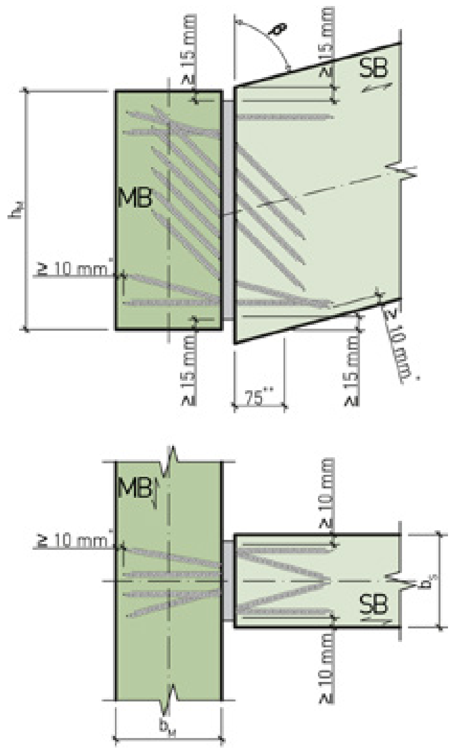
Right-angled connection for supports and secondary beams



Oblique connection for main and secondary beams



Tilted connector for main and secondary beams



α........ The allowable oblique angle must be determined individually for the special screws used

β........ The allowable tilt angle must be determined individually for the special screws used

*........ One must always maintain a minimum 10 mm distance from the screw tips to the next component edge

**...... The reference measurement of 75 mm is related to the XL and XXL Series using standard 8 x 160 mm screws.
All other series must be determined on an individual basis, depending on the screws used and the angle.

2.1.5 Technical data for pre-measurement

The following measurement values of carrying capability in the insertion direction ($R_{2,d}$) apply to plywood quality GL 24 h as per EN 1194 and EN 14080 (γ_M)

» Screw dimension **4.5 x 50 mm**

Series	Type	Minimum cross-section [mm] MB (b l h)		Minimum cross-section [mm] SB (b l h)		Number of screws [units] MB	SB	Σ	$R_{2,k}$ [kN] ↓	$R_{2,d}$ with γ_M = 1.25 [kN] k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XS Series	XS5	50	80	50	80	6	6	12	6.3	3.02	4.03	4.54
	XS10		100		100	8	10	18	11.8	5.66	7.55	8.50
	XS15		120		120	9	12	21	14.4	6.91	9.22	10.37
	XS20		140		140	11	14	25	19.5	9.36	12.48	14.04
S Series	S5	50	80	50	80	6	6	12	6.3	3.02	4.03	4.54
	S10		100		100	8	10	18	11.8	5.66	7.55	8.50
	S15		120		120	9	12	21	14.4	6.91	9.22	10.37
	S20		140		140	11	14	25	19.5	9.36	12.48	14.04

» Screw dimension **6.5 x 65 mm**

Series	Type	Minimum cross-section [mm] MB (b l h)		Minimum cross-section [mm] SB (b l h)		Number of screws [units] MB	SB	Σ	$R_{2,k}$ [kN] ↓	$R_{2,d}$ with γ_M = 1.25 [kN] k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
M Series	M15	65	120	80	120	7	9	16	14.0	6.72	8.96	10.08
	M20		140		140	9	11	20	23.6	11.33	15.10	16.99
	M25		160		160	10	13	23	27.8	13.34	17.79	20.02
	M30		180		180	11	15	26	32.0	15.36	20.48	23.04
	M40		200		200	13	17	30	40.1	19.25	25.66	28.87

» Screw dimension **8 x 100 mm**

Series	Type	Minimum cross-section [mm] MB (b l h)		Minimum cross-section [mm] SB (b l h)		Number of screws [units] MB	SB	Σ	$R_{2,k}$ [kN] ↓	$R_{2,d}$ with γ_M = 1.25 [kN] k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
L Series	L30	100	180	100	180	6	9	15	36.1	17.33	23.10	25.99
	L40		200		200	7	11	18	44.2	21.22	28.29	31.82
	L50		240		240	8	13	21	52.0	24.96	33.28	37.44
	L60		280		280	10	15	25	67.4	32.35	43.14	48.53
	L80		320		320	12	17	29	82.4	39.55	52.74	59.33

» Screw dimension **8 x 120 mm**

Series	Type	Minimum cross-section [mm] MB (b l h)		Minimum cross-section [mm] SB (b l h)		Number of screws [units] MB	SB	Σ	$R_{2,k}$ [kN] ↓	$R_{2,d}$ with γ_M = 1.25 [kN] k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XL Series	XL55	120	280	140	280	8	10	18	46.7	22.39	29.86	33.59
	XL70		320		320	9	12	21	57.0	27.35	36.47	41.02
	XL80		360		360	10	14	24	67.2	32.24	42.98	48.36
	XL100		400		400	11	14	25	77.2	37.06	49.41	55.59
	XL120		440		440	13	16	29	96.8	46.46	61.95	69.69
	XL140		480		480	14	18	32	106.4	51.08	68.10	76.61
	XL170		520		520	16	20	36	125.4	60.17	80.23	90.25
	XL190		560		560	18	22	40	144.0	69.13	92.17	103.69
	XL250		640		640	22	26	48	180.4	86.60	115.46	129.89

» Screw dimension **8 x 140 mm**

	Type	Minimum cross-section [mm]				Number of screws [units]			$R_{2,k}$ [kN]	$R_{2,d}$ with γ_M = 1.25 [kN]		
		MB (b I h)		SB (b I h)		MB	SB	Σ	↓	k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XL Series	XL55	140	280	140	280	8	10	18	56.1	26.92	35.89	40.37
	XL70		320		320	9	12	21	68.5	32.87	43.83	49.31
	XL80		360		360	10	14	24	80.7	38.75	51.67	58.13
	XL100		400		400	11	14	25	92.8	44.55	59.39	66.82
	XL120		440		440	13	16	29	116.3	55.85	74.46	83.77
	XL140		480		480	14	18	32	127.9	61.39	81.86	92.09
	XL170		520		520	16	20	36	150.7	72.32	96.43	108.49
	XL190		560		560	18	22	40	173.1	83.09	110.79	124.64
	XL250		640		640	22	26	48	216.9	104.09	138.79	156.13

» Screw dimension **8 x 160 mm**

	Type	Minimum cross-section [mm]				Number of screws [units]			$R_{2,k}$ [kN]	$R_{2,d}$ with γ_M = 1.25 [kN]		
		MB (b I h)		SB (b I h)		MB	SB	Σ	↓	k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XL Series	XL55	160	280	140	280	8	10	18	65.5	31.44	41.92	47.16
	XL70		320		320	9	12	21	80.0	38.40	51.20	57.60
	XL80		360		360	10	14	24	94.3	45.26	60.35	67.90
	XL100		400		400	11	14	25	108.4	52.03	69.38	78.05
	XL120		440		440	13	16	29	135.9	65.23	86.98	97.85
	XL140		480		480	14	18	32	149.4	71.71	95.62	107.57
	XL170		520		520	16	20	36	176.0	84.48	112.64	126.72
	XL190		560		560	18	22	40	202.2	97.06	129.41	145.58
	XL250		640		640	22	26	48	253.3	121.58	162.11	182.38

» Screw dimension **8 x 180 mm**

	Type	Minimum cross-section [mm]				Number of screws [units]			$R_{2,k}$ [kN]	$R_{2,d}$ with γ_M = 1.25 [kN]		
		MB (b I h)		SB (b I h)		MB	SB	Σ	↓	k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XL Series	XL55	180	280	140	280	8	10	18	74.9	35.96	47.95	53.95
	XL70		320		320	9	12	21	91.5	43.93	58.57	65.89
	XL80		360		360	10	14	24	107.9	51.78	69.04	77.67
	XL100		400		400	11	14	25	124.0	59.52	79.36	89.28
	XL120		440		440	13	16	29	155.5	74.62	99.49	111.93
	XL140		480		480	14	18	32	170.9	82.03	109.37	123.05
	XL170		520		520	16	20	36	201.3	96.64	128.85	144.95
	XL190		560		560	18	22	40	231.3	111.02	148.03	166.53
	XL250		640		640	22	26	48	289.7	139.08	185.44	208.62

MB... Main beam in mm

SB... Secondary beam in mm

$R_{2,k}$ Characteristic value for carrying capability with stress in the insertion direction in kN

$R_{2,d}$ Measurement values for carrying capability with stress in the insertion direction in kN

γ_M.... Partial safety coefficient for construction material properties (glulam GL 24h = 1.25)

k_{mod} Modification coefficient depending on use class (NKL) and duration of load exposure (KLED)

» Screw dimension **8 x 120 mm**

	Type	Minimum cross-section [mm]				Number of screws [units]			$R_{2,k}$ [kN]	$R_{2,d}$ with γ_M = 1.25 [kN]		
		MB (b l h)		SB (b l h)		MB	SB	Σ	↓	k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XXL Series	XXL170	120	440	160	440	16	21	37	125.4	60.17	80.23	90.25
	XXL190		480		480	18	24	42	144.0	69.13	92.17	103.69
	XXL220		520		520	20	27	47	162.4	77.95	103.93	116.92
	XXL250		560		560	22	30	52	180.6	86.66	115.55	130.00
	XXL280		600		600	24	30	54	198.6	95.31	127.08	142.97
	XXL300		640		640	26	33	59	216.3	103.83	138.43	155.74

» Screw dimension **8 x 140 mm**

	Type	Minimum cross-section [mm]				Number of screws [units]			$R_{2,k}$ [kN]	$R_{2,d}$ with γ_M = 1.25 [kN]		
		MB (b l h)		SB (b l h)		MB	SB	Σ	↓	k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XXL Series	XXL170	120	440	160	440	16	21	37	150.7	72.32	96.43	108.49
	XXL190		480		480	18	24	42	173.1	83.09	110.79	124.64
	XXL220		520		520	20	27	47	195.2	93.69	124.92	140.54
	XXL250		560		560	22	30	52	217.0	104.17	138.90	156.26
	XXL280		600		600	24	30	54	238.7	114.57	152.76	171.85
	XXL300		640		640	26	33	59	260.0	124.80	166.40	187.20

» Screw dimension **8 x 160 mm**

	Type	Minimum cross-section [mm]				Number of screws [units]			$R_{2,k}$ [kN]	$R_{2,d}$ with γ_M = 1.25 [kN]		
		MB (b l h)		SB (b l h)		MB	SB	Σ	↓	k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XXL Series	XXL170	120	440	160	440	16	21	37	176.0	84.48	112.64	126.72
	XXL190		480		480	18	24	42	202.2	97.06	129.41	145.58
	XXL220		520		520	20	27	47	228.0	109.44	145.92	164.16
	XXL250		560		560	22	30	52	253.5	121.68	162.24	182.52
	XXL280		600		600	24	30	54	278.8	133.82	178.43	200.74
	XXL300		640		640	26	33	59	303.7	145.78	194.37	218.66

» Screw dimension **8 x 180 mm**

	Type	Minimum cross-section [mm]				Number of screws [units]			$R_{2,k}$ [kN]	$R_{2,d}$ with γ_M = 1.25 [kN]		
		MB (b l h)		SB (b l h)		MB	SB	Σ	↓	k_{mod} = 0.60	k_{mod} = 0.80	k_{mod} = 0.90
XXL Series	XXL170	120	440	160	440	16	21	37	201.3	96.64	128.85	144.95
	XXL190		480		480	18	24	42	231.3	111.02	148.03	166.53
	XXL220		520		520	20	27	47	260.8	125.19	166.92	187.78
	XXL250		560		560	22	30	52	290.0	139.19	185.58	208.78
	XXL280		600		600	24	30	54	318.9	153.08	204.11	229.62
	XXL300		640		640	26	33	59	347.4	166.75	222.33	250.13

MB... Main beam in mm
SB... Secondary beam in mm

$R_{2,k}$ characteristic value for carrying capability with stress in the insertion direction in kN
$R_{2,d}$ Measurement values for carrying capability with stress in the insertion direction in kN
γ_M.... Partial safety coefficient for construction material properties (glulam GL 24h = 1.25)
k_{mod} Modification coefficient depending upon use class (NKL) and duration of load exposure (KLED)

2.2 Instructions for use

10 points for implementation	
1	The surfaces for mounting the connecting plants must be flat. The optimum wood material should show no torsion or curvatures, and be protected against cross-sectional changes as a consequence of swelling and shrinkage after joining.
2	Every connector plate with a large number of drill holes must be secured to end grain.
3	It is not allowed to mount the connection plate on the main beam attached flush to the lower edge or on the side beam flush to the upper edge.
4	The maximum milling depth for invisible installation may not be greater than both connection plates in their locked state. Tolerances must be adjusted to the connection situation and the processing quality. Please ensure that you follow the recommendations in the installation instructions.
5	Milling into the main beam or column reduces the carrying capability of this component. If the connector is milled into the secondary beam, the insertion channel must be stoppered, if applicable, for cosmetic reasons.
6	Only Sherpa special screws may be used in combination with Sherpa connectors. Only this system can guarantee achievement of the given value for carrying capability.
7	The screws must be screwed in so as to ensure that there is no possible deformation of the connector plate. The screws must first be placed in 90 degree drill holes first in order to ensure exact positioning of the connector plate.
8	After delivery to the construction site, or before installation, it is recommended to carry out a visual inspection of the connector plates and to clean dirt off flat surfaces , as required.
9	The components must be installed as horizontally as possible in the position. Before completing the insertion procedure, it is recommended to apply lubricant, such as silicone spray. Please ensure that any leakage of the lubricant cannot contaminate the wood surface.
10	After carrying out all the above points, the components resting on the supports can be equally and slowly lifted into position. Please ensure that the professionals involved in this procedure have good lines of communication.

2.3 Installation instructions

2.3.1 SHERPA Series XS to XXL

Three different types of installation of SHERPA connectors are explained in the following.
The connector plates with the larger number of drill holes into the edge grain must be screwed in with consideration of the relevant distances from the edges. The carrying capability, as per approval, is solely guaranteed by the use of SHERPA special screws.

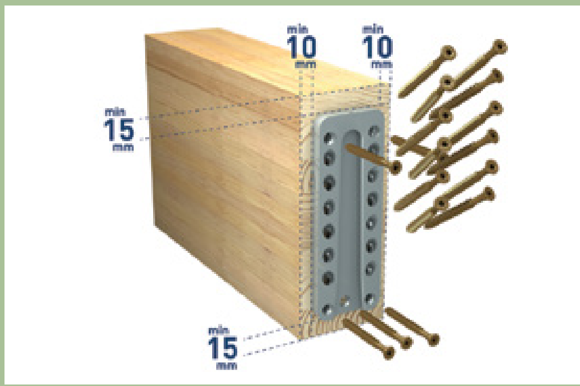
Visible connection

The connecting plates must be screwed onto the main and secondary beam flat, and thus visible.
In order to ensure proper fit, it is recommended to pre-drill the positioning screws.
In this, the drill diameter must never be greater than the core diameter of the screws.

OPTION 1

MILLING INTO THE MAIN BEAM

SCREWED FLAT INTO THE SECONDARY BEAM



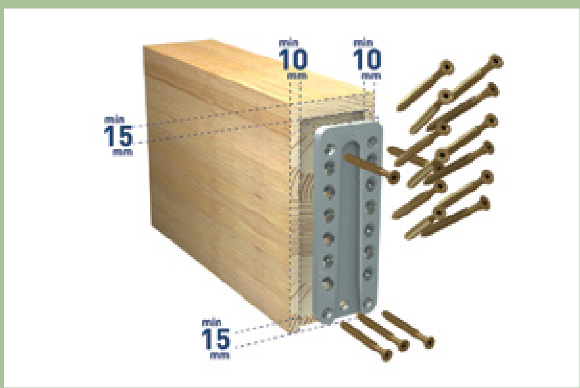
Milling depth:
Mill XS to M connectors to a depth of at least 1 mm less than the total thickness of both plates.
Mill L to XXL connectors to a depth of at least 3 mm less than the total thickness of both plates.

Pre-drilling:
4.5 x 50..max. 2.5 mm
5.0 x 60..max. 3.0 mm
6.5 x 65..max. 3.5 mm
8.0 x 100/120/140/160/180...............max. 5.0 mm

OPTION 2

SCREWED FLAT INTO THE MAIN BEAM

MILLED INTO THE SECONDARY BEAM



Recommended tightening torque:
XS - S ....M_T = 1.5 Nm
M ....M_T = 2.5 Nm
L ....M_T = 5.0 Nm
XL - XXL ....M_T = 10.0 Nm
Minimum: Screw head has a contact in the sunk portion

Note:
Milling into the main beam or column reduces the carrying capability of this component. If the connector is milled into the secondary beam, the insertion channel must be stoppered, if applicable, for cosmetic reasons.

2.3.2 SHERPA CS Series M to XXL

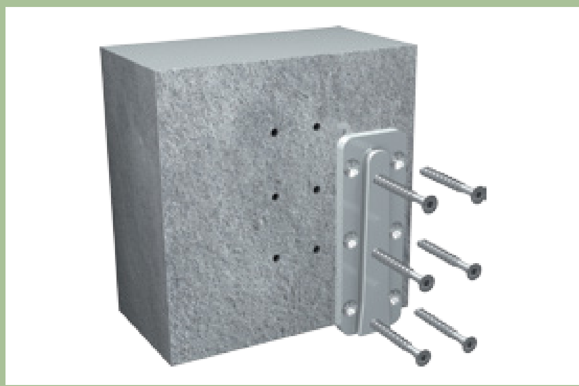
A separator or a corrosion coating must be provided between the concrete or the steel and the back of the SHERPA.

Visible connection

The connecting plates must only be screwed flat, thus visible, onto the steel-reinforced concrete or the steel foundation and on the secondary beam. In order to ensure proper fit, pre-drilling of the positioning screws into the end-grain wood is recommended . In this case, the drill hole diameter must on no accounts be greater than the core diameter of the screws.

Invisible connection

The connecting plates must be screwed flat, thus visible, onto the steel-reinforced concrete or the steel foundation. The secondary beam is milled suitably. In order to ensure proper fit, pre-drilling of the positioning screws into the end-grain wood is recommended . In this case, the drill hole diameter must on no accounts be greater than the core diameter of the screws.



OPTION PART 1

Connection to steel

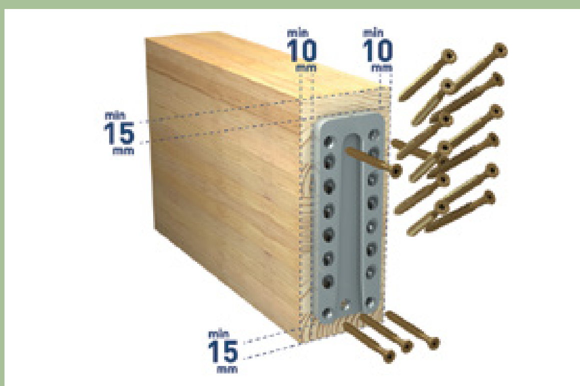
The drill holes must be created in accordance with generally recognised state of the art for steel construction. When connecting to a steel construction component, ensure sufficient space for positioning of the nuts. The following steel construction screws can be used:

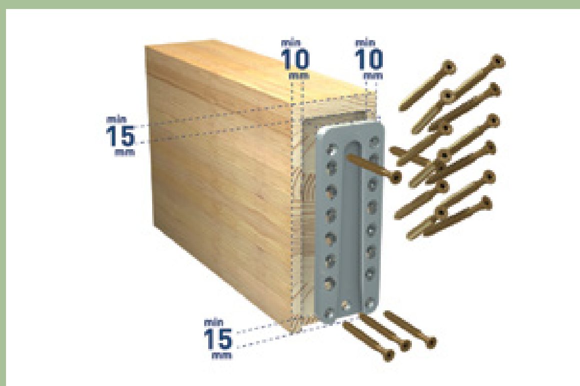
M.........	7.9 / 15.4 mm	DIN 7991	4.6 / 8.8 SK	M 6
L..........	11.0 / 21.0 mm	DIN 7991	4.6 / 8.8 SK	M 10
XL........	11.0 / 21.0 mm	DIN 7991	4.6 / 8.8 SK	M 10
XXL......	11.0 / 21.0 mm	DIN 7991	4.6 / 8.8 SK	M 10

Connection to steel-reinforced concrete

The drill holes must be drilled vertical to the mounting level, and drilled with sufficient depth. Please consult the installation instructions for the connectors used. The following through holes or cuts for concrete screws or metal spreading anchor bolts are provided:

M.........	7.9 / 15.4 mm	e.g. HECO MMS-F	7.5 x 60/5
L..........	11.0 / 21.0 mm	e.g. HECO MMS-F	10,0 x 80/15
XL........	11.0 / 21.0 mm	e.g. HECO MMS-F	10,0 x 80/15
XL........	14.0 / 26.0 mm	e.g. FISHER FH II	12/15 SK
XXL......	11.0 / 21.0 mm	e.g. HECO MMS-F	10,0 x 80/15





OPTION PART 2

Pre-drilling into wood

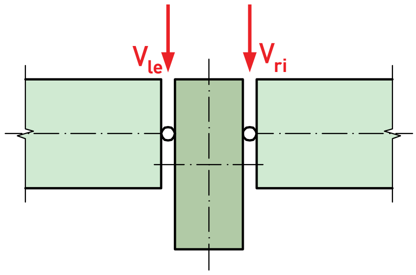
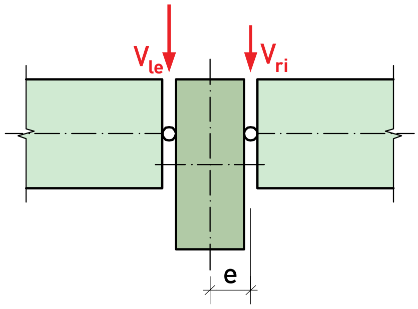
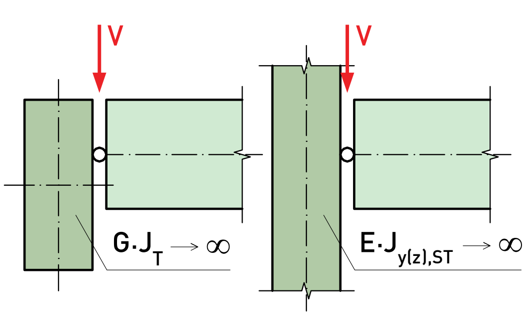
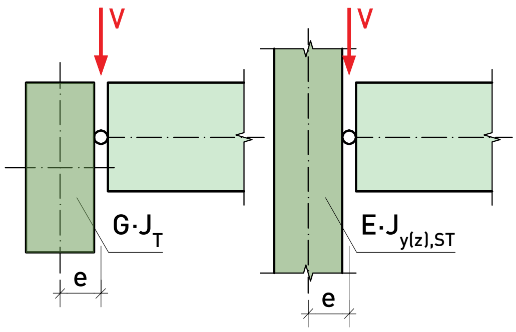
4.5 x 50...max. 2.5 mm
5.0 x 60...max. 3.0 mm
6.5 x 65...max. 3.5 mm
8.0 x 100/120/140/160/180...............max. 5.0 mm

Milling depth in wood:

The following applies for the invisible connection option: Mill XS to M connectors to a depth of at least 1 mm less than the total thickness of both plates.
Mill L to XXL connectors to a depth of at least 3 mm less than the total thickness of both plates.

2.4 Validation in different connection situations

The calculation of carrying capability set in the SHERPA connectors depends on each connection situation. The following summary gives an overview of connection situations in practice:

Connection situation	Main beam / supports torsionally stiff or secured sufficiently against torsion.	Main beam / supports torsionally weak or not sufficiently secured against torsion.
Two-sided connection	 $0{,}83 \leq \frac{V_{le}}{V_{ri}} \leq 1{,}20$	 $0{,}83 \leq \frac{V_{le}}{V_{ri}} \leq 1{,}20$
One-sided connection		
Validation	The main beam is considered torsionally stiff as the effects are introduced via the connector; i.e. the effects do not prompt any, or merely negligible, torsion in the main beam. The support must be stiff against bending, i.e. bending moments do not impact on the supports.	The main beam is seen as torsionally weak or insufficiently strong against torsion for the forces introduced via the the connector. The plans must include distribution of prevailing torsional moments out through the foundation. The main beam supports are therefore constructed using fork restraints to prevent torsion. The supports are considered weak against bending, i.e. the eccentric load distribution means a bending moment is introduced to the supports, which must be considered during validation.

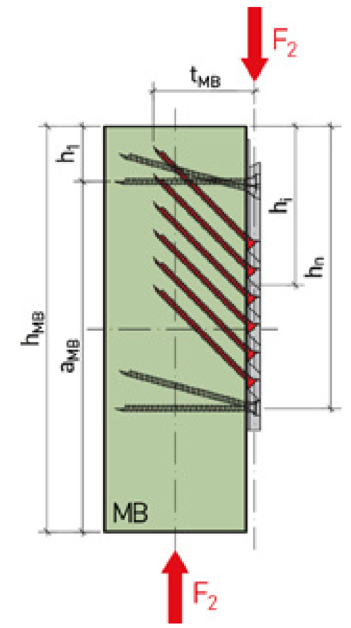
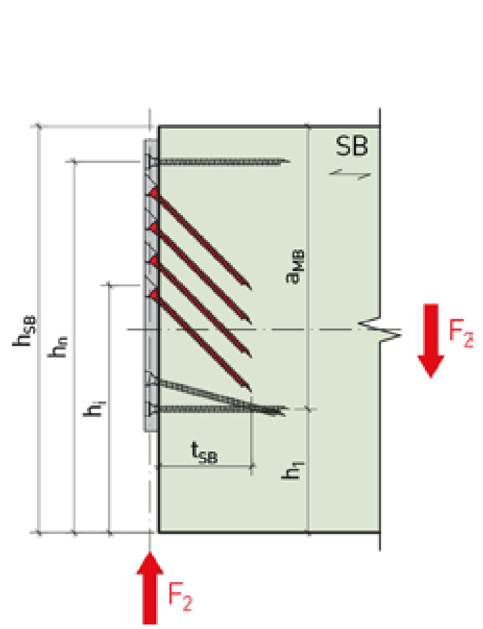
Connection situation		Main beam / supports torsionally stiff or secured sufficiently against torsion.	Main beam / supports torsionally weak or not sufficiently secured against torsion.
Explanation of the meas-ures taken		The value for central stress must be defined without any reduction to validate the limit state of carrying capability.	In order to validate the limit state of carrying capability, the value of an eccentric stress must be reduced due to the interaction between shear force and moments, depending on the degree of eccentricity.
Carrying capability of a SHERPA	in and against	**in and against the insertion direction** $R'_{2/3,k} = R_{2/3,k}$ [kN]	**in and against the insertion direction** $R'_{2/3,k} = \dfrac{R_{2/3,k}}{\left[1+\left(\dfrac{e-e_{limit}}{e_2}\right)^3\right]^{\frac{1}{3}}}$ [kN]
	right angle	**right angle to the insertion direction** $R'_{45,k} = R_{45,k}$ [kN]	**right angle to the insertion direction** $R'_{45,k} = \dfrac{R_{45,k}}{\left[1+\left(\dfrac{e}{e_{45}}\right)^3\right]^{\frac{1}{3}}}$ [kN]

2.5 Validation of transverse stress on the main and/or secondary beam

2.5.1 Principles

Validation of transverse force stresses for SHERPA connectors is generally not used due to the geometric dimensions of the main and the secondary support.

The transverse force stresses must be validated for cases in which the position of the SHERPA connector produces the parameter of a/h ≤ 0.7. This applies in particular to cases in which suitable measures of transverse securing, including self-tapping full thread screws or glued studs, are not undertaken to prevent possible cracking of the main and/or secondary beam. The validation of transverse force must thus be especially determined individually for both components (main and secondary beams). The definition of the relevant distances for the validation of transverse force (a/h ratio as well as screw distances) can be determined using the following figure.

for the main beam	for the secondary beam
	

$\frac{a}{h} > 0{,}7$	$0{,}2 \leq \frac{a}{h} \leq 0{,}7$	$\frac{a}{h} < 0{,}2$
No validation is needed for the transverse stress!	The following must be adhered to: $$\frac{F_{90,d}}{R_{90,d}} \leq 1{,}0$$ with $$R_{90,d} = k_{MB/SB} \cdot k_s \cdot k_r \cdot \left(6{,}5 + \frac{18 \cdot a^2}{h^2}\right) \cdot (t_{ef} \cdot h)^{0{,}8} \cdot f_{t,90,d}$$ whereby $$k_s = \max\left\{\begin{matrix} 1 \\ 0{,}7 + \frac{1{,}4 \cdot a_r}{h} \end{matrix}\right\}$$ and $$k_r = \frac{n}{\sum_{i=1}^{n} \left(\frac{h_1}{h_i}\right)^2}$$ Remark: One may simplify by using $k_r = (h_n / h_1)$. Common joints with $a_r / h > 1.0$ and $F_{90,d} > 0{,}5 \cdot R_{90,d}$ must be strengthened/reinforced..	SHERPA connectors may only be subject to short load stresses such as wind suction forces.

whereby

$F_{90,d}$.... The rated value of the connection direction considered for the respective component in N

$R_{90,d}$... The rated value of the carrying capability considered for the respective component in N

$k_{MB/SB}$ Relevant coefficient for the construction component under consideration
- the following applies for the main beam: $k_{MB/SB}$ = 1.0
- the following applies for the secondary beam: $k_{MB/SB}$ = 0.5

k_s....... Relevant coefficient for several adjacent connectors

a_r....... Distance of the connector

- for the main beam
with stress in the grain direction: Distance of the SHERPA connector screws in the main beam grain direction

- for the secondary beam
with stress in the grain direction: ar = 100 mm
with stress at a right angle to the grain direction: ar = 40 mm

k_r....... Relevant coefficient for several adjacent connectors

a........ Distance of the lowest or highest connector from the stressed edge in mm

h........ Height of the considered construction component in the stress direction in mm

n........ Number of connector rows

h_i....... Distance of the respective connector middle row from the unstressed component edge in mm

t_{ef}....... Effective connection depth in mm, for example in the XL and XXL Series

- for the main beam
with a one-sided SHERPA connector tef = 100 mm
with a both-sided SHERPA connector tef = min (b: 200 mm)
b....... Cross-section width of the considered construction component in mm
t........ Connection depth of the connector screws in mm

- for the secondary beam
with stress in the grain direction: Width of the SHERPA connector in mm
with stress at a right angle to the grain direction: Height of the SHERPA connector in mm

If there are several SHERPA connectors arranged next to one another, the rated value of carrying capability $R_{90,d}$ for a connector group is determined as presented above, provided the distance between the SHERPA connectors is at least 2 * h in the grain direction .
If the clearance distance of several adjacent SHERPA connectors is no greater than 0.5 * h, the fasteners for the connectors must be evaluated as a fastener group.
If the clearance distance in the grain direction of two adjacent SHERPA connectors is at least 0.5 * h and less than 2 * h, the rated value of the carrying capability $R_{90,d}$ for each SHERPA connector must be reduced by the coefficient k_g. This produces:

$$k = \frac{}{4 \cdot h} + 0{,}5$$

with

l_g........ clearance distance between the SHERPA connectors in mm

If there are more than two adjacent SHERPA connectors with $l_g < 2 \cdot h$, in which the rated value of the stress introduced in the considered connection direction in the respective construction component $F_{90,d}$ is larger than half the rated value reduced using the coefficient k_g for the carrying capability $R_{90,d}$, suitable reinforcements must be fitted to accommodate the transverse forces.

This also applies to SHERPA connectors with $F_{90,d} > 0.5 \cdot R_{90,d}$ whose clearance distance from the end of a cantilever arm is less than the support height h.

2.5.2 Validation of reinforcement measures

Reinforcement measures in the main and/or secondary beams with transverse stress must be designed or validated using the formulae presented in the following.

In this, the connectors stressed in the axis direction for reinforcement is designed for a tensile force of $F_{t,90,d}$. This must be determined using the following formula.

$$F_{t,90,d} = \left[1 - 3\cdot\left(\frac{a}{h}\right)^2 + 2\cdot\left(\frac{a}{h}\right)^3\right]\cdot F_{90,d} \ [\mathrm{N}]$$

with

$F_{t,90,d}$	The rated value of the connector stressed in the axis direction for reinforcement, in N
$F_{90,d}$	The rated value stress of the considered connection direction for the respective construction component in N
a........	Distance of the lowest or highest connector from the stressed edge in mm
h........	Height of the considered construction component in the stress direction in mm

Adherence to the following condition is necessary in order to validate that the adhesive stress in glued steel rods is equally distributed:

$$\frac{\tau_{ef,d}}{f_{k1,d}} \leq 1{,}0$$

with

$$\tau_{ef,d} = \frac{F_{t,90,d}}{n \cdot d_r \cdot \pi \cdot l_{ad}} \ [\mathrm{N/mm^2}]$$

with

$\tau_{ef,d}$.....	Rated value of the equally distributed, prevailing adhesive stress for glued steel rods in N/mm²
$f_{k1,d}$.....	Rated value of adhesive gap strength
n........	Number of steel rods; whereby only one rod each may be considered outside the SHERPA connector in the lengthwise support direction.

	Effective adhesive length l_{ad} of the steel rod		
	≤ 250 mm	**250 < l_{ad} ≤ 500 mm**	**500 < l_{ad} ≤1000 mm**
Adhesive gap between the steel rod and the drill hole wall	**4.0**	**5.25 - 0.005 · l_{ad}**	**3.5 - 0.0015 · l_{ad}**
The information in this table may only be used if the adhesive system has been validated as suitable.			

$\tau_{ef,d}$.....	Rated value of the connector stressed in the axis direction for reinforcement, in N
l_{ad}......	Effective adhesive length of the steel rod in mm; $l_{ad} = \min\{l_{ad,c}; l_{ad,t}\}$

3 Technical data

3 Technical data for the SHERPA connector

3.1 Standard characteristics of the SHERPA series XS and S

Connector type		XS 5	XS 10	XS 15	XS 20
Geometric data QR code for PDF					
Width	[mm]	30			
Height	[mm]	50	70	90	110
Thickness	[mm]	12			
Minimum wood cross-section					
Main support	[mm]	50/80	50/100	50/120	50/140
Auxiliary support	[mm]	50/80	50/100	50/120	50/140
Screw type: 4.5 x 50 mm					
Helical screws					
Main support		2	4	5	7
Auxiliary support		2	6	8	10
Torque screws					
Main support		4			
Auxiliary support		4			
Total		12	18	21	25

Connector type		S 5	S 10	S 15	S 20
Geometric data QR code for PDF					
Width	[mm]	40			
Height	[mm]	50	70	90	110
Thickness	[mm]	12			
Minimum wood cross-section					
Main support	[mm]	50/80	50/100	50/120	50/140
Auxiliary support	[mm]	60/80	60/100	60/120	60/140
Screw type: 4.5 x 50 mm					
Helical screws					
Main support		2	4	5	7
Auxiliary support		2	6	8	10
Torque screws					
Main support		4			
Auxiliary support		4			
Total		12	18	21	25

QR

Please scan the QR code to access geometric data for the chosen connector

The following information applies to:

- Full wood made of pine with a minimum solidity class C24 as per EN 338 or EN 14081-1
- All glulam solidity classes as per EN 1194 or EN 14080
- Plywood (LVL) as PER EN 14374
- Construction materials similar to glulam in solid wood (double and triple columns) as pER prEN 14080
- Laminated wood in accordance with European technical approvals or national regulations
- Strand wood (e.g. wood trim strips – intralam, parallel strand wood – Paralam) as per European technical approvals or national regulations

Solid wood must have a moisture content of at most 18 % when manufactured, and must have a minimum core separation at grain connections.

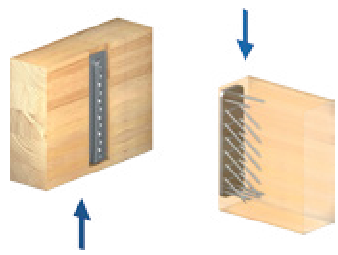
Sherpa may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1 and screws must withstand the following corrosion loads.

- Yellow zinc plated
  Moderate load – corrosive categories C1, C2 and C3 as – EN ISO as per 12944-2

- Zinc-nickel
  Very high load – corrosive categories C1 to C5-M-long as per EN ISO 12944-2

Moisture penetration and regular condensate build-up must be prevented.

$R_{2,k}$ **Characteristic values for supporting capacity $R_{2,k}$ with centre load in the insertion direction in kN**



- SHERPA special screws: 4.5 x 50 mm

For solid wood, in kN
as per EN 338 or EN 14081-1

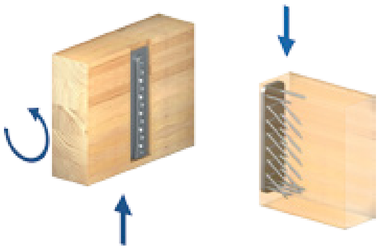
Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	5.1	9.6	11.7	15.9	5.1	9.6	11.7	15.9
C30	ρ_k = 380 kg/m³	5.4	10.3	12.5	17.0	5.4	10.3	12.5	17.0

For glulam in kN
as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	6.3	11.8	14.4	19.5	6.3	11.8	14.4	19.5
GL 28h	ρ_k = 410 kg/m³	6.7	12.5	15.3	20.8	6.7	12.5	15.3	20.8
GL 32h	ρ_k = 430 kg/m³	6.9	13.0	15.9	21.6	6.9	13.0	15.9	21.6
GL 36h	ρ_k = 450 kg/m³	7.2	13.5	16.5	22.4	7.2	13.5	16.5	22.4
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	5.9	11.0	13.5	18.3	5.9	11.0	13.5	18.3
GL 28c	ρ_k = 380 kg/m³	6.3	11.8	14.4	19.5	6.3	11.8	14.4	19.5
GL 32c	ρ_k = 410 kg/m³	6.7	12.5	15.3	20.8	6.7	12.5	15.3	20.8
GL 36c	ρ_k = 430 kg/m³	6.9	13.0	15.9	21.6	6.9	13.0	15.9	21.6

$R'_{2,k}$ Characteristic values of carrying capacity $R'_{2,k}$ with centre stress in the insertion direction in kN

» SHERPA special screws: 4.5 x 50 mm



Off-centre or eccentric dimensions

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
e_{limit}	[mm]	0	8.3	12.5	16.3	0	8.3	12.5	16.3
e_2	[mm]	36.1	18.9	19.4	19.6	36.1	18.9	19.4	19.6

Reduction factors η_2 with eccentric stress in the insertion direction (independent of the gross density of the solid or glulam wood)

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Eccentricity	e = 30 mm	0.860	0.735	0.832	0.907	0.860	0.735	0.832	0.907
	e = 40 mm	0.751	0.559	0.638	0.712	0.751	0.559	0.638	0.712
	e = 50 mm	0.649	0.440	0.495	0.548	0.649	0.440	0.495	0.548
	e = 60 mm	0.563	0.360	0.400	0.436	0.563	0.360	0.400	0.436
	e = 70 mm	0.494	0.303	0.333	0.359	0.494	0.303	0.333	0.359
	e = 80 mm	0.438	0.262	0.285	0.305	0.438	0.262	0.285	0.305
	e = 90 mm	0.393	0.230	0.249	0.264	0.393	0.230	0.249	0.264
	e = 100 mm	0.356	0.206	0.221	0.233	0.356	0.206	0.221	0.233
	e = 110 mm	0.324	0.185	0.198	0.209	0.324	0.185	0.198	0.209
	e = 120 mm	0.298	0.169	0.180	0.189	0.298	0.169	0.180	0.189
	e = 130 mm	0.276	0.155	0.165	0.172	0.276	0.155	0.165	0.172
	e = 140 mm	0.256	0.143	0.152	0.158	0.256	0.143	0.152	0.158
	e = 150 mm	0.240	0.133	0.141	0.146	0.240	0.133	0.141	0.146
	e = 160 mm	0.225	0.125	0.131	0.136	0.225	0.125	0.131	0.136
	e = 170 mm	0.212	0.117	0.123	0.127	0.212	0.117	0.123	0.127
	e = 180 mm	0.200	0.110	0.116	0.120	0.200	0.110	0.116	0.120
	e = 190 mm	0.190	0.104	0.109	0.113	0.190	0.104	0.109	0.113
	e = 200 mm	0.180	0.099	0.103	0.107	0.180	0.099	0.103	0.107

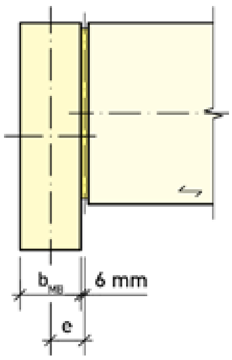
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side, flexible to torsion
main support for solid wood C24 and SHERPA XS 5
b_{MB} = 60 mm

e = b_{MB} / 2 + 6 mm = 60 / 2 + 6 = 36 mm
e = 36 mm

→ η_2 = 0.795 (interpolated)
$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0.795 \cdot 5.1 = 4.1$ kN



Charts for visual assessment

Please scan the QR code to access charts for the chosen connector

$K_{2,ser}$ Calculated value of the slip modulus $K_{2,ser}$ as proof of usability with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,ser} = \frac{R_{2,k}}{1{,}00\ \text{mm}}$$

$R_{2,k}$...... Characteristic value of the supporting capacity of a SHERPA XS/S connector with stress in the insertion direction in kN

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	5.1	9.6	11.7	15.9	5.1	9.6	11.7	15.9
C30	ρ_k = 380 kg/m³	5.4	10.3	12.5	17.0	5.4	10.3	12.5	17.0

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	6.3	11.8	14.4	19.5	6.3	11.8	14.4	19.5
GL 28h	ρ_k = 410 kg/m³	6.7	12.5	15.3	20.8	6.7	12.5	15.3	20.8
GL 32h	ρ_k = 430 kg/m³	6.9	13.0	15.9	21.6	6.9	13.0	15.9	21.6
GL 36h	ρ_k = 450 kg/m³	7.2	13.5	16.5	22.4	7.2	13.5	16.5	22.4
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	5.9	11.0	13.5	18.3	5.9	11.0	13.5	18.3
GL 28c	ρ_k = 380 kg/m³	6.3	11.8	14.4	19.5	6.3	11.8	14.4	19.5
GL 32c	ρ_k = 410 kg/m³	6.7	12.5	15.3	20.8	6.7	12.5	15.3	20.8
GL 36c	ρ_k = 430 kg/m³	6.9	13.0	15.9	21.6	6.9	13.0	15.9	21.6

$K_{2,u}$ Calculated value of the slip modulus $K_{2,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,u} = \frac{2}{3} \cdot K_{2,ser}$$

$K_{2,ser}$.... Calculated value of the slip modulus of a SHERPA XS/S connector for usability evidence with centre or eccentric stress in the insertion direction in kN/mm

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	3.4	6.4	7.8	10.6	3.4	6.4	7.8	10.6
C30	ρ_k = 380 kg/m³	3.6	6.8	8.3	11.3	3.6	6.8	8.3	11.3

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	4.2	7.9	9.6	13.0	4.2	7.9	9.6	13.0
GL 28h	ρ_k = 410 kg/m³	4.4	8.4	10.2	13.8	4.4	8.4	10.2	13.8
GL 32h	ρ_k = 430 kg/m³	4.6	8.7	10.6	14.4	4.6	8.7	10.6	14.4
GL 36h	ρ_k = 450 kg/m³	4.8	9.0	11.0	14.9	4.8	9.0	11.0	14.9
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	3.9	7.4	9.0	12.2	3.9	7.4	9.0	12.2
GL 28c	ρ_k = 380 kg/m³	4.2	7.9	9.6	13.0	4.2	7.9	9.6	13.0
GL 32c	ρ_k = 410 kg/m³	4.4	8.4	10.2	13.8	4.4	8.4	10.2	13.8
GL 36c	ρ_k = 430 kg/m³	4.6	8.7	10.6	14.4	4.6	8.7	10.6	14.4

$K_{2,\varphi,ser}$ Calculated value of the torsion modulus $K_{2,\varphi,ser}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,ser} = 175 \cdot R_{2,k} \cdot e_2$$

$R_{2,k}$...... Characteristic value of the supporting capacity of a SHERPA XS/S connector with stress in the insertion direction in kN
e_2........ Eccentricity of a SHERPA SX/S connector with maximum torque stress around the axis, right-angled to the insertion direction in m

For solid wood in kNm/rad as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	32.2	31.8	39.7	54.5	32.2	31.8	39.7	54.5
C30	ρ_k = 380 kg/m³	34.4	33.9	42.4	58.2	34.4	33.9	42.4	58.2

For glulam in kNm/rad as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	39.8	39.0	48.9	66.9	39.8	39.0	48.9	66.9
GL 28h	ρ_k = 410 kg/m³	42.1	41.4	51.8	71.2	42.1	41.4	51.8	71.2
GL 32h	ρ_k = 430 kg/m³	43.7	43.1	53.9	73.9	43.7	43.1	53.9	73.9
GL 36h	ρ_k = 450 kg/m³	45.3	44.6	55.9	76.7	45.3	44.6	55.9	76.7
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	37.1	36.5	45.7	62.7	37.1	36.5	45.7	62.7
GL 28c	ρ_k = 380 kg/m³	39.6	39.0	48.8	67.0	39.6	39.0	48.8	67.0
GL 32c	ρ_k = 410 kg/m³	42.1	41.4	51.8	71.2	42.1	41.4	51.8	71.2
GL 36c	ρ_k = 430 kg/m³	43.7	43.1	53.9	73.9	43.7	43.1	53.9	73.9

$K_{2,\varphi,u}$ Calculated value of the torsion modulus $K_{2,\varphi,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,u} = \frac{2}{3} \cdot K_{2,\varphi,ser}$$

$K_{2,\varphi,ser}$.. Calculated value of the torsion modulus of a SHERPA XS/S connector as proof of usability with centre or eccentric stress in the insertion direction in kNm/rad

For solid wood in kNm/rad as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	21.5	21.2	26.5	36.4	21.5	21.2	26.5	36.4
C30	ρ_k = 380 kg/m³	22.9	22.6	28.3	38.8	22.9	22.6	28.3	38.8

For glulam in kNm/rad as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	26.5	26.0	32.6	44.6	26.5	26.0	32.6	44.6
GL 28h	ρ_k = 410 kg/m³	28.0	27.6	34.6	47.5	28.0	27.6	34.6	47.5
GL 32h	ρ_k = 430 kg/m³	29.1	28.7	35.9	49.3	29.1	28.7	35.9	49.3
GL 36h	ρ_k = 450 kg/m³	30.2	29.8	37.2	51.1	30.2	29.8	37.2	51.1
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	24.7	24.3	30.5	41.8	24.7	24.3	30.5	41.8
GL 28c	ρ_k = 380 kg/m³	26.4	26.0	32.5	44.7	26.4	26.0	32.5	44.7
GL 32c	ρ_k = 410 kg/m³	28.0	27.6	34.6	47.5	28.0	27.6	34.6	47.5
GL 36c	ρ_k = 430 kg/m³	29.1	28.7	35.9	49.3	29.1	28.7	35.9	49.3

The following information applies to:

- » Solid pine wood with a minimum solidity class C24 as per EN 338 or EN 14081-1.
- » All glulam solidity classes as per EN 1194 or EN 14080
- » Laminated veneer wood (LVL) as per EN 14374
- » Components similar to glulam in solid wood (double and triple column) as per prEN 14080
- » Plywood board as per European technical approvals or national regulations
- » Strand wood (e.g. clamping strip wood – Intralam, parallel strand wood – Paralam) as per European technical approvals or national regulations

Solid wood must have a moisture content of at most 18 % when manufactured, and must have a minimum core separation at grain connections.

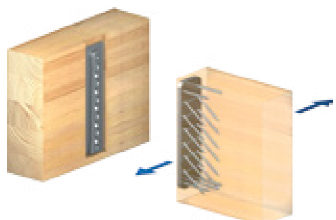
Sherpa may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1 and screws must withstand the following corrosion loads.

- » Yellow zinc plated
  Moderate load – corrosive categories C1, C2 and C3 as per EN ISO 12944-2

- » Zinc-nickel
  Very high load – corrosive categories C1 to C5-M-long as per EN ISO 12944-2

Moisture penetration and regular condensate build-up must be prevented.

$R_{45,k}$ **Characteristic values of carrying capacity $R_{45,k}$ with centre stress at a right angle to the insertion direction in kN**



- » SHERPA special screws: 4.5 x 50 mm

For solid wood in kN
as per EN 338 or EN 14081-1

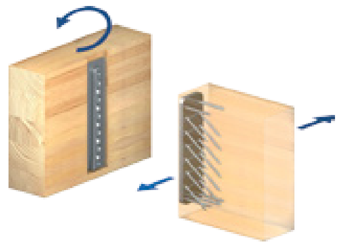
Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	3.2	5.0	5.9	6.8	3.2	5.0	5.9	6.8
C30	ρ_k = 380 kg/m³	3.3	5.2	6.1	7.1	3.3	5.2	6.1	7.1

For glulam in kN
as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	3.3	5.2	6.2	7.1	3.3	5.2	6.2	7.1
GL 28h	ρ_k = 410 kg/m³	3.5	5.4	6.4	7.4	3.5	5.4	6.4	7.4
GL 32h	ρ_k = 430 kg/m³	3.5	5.5	6.5	7.5	3.5	5.5	6.5	7.5
GL 36h	ρ_k = 450 kg/m³	3.6	5.7	6.7	7.7	3.6	5.7	6.7	7.7
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	3.2	5.0	5.9	6.8	3.2	5.0	5.9	6.8
GL 28c	ρ_k = 380 kg/m³	3.3	5.2	6.1	7.1	3.3	5.2	6.1	7.1
GL 32c	ρ_k = 410 kg/m³	3.5	5.4	6.4	7.4	3.5	5.4	6.4	7.4
GL 36c	ρ_k = 430 kg/m³	3.5	5.5	6.5	7.5	3.5	5.5	6.5	7.5

$R'_{45,k}$ Characteristic values of carrying capacity $R'_{45,k}$ with centre stress at a right angle to the insertion direction in kN

» SHERPA special screws: 4.5 x 50 mm



Eccentric or eccentricity dimensions

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
e_{45}	[mm]	33.5	21.3	18.1	15.7	44.2	28.2	23.9	20.7

Reduction factors η_2 with eccentric stress at a right angle to insertion direction (independent of the gross depth of solid wood or glulam)

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Eccentric	e = 30 mm	0.835	0.641	0.565	0.500	0.913	0.768	0.695	0.628
	e = 40 mm	0.718	0.508	0.439	0.385	0.831	0.638	0.560	0.496
	e = 50 mm	0.614	0.416	0.356	0.311	0.742	0.534	0.462	0.405
	e = 60 mm	0.529	0.350	0.299	0.260	0.659	0.455	0.390	0.340
	e = 70 mm	0.462	0.301	0.257	0.223	0.586	0.394	0.337	0.293
	e = 80 mm	0.409	0.265	0.225	0.196	0.525	0.347	0.296	0.257
	e = 90 mm	0.366	0.236	0.201	0.174	0.473	0.310	0.264	0.229
	e = 100 mm	0.331	0.212	0.181	0.157	0.430	0.280	0.238	0.206
	e = 110 mm	0.302	0.193	0.164	0.143	0.393	0.255	0.217	0.188
	e = 120 mm	0.277	0.177	0.151	0.131	0.362	0.234	0.199	0.172
	e = 130 mm	0.256	0.164	0.139	0.121	0.336	0.216	0.183	0.159
	e = 140 mm	0.238	0.152	0.129	0.112	0.312	0.201	0.170	0.148
	e = 150 mm	0.223	0.142	0.121	0.105	0.292	0.188	0.159	0.138
	e = 160 mm	0.209	0.133	0.113	0.098	0.274	0.176	0.149	0.129
	e = 170 mm	0.197	0.125	0.106	0.092	0.258	0.166	0.140	0.122
	e = 180 mm	0.186	0.118	0.101	0.087	0.244	0.156	0.133	0.115
	e = 190 mm	0.176	0.112	0.095	0.083	0.232	0.148	0.126	0.109
	e = 200 mm	0.167	0.106	0.090	0.078	0.220	0.141	0.119	0.103

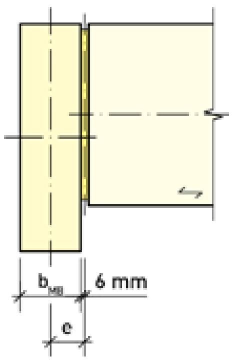
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side, flexible to torsion
main support for solid wood C24 and SHERPA XS 5
b_{MB} = 60 mm

e = b_{MB} / 2 + 6 mm = 60 / 2 + 6 = 36 mm
e = 36 mm

→ η_2 = 0.795 (interpolated)
$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0.795 \cdot 5.1 = 4.1$ kN



Charts for visual assessment

QR

Please scan the QR code to access charts for the chosen connector

$K_{45,ser}$ Calculated value of the slip modulus $K_{45,ser}$ for the proof of carrying capacity with centre or eccentric stress at a right angle to the insertion direction in kN/mm

$$K_{45,ser} = \frac{R_{45,k}}{1{,}25\ mm}$$

$R_{45,k}$.... Characteristic value of a SHERPA XS/S connector with centre or eccentric stress at a right angle to the insertion direction in kN

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	2.6	4.0	4.7	5.4	2.6	4.0	4.7	5.4
C30	ρ_k = 380 kg/m³	2.7	4.2	4.9	5.7	2.7	4.2	4.9	5.7

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	2.6	4.2	5.0	5.7	2.6	4.2	5.0	5.7
GL 28h	ρ_k = 410 kg/m³	2.8	4.3	5.1	5.9	2.8	4.3	5.1	5.9
GL 32h	ρ_k = 430 kg/m³	2.8	4.4	5.2	6.0	2.8	4.4	5.2	6.0
GL 36h	ρ_k = 450 kg/m³	2.9	4.5	5.4	6.2	2.9	4.5	5.4	6.2
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	2.6	4.0	4.7	5.4	2.6	4.0	4.7	5.4
GL 28c	ρ_k = 380 kg/m³	2.7	4.2	4.9	5.7	2.7	4.2	4.9	5.7
GL 32c	ρ_k = 410 kg/m³	2.8	4.3	5.1	5.9	2.8	4.3	5.1	5.9
GL 36c	ρ_k = 430 kg/m³	2.8	4.4	5.2	6.0	2.8	4.4	5.2	6.0

$K_{45,u}$ Calculated value of the slip modulus $K_{45,u}$ for the proof of carrying capacity with centre or eccentric stress at a right angle to the insertion direction in kN/mm

$$K_{45,u} = \frac{2}{3} \cdot K_{45,ser}$$

$K_{45,ser}$.. Calculated value of the slip modulus of a SHERPA XS/S connector as proof of usability with centre or eccentric stress at a right angle to the insertion direction in kN/mm

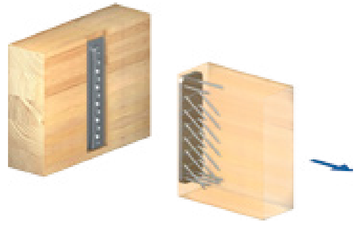
For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	1.7	2.7	3.1	3.6	1.7	2.7	3.1	3.6
C30	ρ_k = 380 kg/m³	1.8	2.8	3.3	3.8	1.8	2.8	3.3	3.8

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	1.8	2.8	3.3	3.8	1.8	2.8	3.3	3.8
GL 28h	ρ_k = 410 kg/m³	1.8	2.9	3.4	3.9	1.8	2.9	3.4	3.9
GL 32h	ρ_k = 430 kg/m³	1.9	3.0	3.5	4.0	1.9	3.0	3.5	4.0
GL 36h	ρ_k = 450 kg/m³	1.9	3.0	3.6	4.1	1.9	3.0	3.6	4.1
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	1.7	2.7	3.1	3.6	1.7	2.7	3.1	3.6
GL 28c	ρ_k = 380 kg/m³	1.8	2.8	3.3	3.8	1.8	2.8	3.3	3.8
GL 32c	ρ_k = 410 kg/m³	1.8	2.9	3.4	3.9	1.8	2.9	3.4	3.9
GL 36c	ρ_k = 430 kg/m³	1.9	3.0	3.5	4.0	1.9	3.0	3.5	4.0

$R_{1,k}$ Characteristic value of carrying capacity $R_{1,k}$ with stress in the direction of the auxiliary support longitudinal axis in kN



» SHERPA special screws: 4.5 x 50 mm

For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	3.6	6.7	8.2	11.2	3.6	6.7	8.2	11.2
C30	ρ_k = 380 kg/m³	3.8	7.2	8.8	12.0	3.8	7.2	8.8	12.0

For glulam in kN
as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	4.4	8.3	10.1	13.7	4.4	8.3	10.1	13.7
GL 28h	ρ_k = 410 kg/m³	4.7	8.7	10.7	14.6	4.7	8.7	10.7	14.6
GL 32h	ρ_k = 430 kg/m³	4.9	9.1	11.1	15.2	4.9	9.1	11.1	15.2
GL 36h	ρ_k = 450 kg/m³	5.1	9.4	11.5	15.7	5.1	9.4	11.5	15.7
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	4.1	7.7	9.4	12.9	4.1	7.7	9.4	12.9
GL 28c	ρ_k = 380 kg/m³	4.4	8.2	10.1	13.8	4.4	8.2	10.1	13.8
GL 32c	ρ_k = 410 kg/m³	4.7	8.7	10.7	14.6	4.7	8.7	10.7	14.6
GL 36c	ρ_k = 430 kg/m³	4.9	9.1	11.1	15.2	4.9	9.1	11.1	15.2

$K_{1,ser}$ Calculated value of the slip modulus $K_{1,ser}$ as proof of usability with stress in the direction of the auxiliary support longitudinal axis in kN/mm

$$K_{1,ser} = \frac{R_{1,k}}{0{,}75\ \text{mm}}$$

$R_{1,k}$...... Characteristic value of the carrying capacity $R_{1,k}$ of a SHERPA XS/S connector with stress in the direction of the auxiliary support longitudinal axis in kN/mm

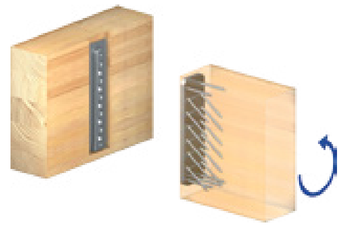
For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	4.8	8.9	10.9	14.9	4.8	8.9	10.9	14.9
C30	ρ_k = 380 kg/m³	5.1	9.5	11.7	15.9	5.1	9.5	11.7	15.9

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	5.9	11.1	13.5	18.3	5.9	11.1	13.5	18.3
GL 28h	ρ_k = 410 kg/m³	6.3	11.7	14.3	19.5	6.3	11.7	14.3	19.5
GL 32h	ρ_k = 430 kg/m³	6.5	12.1	14.8	20.2	6.5	12.1	14.8	20.2
GL 36h	ρ_k = 450 kg/m³	6.7	12.6	15.4	21.0	6.7	12.6	15.4	21.0
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	5.5	10.3	12.6	17.2	5.5	10.3	12.6	17.2
GL 28c	ρ_k = 380 kg/m³	5.9	11.0	13.4	18.3	5.9	11.0	13.4	18.3
GL 32c	ρ_k = 410 kg/m³	6.3	11.7	14.3	19.5	6.3	11.7	14.3	19.5
GL 36c	ρ_k = 430 kg/m³	6.5	12.1	14.8	20.2	6.5	12.1	14.8	20.2

$R_{tor,k}$ Characteristic values for carrying capacity $R_{tor,k}$ with torsion stress around the auxiliary support longitudinal axis in kNmm



» SHERPA special screws: 4.5 x 50 mm

For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
C24	ρ_k = 350 kg/m³	59.0	117.0	176.0	246.0	66.0	128.0	187.0	258.0
C30	ρ_k = 380 kg/m³	61.5	121.9	183.4	256.3	68.8	133.4	194.8	268.8

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		XS 5	XS 10	XS 15	XS 20	S 5	S 10	S 15	S 20
Uniform cross-sectional configuration									
GL 24h	ρ_k = 380 kg/m³	61.0	122.0	183.0	256.0	69.0	134.0	195.0	268.0
GL 28h	ρ_k = 410 kg/m³	63.9	126.6	190.5	266.3	71.4	138.5	202.4	279.2
GL 32h	ρ_k = 430 kg/m³	65.4	129.7	195.1	272.7	73.2	141.9	207.3	286.0
GL 36h	ρ_k = 450 kg/m³	66.9	132.7	199.6	278.9	74.8	145.1	212.0	292.5
Combined cross-sectional configuration									
GL 24c	ρ_k = 350 kg/m³	59.0	117.0	176.0	246.0	66.0	128.0	187.0	258.0
GL 28c	ρ_k = 380 kg/m³	61.5	121.9	183.4	256.3	68.8	133.4	194.8	268.8
GL 32c	ρ_k = 410 kg/m³	63.9	126.6	190.5	266.3	71.4	138.5	202.4	279.2
GL 36c	ρ_k = 430 kg/m³	65.4	129.7	195.1	272.7	73.2	141.9	207.3	286.0

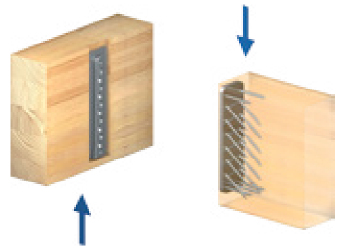
3.2 Standard characteristics for SHERPA Series M

Connector type		M 15	M 20	M 25	M 30	M 40
Geometric data QR code for PDF						
Width	[mm]	60				
Height	[mm]	90	110	130	150	170
Thickness	[mm]	14				
Minimum wood cross-section						
Main support	[mm]	65/120	65/140	65/160	65/180	65/200
Auxiliary support	[mm]	80/120	80/140	80/160	80/180	80/200
Screw type: 6.5 x 65 mm						
Helical screws						
Main support		3	5	6	7	9
Auxiliary support		4	6	8	10	12
Torque screws						
Main support		4				
Auxiliary support		5				
Total		16	20	23	26	30

QR

Please scan the QR code to access charts for the chosen connector

$R_{2,k}$ **Characteristic values for carrying capacity $R_{2,k}$ with centre stress in the insertion direction in kN**



» SHERPA special screws: 6.5 x 65 mm

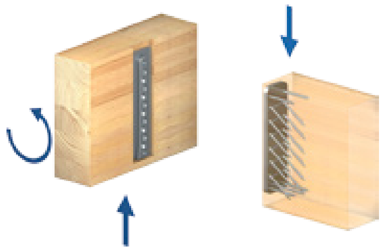
For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	12.1	19.2	22.7	26.0	32.6
C30	ρ_k = 380 kg/m³	12.9	20.5	24.2	27.8	34.8

For glulam in kN
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	14.9	23.6	27.8	32.0	40.1
GL 28h	ρ_k = 410 kg/m³	15.8	25.1	29.6	33.9	42.5
GL 32h	ρ_k = 430 kg/m³	16.4	26.0	30.8	35.3	44.2
GL 36h	ρ_k = 450 kg/m³	17.0	27.0	31.9	36.6	45.8
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	13.9	22.1	26.1	29.9	37.5
GL 28c	ρ_k = 380 kg/m³	14.9	23.6	27.9	31.9	40.0
GL 32c	ρ_k = 410 kg/m³	15.8	25.1	29.6	33.9	42.5
GL 36c	ρ_k = 430 kg/m³	16.4	26.0	30.8	35.3	44.2

$R'_{2,k}$ Characteristic values of carrying capacity $R'_{2,k}$ with eccentric stress in the insertion direction in kN



» SHERPA special screws: 6.5 x 65 mm

Eccentric or eccentricity dimensions

Connector type		M 15	M 20	M 25	M 30	M 40
e_{limit}	[mm]	10	13.3	16.7	20	23.3
e_2	[mm]	32.3	28.4	26.5	25.3	24.5

Reduction factors η_2 with eccentric stress in the insertion direction (independent of the gross density of the solid wood or glulam)

Connector type		M 15	M 20	M 25	M 30	M 40
Eccentric	e = 30 mm	0.931	0.940	0.961	0.980	0.993
	e = 40 mm	0.822	0.817	0.841	0.875	0.912
	e = 50 mm	0.701	0.682	0.695	0.721	0.758
	e = 60 mm	0.597	0.568	0.571	0.587	0.612
	e = 70 mm	0.513	0.482	0.478	0.486	0.502
	e = 80 mm	0.447	0.415	0.409	0.412	0.421
	e = 90 mm	0.395	0.364	0.356	0.356	0.361
	e = 100 mm	0.354	0.324	0.315	0.313	0.316
	e = 110 mm	0.319	0.291	0.282	0.279	0.280
	e = 120 mm	0.291	0.265	0.255	0.252	0.252
	e = 130 mm	0.267	0.242	0.233	0.229	0.229
	e = 140 mm	0.247	0.223	0.214	0.210	0.209
	e = 150 mm	0.230	0.207	0.198	0.194	0.193
	e = 160 mm	0.215	0.193	0.185	0.180	0.179
	e = 170 mm	0.201	0.181	0.173	0.168	0.167
	e = 180 mm	0.190	0.170	0.162	0.158	0.156
	e = 190 mm	0.179	0.161	0.153	0.149	0.147
	e = 200 mm	0.170	0.152	0.144	0.140	0.139

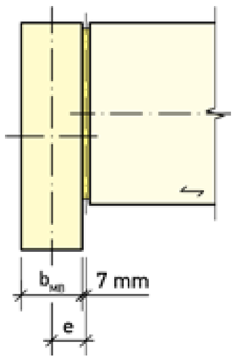
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side, flexible to torsion, main support for C24 solid wood and SHERPA M 20
b_{MB} = 120 mm

$e = b_{MB} / 2 + 7mm = 120 / 2 + 7 = 67$ mm
e = 67 mm

→ $\eta_2 = 0.508$ (interpolated)
$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0.508 \cdot 19.2 = 9.8$ kN



Charts for visual assessment

Please scan the QR code to access charts for the chosen connector.

$K_{2,ser}$ Calculated value of a slip modulus $K_{2,ser}$ as proof of usability with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,ser} = \frac{R_{2,k}}{1{,}50\ \text{mm}}$$

$R_{2,k}$..... Characteristic value of the carrying capacity of a SHERPA M connector with stress in the insertion direction in kN

For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	8.1	12.8	15.1	17.3	21.7
C30	ρ_k = 380 kg/m³	8.6	13.7	16.2	18.5	23.2

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	9.9	15.7	18.5	21.3	26.7
GL 28h	ρ_k = 410 kg/m³	10.5	16.7	19.8	22.6	28.4
GL 32h	ρ_k = 430 kg/m³	10.9	17.4	20.5	23.5	29.5
GL 36h	ρ_k = 450 kg/m³	11.3	18.0	21.3	24.4	30.6
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	9.3	14.7	17.4	19.9	25.0
GL 28c	ρ_k = 380 kg/m³	9.9	15.7	18.6	21.3	26.7
GL 32c	ρ_k = 410 kg/m³	10.5	16.7	19.8	22.6	28.4
GL 36c	ρ_k = 430 kg/m³	10.9	17.4	20.5	23.5	29.5

$K_{2,u}$ Calculated value of a slip modulus $K_{2,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,u} = \frac{2}{3} \cdot K_{2,ser}$$

$K_{2,ser}$... Calculated value of the slip modulus for a SHERPA M connector for usability evidence with centre or eccentric stress in the insertion direction in kN/mm

For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	5.4	8.5	10.1	11.6	14.5
C30	ρ_k = 380 kg/m³	5.7	9.1	10.8	12.3	15.5

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	6.6	10.5	12.4	14.2	17.8
GL 28h	ρ_k = 410 kg/m³	7.0	11.1	13.2	15.1	18.9
GL 32h	ρ_k = 430 kg/m³	7.3	11.6	13.7	15.7	19.6
GL 36h	ρ_k = 450 kg/m³	7.6	12.0	14.2	16.2	20.4
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	6.2	9.8	11.6	13.3	16.7
GL 28c	ρ_k = 380 kg/m³	6.6	10.5	12.4	14.2	17.8
GL 32c	ρ_k = 410 kg/m³	7.0	11.1	13.2	15.1	18.9
GL 36c	ρ_k = 430 kg/m³	7.3	11.6	13.7	15.7	19.6

$K_{2,\varphi,ser}$ Calculated value of the torsion modulus $K_{2,\varphi,ser}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,ser} = 200 \cdot R_{2,k} \cdot e_2$$

$R_{2,k}$...... Characteristic value of the carrying capacity of a SHERPA M connector with stress in the insertion direction in kN

e_2........ Eccentric SHERPA M connector at maximum torque stress around the axis at a right angle to the insertion direction in m

For solid wood in kNm/rad
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	78.2	109.1	120.3	131.6	159.7
C30	ρ_k = 380 kg/m³	83.5	116.5	128.5	140.5	170.6

For glulam in kNm/rad
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	96.3	134.0	147.3	161.9	196.5
GL 28h	ρ_k = 410 kg/m³	102.0	142.3	157.0	171.7	208.5
GL 32h	ρ_k = 430 kg/m³	106.0	147.9	163.1	178.4	216.6
GL 36h	ρ_k = 450 kg/m³	109.9	153.3	169.2	185.0	224.6
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	89.9	125.4	138.4	151.3	183.7
GL 28c	ρ_k = 380 kg/m³	96.0	133.9	147.8	161.6	196.2
GL 32c	ρ_k = 410 kg/m³	102.0	142.3	157.0	171.7	208.5
GL 36c	ρ_k = 430 kg/m³	106.0	147.9	163.1	178.4	216.6

$K_{2,\varphi,u}$ Calculated value of the torsion modulus $K_{2,\varphi,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,u} = \frac{2}{3} \cdot K_{2,\varphi,ser}$$

$K_{2,\varphi,ser}$.. Calculated value of the torsion modulus of a SHERPA M connector as proof of usability with centre or eccentric stress in the insertion direction in kNm/rad

For solid wood in kNm/rad
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	52.1	72.7	80.2	87.7	106.5
C30	ρ_k = 380 kg/m³	55.7	77.6	85.7	93.7	113.7

For glulam in kNm/rad
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	64.2	89.4	98.2	107.9	131.0
GL 28h	ρ_k = 410 kg/m³	68.0	94.9	104.7	114.5	139.0
GL 32h	ρ_k = 430 kg/m³	70.7	98.6	108.7	118.9	144.4
GL 36h	ρ_k = 450 kg/m³	73.3	102.2	112.8	123.3	149.7
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	59.9	83.6	92.2	100.9	122.5
GL 28c	ρ_k = 380 kg/m³	64.0	89.3	98.5	107.7	130.8
GL 32c	ρ_k = 410 kg/m³	68.0	94.9	104.7	114.5	139.0
GL 36c	ρ_k = 430 kg/m³	70.7	98.6	108.7	118.9	144.4

The following information is valid for:

- Solid pine wood with a minimum solidity class of C24 as per EN 338 or EN 14081-1
- all glulam solidity classes as per EN 1194 or EN 14080
- Layered veneer wood (LVL) as per EN 14374
- Components similar to glulam in solid wood (double and triple column) as per prEN 14080
- Plywood as per European technical approvals or national requirements
- Strand wood (e.g. wood trim strips – intralam, parallel strand wood – Paralam) as per European technical approvals or national regulations

Solid wood must have a moisture content of at most 18 % when manufactured, and must have a minimum core separation at grain connections.

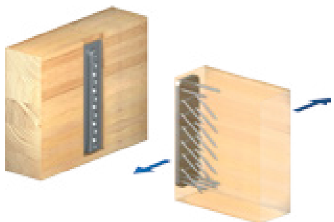
Sherpa may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1 and screws must withstand the following corrosion loads.

- Yellow zinc plated
  moderate load – corrosive categories C1, C2 and C3 as per EN ISO 12944-2

- Zinc-nickel
  very high load – corrosive categories C1 to C5-M-long as per EN ISO12944-2

Moisture penetration and regular condensate build-up must be prevented.

$R_{45,k}$ **Characteristic values for carrying capacity $R_{45,k}$ with centre stress at a right angle to the insertion direction in kN**



- SHERPA special screws: 6.5 x 65 mm

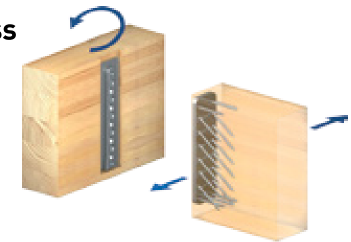
For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	8.1	9.6	11.2	12.8	14.3
C30	ρ_k = 380 kg/m³	8.4	10.0	11.7	13.3	14.9

For glulam in kN
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	8.4	10.0	11.7	13.3	14.9
GL 28h	ρ_k = 410 kg/m³	8.8	10.4	12.1	13.9	15.5
GL 32h	ρ_k = 430 kg/m³	9.0	10.6	12.4	14.2	15.9
GL 36h	ρ_k = 450 kg/m³	9.2	10.9	12.7	14.5	16.2
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	8.1	9.6	11.2	12.8	14.3
GL 28c	ρ_k = 380 kg/m³	8.4	10.0	11.7	13.3	14.9
GL 32c	ρ_k = 410 kg/m³	8.8	10.4	12.1	13.9	15.5
GL 36c	ρ_k = 430 kg/m³	9.0	10.6	12.4	14.2	15.9

$R'_{45,k}$ Characteristic values for carrying capacity $R'_{45,k}$ with eccentric stress at a right angle to the insertion direction in kN



» SHERPA special screws: 6.5 x 65 mm

Eccentric or eccentricity dimensions

Connector type		M 15	M 20	M 25	M30	M 40
e_{45}	[mm]	50.5	42.3	36.4	31.9	28.4

Reduction factors η_2 with eccentric stress at a right angle to the insertion direction (independent of the gross density of solid wood or glulam)

Connector type		M 15	M 20	M 25	M 30	M 40
Eccentric	e = 30 mm	0.939	0.903	0.862	0.817	0.771
	e = 40 mm	0.874	0.815	0.755	0.696	0.641
	e = 50 mm	0.798	0.722	0.653	0.591	0.537
	e = 60 mm	0.720	0.638	0.567	0.507	0.458
	e = 70 mm	0.649	0.565	0.498	0.442	0.397
	e = 80 mm	0.586	0.505	0.442	0.391	0.350
	e = 90 mm	0.531	0.455	0.396	0.349	0.312
	e = 100 mm	0.485	0.413	0.358	0.316	0.282
	e = 110 mm	0.445	0.378	0.327	0.288	0.257
	e = 120 mm	0.411	0.347	0.301	0.264	0.236
	e = 130 mm	0.381	0.322	0.278	0.244	0.218
	e = 140 mm	0.355	0.299	0.258	0.227	0.202
	e = 150 mm	0.332	0.280	0.242	0.212	0.189
	e = 160 mm	0.312	0.263	0.227	0.199	0.177
	e = 170 mm	0.295	0.248	0.213	0.187	0.167
	e = 180 mm	0.279	0.234	0.202	0.177	0.158
	e = 190 mm	0.264	0.222	0.191	0.168	0.149
	e = 200 mm	0.251	0.211	0.182	0.159	0.142

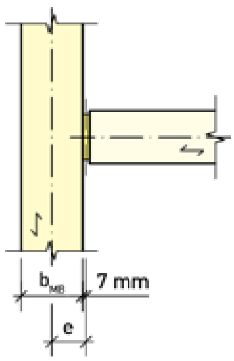
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side around the z axis flexible to bending main support for C24 solid wood and SHERPA M 20
b_{HT} = 120 mm

$e = b_{MB} / 2 + 7$ mm = 120 / 2 + 7 = 67 mm
e = 67 mm

→ $\eta_2 = 0.587$ (interpolated)
$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0.587 \cdot 9.6 = 5.6$ kN



Charts for visual assessment

Please scan the QR code to access charts for the chosen connector.

$K_{45,ser}$ Calculated value of the slip modulus $K_{45,ser}$ as proof of carrying capacity with centre or eccentric stress at a right angle to the insertion direction in kN/mm

$$K_{45,ser} = \frac{R_{45,k}}{1{,}75\ \text{mm}}$$

$R_{45,k}$.... Characteristic value of the carrying capacity of a SHERPA M connector with centre or eccentric stress at a right angle to the insertion direction in kN

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	4.6	5.5	6.4	7.3	8.2
C30	ρ_k = 380 kg/m³	4.8	5.7	6.7	7.6	8.5

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	4.8	5.7	6.7	7.6	8.5
GL 28h	ρ_k = 410 kg/m³	5.0	5.9	6.9	7.9	8.8
GL 32h	ρ_k = 430 kg/m³	5.1	6.1	7.1	8.1	9.1
GL 36h	ρ_k = 450 kg/m³	5.2	6.2	7.3	8.3	9.3
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	4.6	5.5	6.4	7.3	8.2
GL 28c	ρ_k = 380 kg/m³	4.8	5.7	6.7	7.6	8.5
GL 32c	ρ_k = 410 kg/m³	5.0	5.9	6.9	7.9	8.8
GL 36c	ρ_k = 430 kg/m³	5.1	6.1	7.1	8.1	9.1

$K_{45,u}$ Calculated value of a slip modulus $K_{45,u}$ as proof of carrying capacity with centre or eccentric stress at a right angle to the insertion value in kN/mm

$$K_{45,u} = \frac{2}{3} \cdot K_{45,ser}$$

$K_{45,ser}$.. Calculated value of the slip modulus for a SHERPA M connector as proof of usability with centre or eccentric stress at a right angle to the insertion direction in kN/mm

For solid wood in kN/mm as per EN 338 or EN 14081-1

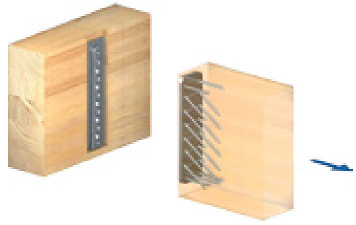
Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	3.1	3.7	4.3	4.9	5.4
C30	ρ_k = 380 kg/m³	3.2	3.8	4.4	5.1	5.7

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	3.2	3.8	4.5	5.1	5.7
GL 28h	ρ_k = 410 kg/m³	3.3	4.0	4.6	5.3	5.9
GL 32h	ρ_k = 430 kg/m³	3.4	4.1	4.7	5.4	6.0
GL 36h	ρ_k = 450 kg/m³	3.5	4.1	4.8	5.5	6.2
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	3.1	3.7	4.3	4.9	5.4
GL 28c	ρ_k = 380 kg/m³	3.2	3.8	4.4	5.1	5.7
GL 32c	ρ_k = 410 kg/m³	3.3	4.0	4.6	5.3	5.9
GL 36c	ρ_k = 430 kg/m³	3.4	4.1	4.7	5.4	6.0

$R_{1,k}$ Characteristic value of carrying capacity $R_{1,k}$ with stress in the direction of the auxiliary support longitudinal axis in kN

» SHERPA special screws: 6.5 x 65 mm



For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	8.5	13.5	15.9	18.3	22.9
C30	ρ_k = 380 kg/m³	9.1	14.4	17.0	19.5	24.5

For glulam in kN
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	10.5	16.6	19.5	22.4	28.1
GL 28h	ρ_k = 410 kg/m³	11.1	17.6	20.8	23.9	29.9
GL 32h	ρ_k = 430 kg/m³	11.5	18.3	21.6	24.8	31.0
GL 36h	ρ_k = 450 kg/m³	12.0	19.0	22.4	25.7	32.2
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	9.8	15.5	18.3	21.0	26.3
GL 28c	ρ_k = 380 kg/m³	10.4	16.6	19.5	22.5	28.1
GL 32c	ρ_k = 410 kg/m³	11.1	17.6	20.8	23.9	29.9
GL 36c	ρ_k = 430 kg/m³	11.5	18.3	21.6	24.8	31.0

$K_{1,ser}$ Calculated value of the slip modulus $K_{1,ser}$ as proof of usability with stress in the direction of the auxiliary support longitudinal axis in kN/mm

$$K_{1,ser} = \frac{R_{1,k}}{1{,}00\text{ mm}}$$

$R_{1,k}$...... Characteristic value of carrying capacity $R_{1,k}$ of a SHERPA M connector with stress in the direction of the auxiliary support longitudinal axis in kN/mm

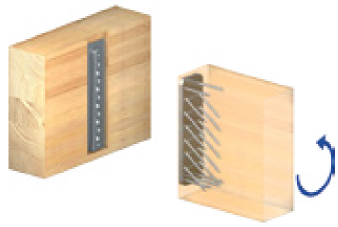
For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	8.5	13.5	15.9	18.3	22.9
C30	ρ_k = 380 kg/m³	9.1	14.4	17.0	19.5	24.5

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	10.5	16.6	19.5	22.4	28.1
GL 28h	ρ_k = 410 kg/m³	11.1	17.6	20.8	23.9	29.9
GL 32h	ρ_k = 430 kg/m³	11.5	18.3	21.6	24.8	31.0
GL 36h	ρ_k = 450 kg/m³	12.0	19.0	22.4	25.7	32.2
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	9.8	15.5	18.3	21.0	26.3
GL 28c	ρ_k = 380 kg/m³	10.4	16.6	19.5	22.5	28.1
GL 32c	ρ_k = 410 kg/m³	11.1	17.6	20.8	23.9	29.9
GL 36c	ρ_k = 430 kg/m³	11.5	18.3	21.6	24.8	31.0

$R_{tor,k}$ Characteristic values for carrying capacity $R_{tor,k}$ with torsion stress around the auxiliary support longitudinal axis in kNmm



» SHERPA special screws: 6.5 x 65 mm

For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		M 15	M 20	M 25	M 30	M 40
C24	ρ_k = 350 kg/m³	271.0	379.0	505.0	651.0	813.0
C30	ρ_k = 380 kg/m³	282.4	394.9	526.2	678.3	847.1

For glulam in kNmm
as per EN 1194 or EN 14080

Connector type		M 15	M 20	M 25	M 30	M 40
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	283.0	395.0	527.0	678.0	848.0
GL 28h	ρ_k = 410 kg/m³	293.3	410.2	546.6	704.6	879.9
GL 32h	ρ_k = 430 kg/m³	300.4	420.1	559.7	721.6	901.1
GL 36h	ρ_k = 450 kg/m³	307.3	429.7	572.6	738.2	921.9
Combined cross-sectional configuration						
Connector type		M 15	M 20	M 25	M 30	M 40
GL 24c	ρ_k = 350 kg/m³	271.0	379.0	505.0	651.0	813.0
GL 28c	ρ_k = 380 kg/m³	282.4	394.9	526.2	678.3	847.1
GL 32c	ρ_k = 410 kg/m³	293.3	410.2	546.6	704.6	879.9
GL 36c	ρ_k = 430 kg/m³	300.4	420.1	559.7	721.6	901.1

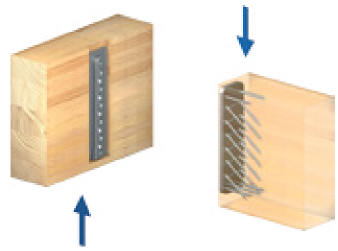
3.3 Standard characteristics for SHERPA Series L

Connector type		L 30	L 40	L 50	L 60	L 80
Geometric data QR code for PDF						
Width	[mm]			80		
Height	[mm]	150	170	210	250	290
Thickness	[mm]			18		
Minimum wood cross-section						
Main support	[mm]	100/180	100/200	100/240	100/280	100/320
Auxiliary support	[mm]	100/180	100/200	100/240	100/280	100/320
Screw type: 8.0 x 100 mm						
Helical screws						
Main support		4	5	6	8	10
Auxiliary support		4	6	8	10	12
Torque screws						
Main support				2		
Auxiliary support				5		
Total		15	18	21	25	29

Please scan the QR code to access charts for the chosen connector

$R_{2,k}$ Characteristic value for carrying capacity $R_{2,k}$ with centre stress in the insertion direction in kN

» SHERPA special screws: 8.0 x 100 mm



For solid wood in kN
as per EN 338 or EN 14081-1

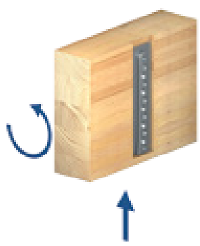
Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	29.4	36.0	42.4	54.9	67.1
C30	ρ_k = 380 kg/m³	31.4	38.4	45.3	58.6	71.7

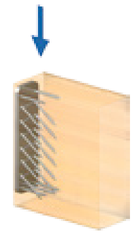
For glulam in kN
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	36.1	44.2	52.0	67.4	82.4
GL 28h	ρ_k = 410 kg/m³	38.4	47.0	55.3	71.7	87.6
GL 32h	ρ_k = 430 kg/m³	39.9	48.8	57.5	74.4	91.0
GL 36h	ρ_k = 450 kg/m³	41.3	50.6	59.6	77.2	94.3
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	33.8	41.4	48.8	63.1	77.2
GL 28c	ρ_k = 380 kg/m³	36.1	44.2	52.1	67.4	82.4
GL 32c	ρ_k = 410 kg/m³	38.4	47.0	55.3	71.7	87.6
GL 36c	ρ_k = 430 kg/m³	39.9	48.8	57.5	74.4	91.0

$R'_{2,k}$ Characteristic values of carrying capacity $R'_{2,k}$ with eccentric stress in the insertion direction in kN

» SHERPA special screws: 8.0 x 100 mm





Eccentric or eccentricity dimensions

Connector type		L 30	L 40	L 50	L 60	L 80
e_{limit}	[mm]	16.7	20	28	34.3	40.7
e_2	[mm]	31.7	30.4	33.6	31.4	30

Reduction factors η_2 with eccentric stress in the insertion direction (independent of the gross density of the solid wood or glulam)

Connector type		L 30	L 40	L 50	L 60	L 80
Eccentric	e = 40 mm	0.895	0.920	0.985	0.998	1.000
	e = 50 mm	0.774	0.799	0.921	0.961	0.990
	e = 60 mm	0.656	0.673	0.813	0.864	0.924
	e = 70 mm	0.558	0.568	0.697	0.740	0.803
	e = 80 mm	0.481	0.486	0.597	0.626	0.675
	e = 90 mm	0.421	0.423	0.516	0.534	0.569
	e = 100 mm	0.374	0.373	0.452	0.462	0.486
	e = 110 mm	0.335	0.334	0.401	0.405	0.422
	e = 120 mm	0.304	0.301	0.359	0.361	0.372
	e = 130 mm	0.278	0.274	0.326	0.324	0.332
	e = 140 mm	0.256	0.252	0.297	0.295	0.299
	e = 150 mm	0.237	0.233	0.274	0.270	0.273
	e = 160 mm	0.220	0.216	0.253	0.249	0.250
	e = 170 mm	0.206	0.202	0.236	0.230	0.231
	e = 180 mm	0.194	0.190	0.220	0.215	0.215
	e = 190 mm	0.183	0.178	0.207	0.201	0.200
	e = 200 mm	0.173	0.169	0.195	0.189	0.188

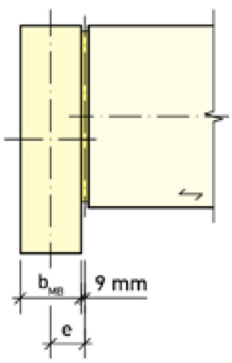
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side, flexible to torsion main support for GL 24h and SHERPA L 50
b_{MB} = 140 mm

e = b_{MB} / 2 + 9 mm = 140 / 2 + 9 = 79 mm
e = 79 mm

→ η_2 = 0.607 (interpolated)
$R'_{2,k} = \eta_2 \cdot R_{2,k}$ = 0.607 · 52 = 31.6 kN



Charts for visual assessment

Please scan the QR code to access charts for the chosen connector

$K_{2,ser}$ Calculated value of a slip modulus $K_{2,ser}$ as proof of usability with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,ser} = \frac{R_{2,k}}{2{,}00\ \text{mm}}$$

$R_{2,k}$...... Characteristic value of the carrying capacity of a SHERPA L connector with stress in the insertion direction in kN

For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	14.7	18.0	21.2	27.5	33.6
C30	ρ_k = 380 kg/m³	15.7	19.2	22.6	29.3	35.8

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	18.1	22.1	26.0	33.7	41.2
GL 28h	ρ_k = 410 kg/m³	19.2	23.5	27.7	35.8	43.8
GL 32h	ρ_k = 430 kg/m³	19.9	24.4	28.7	37.2	45.5
GL 36h	ρ_k = 450 kg/m³	20.7	25.3	29.8	38.6	47.2
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	16.9	20.7	24.4	31.6	38.6
GL 28c	ρ_k = 380 kg/m³	18.1	22.1	26.0	33.7	41.2
GL 32c	ρ_k = 410 kg/m³	19.2	23.5	27.7	35.8	43.8
GL 36c	ρ_k = 430 kg/m³	19.9	24.4	28.7	37.2	45.5

$K_{2,u}$ Calculated value of a slip modulus $K_{2,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,u} = \frac{2}{3} \cdot K_{2,ser}$$

$K_{2,ser}$.... Calculated value of a slip modulus for a SHERPA L connector for usability evidence with centre or eccentric stress in the insertion direction in kN/mm

For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	9.8	12.0	14.1	18.3	22.4
C30	ρ_k = 380 kg/m³	10.5	12.8	15.1	19.5	23.9

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	12.0	14.7	17.3	22.5	27.5
GL 28h	ρ_k = 410 kg/m³	12.8	15.7	18.4	23.9	29.2
GL 32h	ρ_k = 430 kg/m³	13.3	16.3	19.2	24.8	30.3
GL 36h	ρ_k = 450 kg/m³	13.8	16.9	19.9	25.7	31.4
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	11.3	13.8	16.3	21.0	25.7
GL 28c	ρ_k = 380 kg/m³	12.0	14.7	17.4	22.5	27.5
GL 32c	ρ_k = 410 kg/m³	12.8	15.7	18.4	23.9	29.2
GL 36c	ρ_k = 430 kg/m³	13.3	16.3	19.2	24.8	30.3

$K_{2,\varphi,ser}$ Calculated value of the torsion modulus $K_{2,\varphi,ser}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,ser} = 275 \cdot R_{2,k} \cdot e_2$$

$R_{2,k}$...... Characteristic value of the carrying capacity of a SHERPA L connector with stress in the insertion direction in kN

e_2........ Eccentricity of a SHERPA L connector for maximum torque stress around the axis at a right angle to the insertion direction in m

For solid wood in kNm/rad as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	256.3	301.0	391.8	474.1	553.6
C30	ρ_k = 380 kg/m³	273.7	321.4	418.4	506.3	591.2

For glulam in kNm/rad as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	314.7	369.5	480.5	582.0	679.8
GL 28h	ρ_k = 410 kg/m³	334.5	392.8	511.3	618.7	722.5
GL 32h	ρ_k = 430 kg/m³	347.5	408.1	531.2	642.8	750.6
GL 36h	ρ_k = 450 kg/m³	360.4	423.2	550.9	666.6	778.4
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	294.7	346.1	450.5	545.2	636.6
GL 28c	ρ_k = 380 kg/m³	314.8	369.6	481.2	582.2	679.9
GL 32c	ρ_k = 410 kg/m³	334.5	392.8	511.3	618.7	722.5
GL 36c	ρ_k = 430 kg/m³	347.5	408.1	531.2	642.8	750.6

$K_{2,\varphi,u}$ Calculated value of a torsion modulus $K_{2,\varphi,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,u} = \frac{2}{3} \cdot K_{2,\varphi,ser}$$

$K_{2,\varphi,ser}$.. Calculated value of torsion modulus for a SHERPA L connector as proof of usability with centre or eccentric stress in the insertion direction in kNm/rad

For solid wood in kNm/rad as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	170.9	200.6	261.2	316.0	369.1
C30	ρ_k = 380 kg/m³	182.5	214.3	278.9	337.5	394.1

For glulam in kNm/rad as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	209.8	246.3	320.3	388.0	453.2
GL 28h	ρ_k = 410 kg/m³	223.0	261.9	340.9	412.5	481.7
GL 32h	ρ_k = 430 kg/m³	231.7	272.0	354.1	428.5	500.4
GL 36h	ρ_k = 450 kg/m³	240.2	282.1	367.2	444.4	518.9
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	196.5	230.7	300.4	363.4	424.4
GL 28c	ρ_k = 380 kg/m³	209.9	246.4	320.8	388.2	453.3
GL 32c	ρ_k = 410 kg/m³	223.0	261.9	340.9	412.5	481.7
GL 36c	ρ_k = 430 kg/m³	231.7	272.0	354.1	428.5	500.4

The following information is valid for:

- Solid pine wood with a minimum solidity class of C24 as per EN 338 or EN 14081-1
- all glulam solidity classes as per EN 1194 or EN 14080
- Layered veneer wood (LVL) as per EN 14374
- Components similar to glulam in solid wood (double and triple column) as per prEN 14080
- Plywood as per European technical approvals or national requirements
- Strand wood (e.g. wood trim strips – intralam, parallel strand wood – Paralam) as per European technical approvals or national regulations

Solid wood must have a moisture content of at most 18 % when manufactured, and must have a minimum core separation at grain connections.

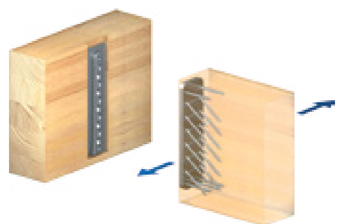
Sherpa may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1 and screws must withstand the following corrosion loads.

- Yellow zinc plated
  Moderate load – corrosive categories C1, C2 and C3 as per EN ISO 12944-2

- Zinc-nickel
  Very high load – corrosive categories C1 to C5-M-long as per EN ISO 12944-2

Moisture penetration and regular condensate build-up must be prevented.

$R_{45,k}$ **Characteristic values of carrying capacity $R_{45,k}$ with centre stress at a right angle to the insertion direction in kN**



- SHERPA special screws: 8.0 x 100 mm

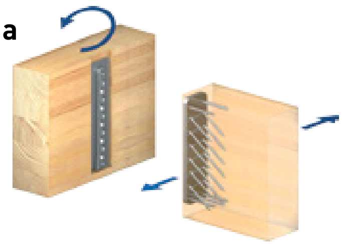
For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	14.7	17.5	20.4	23.2	26.0
C30	ρ_k = 380 kg/m³	15.3	18.2	21.3	24.2	27.1

For glulam in kN
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	15.3	18.2	21.2	24.2	27.1
GL 28h	ρ_k = 410 kg/m³	15.9	18.9	22.1	25.1	28.1
GL 32h	ρ_k = 430 kg/m³	16.3	19.4	22.6	25.7	28.8
GL 36h	ρ_k = 450 kg/m³	16.7	19.8	23.1	26.3	29.5
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	14.7	17.5	20.4	23.2	26.0
GL 28c	ρ_k = 380 kg/m³	15.3	18.2	21.3	24.2	27.1
GL 32c	ρ_k = 410 kg/m³	15.9	18.9	22.1	25.1	28.1
GL 36c	ρ_k = 430 kg/m³	16.3	19.4	22.6	25.7	28.8

$R'_{45,k}$ Characteristic values of carrying capacity $R'_{45,k}$ with centre stress at a right angle to the insertion direction in kN



» SHERPA special screws: 6.5 x 65 mm

Eccentric or eccentricity dimensions

Connector type		L 30	L 40	L 50	L 60	L 80
e_{45}	[mm]	21	22	17	14	12

Reduction factors η_2 with eccentric stress at a right angle to the insertion direction (independent of the gross density of solid wood or glulam)

Connector type		L 30	L 40	L 50	L 60	L 80
Eccentric	e = 30 mm	0.634	0.656	0.536	0.452	0.392
	e = 40 mm	0.502	0.522	0.415	0.345	0.297
	e = 50 mm	0.410	0.428	0.336	0.278	0.239
	e = 60 mm	0.345	0.361	0.281	0.232	0.199
	e = 70 mm	0.297	0.311	0.242	0.199	0.171
	e = 80 mm	0.261	0.273	0.212	0.175	0.150
	e = 90 mm	0.232	0.243	0.188	0.155	0.133
	e = 100 mm	0.209	0.219	0.170	0.140	0.120
	e = 110 mm	0.190	0.199	0.154	0.127	0.109
	e = 120 mm	0.175	0.183	0.142	0.117	0.100
	e = 130 mm	0.161	0.169	0.131	0.108	0.092
	e = 140 mm	0.150	0.157	0.121	0.100	0.086
	e = 150 mm	0.140	0.147	0.113	0.093	0.080
	e = 160 mm	0.131	0.137	0.106	0.087	0.075
	e = 170 mm	0.123	0.129	0.100	0.082	0.071
	e = 180 mm	0.117	0.122	0.094	0.078	0.067
	e = 190 mm	0.110	0.116	0.089	0.074	0.063
	e = 200 mm	0.105	0.110	0.085	0.070	0.060

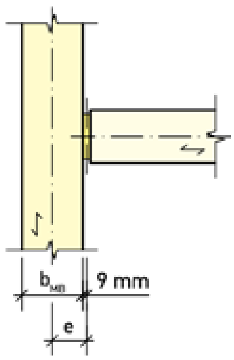
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side around the z axis
flexible to bending main carrier for GL 24h and SHERPA L 40
b_{MB} = 120 mm

$e = b_{MB} / 2 + 9 \text{ mm} = 120 / 2 + 9 = 69 \text{ mm}$
e = 69 mm

→ $\eta_2 = 0.316$ (interpolated)
$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0.316 \cdot 18.2 = 5.8$ kN



Charts for visual assessment

QR

Please scan the QR code to access charts for the chosen connector.

$K_{45,ser}$ Calculated value of a slip modulus $K_{45,ser}$ as proof of carrying capacity with centre or eccentric stress at a right angle to the insertion direction in kN/mm

$$K_{45,ser} = \frac{R_{45,k}}{2{,}00\ \text{mm}}$$

$R_{45,k}$.... Characteristic value of the carrying capacity of a SHERPA L connector with centre or eccentric stress at a right angle to the insertion direction in kN

For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	7.4	8.8	10.2	11.6	13.0
C30	ρ_k = 380 kg/m³	7.7	9.1	10.6	12.1	13.5

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	7.7	9.1	10.6	12.1	13.6
GL 28h	ρ_k = 410 kg/m³	8.0	9.5	11.0	12.6	14.1
GL 32h	ρ_k = 430 kg/m³	8.1	9.7	11.3	12.9	14.4
GL 36h	ρ_k = 450 kg/m³	8.3	9.9	11.6	13.2	14.7
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	7.4	8.8	10.2	11.6	13.0
GL 28c	ρ_k = 380 kg/m³	7.7	9.1	10.6	12.1	13.5
GL 32c	ρ_k = 410 kg/m³	8.0	9.5	11.0	12.6	14.1
GL 36c	ρ_k = 430 kg/m³	8.1	9.7	11.3	12.9	14.4

$K_{45,u}$ Calculated value of a slip modulus $K_{45,u}$ as proof of carrying capacity with centre or eccentric stress at a right angle to the insertion direction in kN/mm

$$K_{45,u} = \frac{2}{3} \cdot K_{45,ser}$$

$K_{45,ser}$.. Calculated value of a slip modulus for a SHERPA L connector as proof of usability with centre or eccentric stress at a right angle to the insertion direction in kN/mm

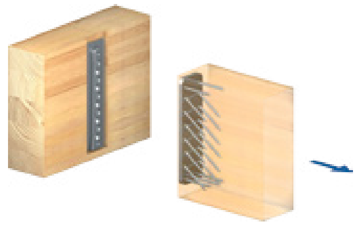
For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	4.9	5.8	6.8	7.7	8.7
C30	ρ_k = 380 kg/m³	5.1	6.1	7.1	8.1	9.0

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	5.1	6.1	7.1	8.1	9.0
GL 28h	ρ_k = 410 kg/m³	5.3	6.3	7.4	8.4	9.4
GL 32h	ρ_k = 430 kg/m³	5.4	6.5	7.5	8.6	9.6
GL 36h	ρ_k = 450 kg/m³	5.6	6.6	7.7	8.8	9.8
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	4.9	5.8	6.8	7.7	8.7
GL 28c	ρ_k = 380 kg/m³	5.1	6.1	7.1	8.1	9.0
GL 32c	ρ_k = 410 kg/m³	5.3	6.3	7.4	8.4	9.4
GL 36c	ρ_k = 430 kg/m³	5.4	6.5	7.5	8.6	9.6

$R_{1,k}$ Characteristic value of carrying capacity $R_{1,k}$ with stress in the direction of the auxiliary support longitudinal axis in kN



» SHERPA special screws: 8.0 x 100 mm

For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	20.7	25.3	29.8	38.5	47.1
C30	ρ_k = 380 kg/m³	22.1	27.0	31.8	41.1	50.3

For glulam in kN
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	25.4	31.0	36.5	47.3	57.9
GL 28h	ρ_k = 410 kg/m³	27.0	33.0	38.9	50.2	61.5
GL 32h	ρ_k = 430 kg/m³	28.1	34.3	40.4	52.2	63.9
GL 36h	ρ_k = 450 kg/m³	29.1	35.6	41.9	54.1	66.2
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	23.8	29.1	34.3	44.3	54.2
GL 28c	ρ_k = 380 kg/m³	25.4	31.1	36.6	47.3	57.8
GL 32c	ρ_k = 410 kg/m³	27.0	33.0	38.9	50.2	61.5
GL 36c	ρ_k = 430 kg/m³	28.1	34.3	40.4	52.2	63.9

$K_{1,ser}$ Calculated value of the slip modulus $K_{1,ser}$ as proof of usability with stress in the direction of the auxiliary support longitudinal axis in kN/mm

$$K_{1,ser} = \frac{R_{1,k}}{2{,}50\ \text{mm}}$$

$R_{1,k}$..... Characteristic value of carrying capacity $R_{1,k}$ of a SHERPA L connector with stress in the direction of the auxiliary support longitudinal axis in kN/mm

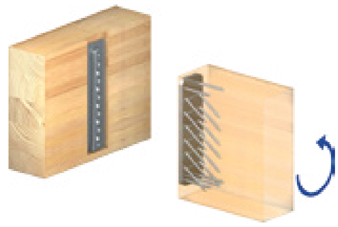
For solid wood in kN/mm
as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	8.3	10.1	11.9	15.4	18.8
C30	ρ_k = 380 kg/m³	8.8	10.8	12.7	16.4	20.1

For glulam in kN/mm
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	10.2	12.4	14.6	18.9	23.2
GL 28h	ρ_k = 410 kg/m³	10.8	13.2	15.6	20.1	24.6
GL 32h	ρ_k = 430 kg/m³	11.2	13.7	16.2	20.9	25.5
GL 36h	ρ_k = 450 kg/m³	11.6	14.2	16.8	21.7	26.5
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	9.5	11.6	13.7	17.7	21.7
GL 28c	ρ_k = 380 kg/m³	10.2	12.4	14.6	18.9	23.1
GL 32c	ρ_k = 410 kg/m³	10.8	13.2	15.6	20.1	24.6
GL 36c	ρ_k = 430 kg/m³	11.2	13.7	16.2	20.9	25.5

$R_{tor,k}$ Characteristic values for carrying capacity $R_{tor,k}$ with torsion stress around the auxiliary support longitudinal axis in kNmm



» SHERPA special screws: 8.0 x 100 mm

For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		L 30	L 40	L 50	L 60	L 80
C24	ρ_k = 350 kg/m³	774.0	1036.0	1467.0	1970.0	2537.0
C30	ρ_k = 380 kg/m³	806.5	1079.5	1528.6	2052.7	2643.5

For glulam in kNmm
as per EN 1194 or EN 14080

Connector type		L 30	L 40	L 50	L 60	L 80
Uniform cross-sectional configuration						
GL 24h	ρ_k = 380 kg/m³	839.0	1090.0	1529.0	2052.0	2643.0
GL 28h	ρ_k = 410 kg/m³	837.7	1121.3	1587.8	2132.2	2745.9
GL 32h	ρ_k = 430 kg/m³	857.9	1148.3	1626.0	2183.6	2812.0
GL 36h	ρ_k = 450 kg/m³	877.6	1174.7	1663.4	2233.8	2876.7
Combined cross-sectional configuration						
GL 24c	ρ_k = 350 kg/m³	774.0	1036.0	1467.0	1970.0	2537.0
GL 28c	ρ_k = 380 kg/m³	806.5	1079.5	1528.6	2052.7	2643.5
GL 32c	ρ_k = 410 kg/m³	837.7	1121.3	1587.8	2132.2	2745.9
GL 36c	ρ_k = 430 kg/m³	857.9	1148.3	1626.0	2183.6	2812.0

3.4 Standard characteristics for SHERPA Series XL

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120
Geometric data QR code for PDF						
Width	[mm]	120				
Height	[mm]	250	290	330	370	410
Thickness	[mm]	20				
Minimum wood cross-section						
Main support	[mm]	160/280	160/320	160/360	160/400	160/440
Auxiliary support	[mm]	140/280	140/320	140/360	140/400	140/440
Screw type 8 x 160 mm or optionally, 8 x 120/140/180 mm						
Helical screws						
Main support		4	5	6	7	9
Auxiliary support		4	6	8	8	10
Torque screws						
Main support		4				
Auxiliary support		6				
Total		18	21	24	25	29

Connector type		XL 140	XL 170	XL 190	XL 250
Geometric data QR code for PDF					
Width	[mm]	120			
Height	[mm]	450	490	530	610
Thickness	[mm]	20			
Minimum wood cross-section					
Main support	[mm]	160/480	160/520	160/560	160/640
Auxiliary support	[mm]	140/480	140/520	140/560	140/640
Screw type 8 x 160 mm or optionally, 8 x 120/140/180 mm					
Helical screws					
Main support		10	12	14	18
Auxiliary support		12	14	16	20
Torque screws					
Main support		4			
Auxiliary support		6			
Total		32	36	40	48

QR

Please scan the QR code to access charts for the chosen connector.

The following information is valid for:

- Solid pine wood with a minimum solidity class of C24 as per EN 338 or EN 14081-1
- all glulam solidity classes as per EN 1194 or EN 14080
- Layered veneer wood (LVL) as per EN 14374
- Components similar to glulam in solid wood (double and triple column) as per prEN 14080
- Plywood as per European technical approvals or national requirements
- Strand wood (e.g. wood trim strips – intralam, parallel strand wood – Paralam) as per European technical approvals or national regulations

Solid wood must have a moisture content of at most 18 % when manufactured, and must have a minimum core separation at grain connections.

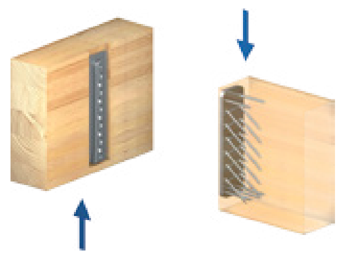
Sherpa may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1 and screws must withstand the following corrosion loads.

- Yellow zinc plated
  Moderate load – corrosive categories C1, C2 and C3 as per EN ISO 12944-2

- Zinc-nickel
  Very high load – corrosive categories C1 to C5-M-long as per EN ISO 12944-2

Moisture penetration and regular condensate build-up must be prevented.

$R_{2,k}$ Characteristic values for carrying capacity $R_{2,k}$ with centre stress in the insertion direction in kN



- SHERPA special screws: 8.0 x 160 mm

For solid wood in kN as per EN 338 or EN 14081-1

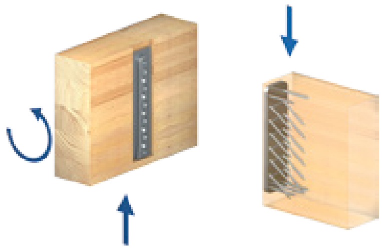
Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	53.3	65.2	76.8	88.2	110.6	121.6	143.3	164.6	206.4
C30	ρ_k = 380 kg/m³	56.9	69.6	82.0	94.2	118.1	129.9	153.0	175.8	220.4

For glulam in kN as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	65.5	80.0	94.3	108.4	135.9	149.4	176.0	202.2	253.5
GL 28h	ρ_k = 410 kg/m³	69.6	85.1	100.2	115.1	144.4	158.7	187.0	214.8	269.4
GL 32h	ρ_k = 430 kg/m³	72.3	88.4	104.1	119.6	150.0	164.9	194.3	223.2	279.9
GL 36h	ρ_k = 450 kg/m³	74.9	91.7	108.0	124.0	155.5	171.0	201.5	231.4	290.2
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	61.3	75.0	88.3	101.4	127.2	139.8	164.8	189.3	237.4
GL 28c	ρ_k = 380 kg/m³	65.5	80.1	94.3	108.3	135.8	149.3	176.0	202.2	253.5
GL 32c	ρ_k = 410 kg/m³	69.6	85.1	100.2	115.1	144.4	158.7	187.0	214.8	269.4
GL 36c	ρ_k = 430 kg/m³	72.3	88.4	104.1	119.6	150.0	164.9	194.3	223.2	279.9

$R'_{2,k}$ Characteristic values for carrying capacity $R'_{2,k}$ with centre stress in the insertion direction in kN

» SHERPA special screws: 8.0 x 160 mm



Eccentric or eccentricity dimensions

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
e_{limit}	[mm]	17.5	25	31.9	43.1	48.8	54.8	61.1	67.5	80.4
e_2	[mm]	88.1	71	62.5	71.8	64.9	60.3	57	54.6	51.2

Reduction factors η_2 with eccentric stress in the insertion direction
(independent of the gross density of the solid wood or glulam)

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Eccentric	e = 30 mm	1	1	1	1	1	1	1	1	1
	e = 40 mm	0.995	0.997	1	1	1	1	1	1	1
	e = 50 mm	0.984	0.986	0.992	1	1	1	1	1	1
	e = 60 mm	0.965	0.963	0.971	0.996	0.998	1	1	1	1
	e = 70 mm	0.938	0.927	0.934	0.983	0.989	0.998	1	1	1
	e = 80 mm	0.903	0.881	0.882	0.958	0.965	0.990	0.994	1	1
	e = 90 mm	0.863	0.827	0.822	0.921	0.927	0.973	0.979	0.987	1
	e = 100 mm	0.819	0.771	0.758	0.874	0.875	0.946	0.952	0.962	0.986
	e = 110 mm	0.774	0.717	0.697	0.821	0.816	0.909	0.913	0.922	0.954
	e = 120 mm	0.730	0.665	0.641	0.766	0.755	0.865	0.864	0.870	0.901
	e = 130 mm	0.687	0.618	0.590	0.712	0.697	0.817	0.810	0.811	0.834
	e = 140 mm	0.647	0.575	0.545	0.661	0.642	0.767	0.755	0.750	0.763
	e = 150 mm	0.610	0.537	0.505	0.615	0.593	0.718	0.701	0.692	0.694
	e = 160 mm	0.576	0.503	0.470	0.573	0.549	0.672	0.652	0.638	0.631
	e = 170 mm	0.545	0.472	0.439	0.535	0.511	0.630	0.606	0.590	0.575
	e = 180 mm	0.516	0.444	0.412	0.501	0.476	0.590	0.565	0.547	0.527
	e = 190 mm	0.490	0.419	0.387	0.471	0.446	0.555	0.528	0.509	0.485
	e = 200 mm	0.466	0.397	0.366	0.444	0.418	0.522	0.495	0.475	0.448

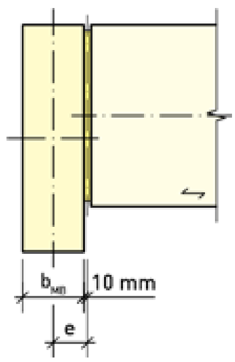
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side, flexible to torsion
Main support for GL 24 h and SHERPA XL 55
b_{MB} = 160 mm

$e = b_{MB} / 2 + 10 \text{ mm} = 160 / 2 + 10 = 90 \text{ mm}$
e = 90mm

→ $\eta_2 = 0.863$
$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0.863 \cdot 65.5 = 56.5$ kN



Charts for visual assessment

Please scan the QR code to access charts for the chosen connector.

$K_{2,ser}$ Calculated value of a slip modulus $K_{2,ser}$ as proof of usability with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,ser} = \frac{R_{2,k}}{3{,}00\ \text{mm}}$$

$R_{2,k}$...... Characteristic value of the carrying capacity of a SHERPA XL connector with stress in the insertion direction in kN

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	17.8	21.7	25.6	29.4	36.9	40.5	47.8	54.9	68.8
C30	ρ_k = 380 kg/m³	19.0	23.2	27.3	31.4	39.4	43.3	51.0	58.6	73.5

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	21.8	26.7	31.4	36.1	45.3	49.8	58.7	67.4	84.5
GL 28h	ρ_k = 410 kg/m³	23.2	28.4	33.4	38.4	48.1	52.9	62.3	71.6	89.8
GL 32h	ρ_k = 430 kg/m³	24.1	29.5	34.7	39.9	50.0	55.0	64.8	74.4	93.3
GL 36h	ρ_k = 450 kg/m³	25.0	30.6	36.0	41.3	51.8	57.0	67.2	77.1	96.7
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	20.4	25.0	29.4	33.8	42.4	46.6	54.9	63.1	79.1
GL 28c	ρ_k = 380 kg/m³	21.8	26.7	31.4	36.1	45.3	49.8	58.7	67.4	84.5
GL 32c	ρ_k = 410 kg/m³	23.2	28.4	33.4	38.4	48.1	52.9	62.3	71.6	89.8
GL 36c	ρ_k = 430 kg/m³	24.1	29.5	34.7	39.9	50.0	55.0	64.8	74.4	93.3

$K_{2,u}$ Calculated value of a slip modulus $K_{2,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,u} = \frac{2}{3} \cdot K_{2,ser}$$

$K_{2,ser}$.... Calculated value of a slip modulus of a SHERPA XL connector for usability evidence with centre or eccentric stress in the insertion direction in kN/mm

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	11.8	14.5	17.1	19.6	24.6	27.0	31.8	36.6	45.9
C30	ρ_k = 380 kg/m³	12.6	15.5	18.2	20.9	26.2	28.9	34.0	39.1	49.0

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	14.6	17.8	21.0	24.1	30.2	33.2	39.1	44.9	56.3
GL 28h	ρ_k = 410 kg/m³	15.5	18.9	22.3	25.6	32.1	35.3	41.6	47.7	59.9
GL 32h	ρ_k = 430 kg/m³	16.1	19.6	23.1	26.6	33.3	36.6	43.2	49.6	62.2
GL 36h	ρ_k = 450 kg/m³	16.7	20.4	24.0	27.6	34.6	38.0	44.8	51.4	64.5
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	13.6	16.7	19.6	22.5	28.3	31.1	36.6	42.1	52.7
GL 28c	ρ_k = 380 kg/m³	14.5	17.8	21.0	24.1	30.2	33.2	39.1	44.9	56.3
GL 32c	ρ_k = 410 kg/m³	15.5	18.9	22.3	25.6	32.1	35.3	41.6	47.7	59.9
GL 36c	ρ_k = 430 kg/m³	16.1	19.6	23.1	26.6	33.3	36.6	43.2	49.6	62.2

$K_{2,\varphi,ser}$ Calculated value of the torsion modulus $K_{2,\varphi,ser}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,ser} = 100 \cdot R_{2,k} \cdot e_2$$

$R_{2,k}$...... Characteristic value of the carrying capacity of a SHERPA XL connector with stress in the insertion direction in kN

e_2........ Eccentricity of a SHERPA XL connector with a maximum torque stress around the axis at a right angle to the insertion direction in m

For solid wood in kNm/rad as per EN 338 or EN 14081-1

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	469.6	462.9	480.0	633.3	717.8	733.2	816.8	898.7	1056.8
C30	ρ_k = 380 kg/m³	501.5	494.4	512.6	676.3	766.6	783.1	872.4	959.8	1128.6

For glulam in kNm/rad as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	577.1	568.0	589.4	778.3	882.0	900.9	1003.2	1104.0	1297.9
GL 28h	ρ_k = 410 kg/m³	612.9	604.2	626.5	826.5	936.9	957.0	1066.1	1173.0	1379.3
GL 32h	ρ_k = 430 kg/m³	636.7	627.7	650.8	858.6	973.2	994.2	1107.5	1218.5	1432.8
GL 36h	ρ_k = 450 kg/m³	660.3	650.9	674.9	890.4	1009.3	1031.0	1148.5	1263.7	1485.9
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	540.0	532.4	552.0	728.3	825.5	843.2	939.3	1033.5	1215.3
GL 28c	ρ_k = 380 kg/m³	576.7	568.6	589.5	777.8	881.6	900.6	1003.2	1103.8	1297.9
GL 32c	ρ_k = 410 kg/m³	612.9	604.2	626.5	826.5	936.9	957.0	1066.1	1173.0	1379.3
GL 36c	ρ_k = 430 kg/m³	636.7	627.7	650.8	858.6	973.2	994.2	1107.5	1218.5	1432.8

$K_{2,\varphi,u}$ Calculated value of a torsion modulus $K_{2,\varphi,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,u} = \frac{2}{3} \cdot K_{2,\varphi,ser}$$

$K_{2,\varphi,ser}$.. Calculated value of a torsion modulus for a SHERPA XL connector as proof of usability with centre or eccentric stress in the insertion direction in kNm/rad

For solid wood in kNm/rad as per EN 338 or EN 14081-1

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	313.0	308.6	320.0	422.2	478.5	488.8	544.5	599.1	704.5
C30	ρ_k = 380 kg/m³	334.3	329.6	341.8	450.9	511.1	522.1	581.6	639.9	752.4

For glulam in kNm/rad as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	384.7	378.7	392.9	518.9	588.0	600.6	668.8	736.0	865.3
GL 28h	ρ_k = 410 kg/m³	408.6	402.8	417.7	551.0	624.6	638.0	710.7	782.0	919.5
GL 32h	ρ_k = 430 kg/m³	424.5	418.4	433.9	572.4	648.8	662.8	738.3	812.4	955.2
GL 36h	ρ_k = 450 kg/m³	440.2	433.9	449.9	593.6	672.9	687.3	765.7	842.5	990.6
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	360.0	354.9	368.0	485.5	550.3	562.2	626.2	689.0	810.2
GL 28c	ρ_k = 380 kg/m³	384.5	379.0	393.0	518.5	587.7	600.4	668.8	735.9	865.3
GL 32c	ρ_k = 410 kg/m³	408.6	402.8	417.7	551.0	624.6	638.0	710.7	782.0	919.5
GL 36c	ρ_k = 430 kg/m³	424.5	418.4	433.9	572.4	648.8	662.8	738.3	812.4	955.2

The following information is valid for:

- Full wood made of pine with a minimum solidity class C24 as per EN 338 or EN 14081-1
- all glulam solidity classes as per EN 1194 or EN 14080
- Plywood (LVL) as PER EN 14374
- Construction materials similar to glulam in solid wood (double and triple columns) as per prEN 14080
- Laminated wood in accordance with European technical approvals or national regulations
- Strand wood (e.g. wood trim strips – intralam, parallel strand wood – Paralam) as per European technical approvals or national regulations

Solid wood must have a moisture content of at most 18 % when manufactured, and must have a minimum core separation at grain connections.

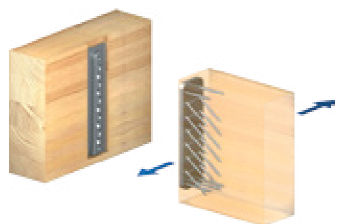
Sherpa may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1 and screws must withstand the following corrosion loads.

- Yellow zinc plated
  Moderate load – corrosive categories C1, C2 and C3 as per EN ISO 12944-2

- Zinc-nickel
  Very high load – corrosive categories C1 to C5-M length as per EN ISO 12944-2

Moisture penetration and regular condensate build-up must be prevented.

$R_{45,k}$ Characteristic values for carrying capacity $R_{45,k}$ with centre stress at a right angle to the insertion direction in kN



- SHERPA special screws: 8.0 x 160 mm

For solid wood in kN
as per EN 338 or EN 14081-1

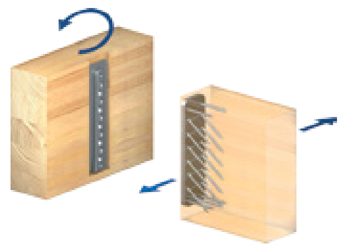
Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	26.5	30.7	34.9	34.9	39.2	43.4	47.6	51.9	60.4
C30	ρ_k = 380 kg/m³	27.6	32.0	36.4	36.4	40.8	45.2	49.6	54.1	62.9

For glulam in kN
as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	27.6	32.0	36.4	36.4	40.8	45.2	49.6	54.1	62.9
GL 28h	ρ_k = 410 kg/m³	28.7	33.2	37.8	37.8	42.4	47.0	51.5	56.2	65.4
GL 32h	ρ_k = 430 kg/m³	29.4	34.0	38.7	38.7	43.4	48.1	52.8	57.5	66.9
GL 36h	ρ_k = 450 kg/m³	30.0	34.8	39.6	39.6	44.4	49.2	54.0	58.8	68.5
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	26.5	30.7	34.9	34.9	39.2	43.4	47.6	51.9	60.4
GL 28c	ρ_k = 380 kg/m³	27.6	32.0	36.4	36.4	40.8	45.2	49.6	54.1	62.9
GL 32c	ρ_k = 410 kg/m³	28.7	33.2	37.8	37.8	42.4	47.0	51.5	56.2	65.4
GL 36c	ρ_k = 430 kg/m³	29.4	34.0	38.7	38.7	43.4	48.1	52.8	57.5	66.9

$R'_{45,k}$ Characteristic values of carrying capacity $R'_{45,k}$ with eccentric stress at a right angle to the insertion direction in kN

» SHERPA special screws: 8.0 x 160 mm



Eccentric or eccentricity dimensions

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
e_{45}	[mm]	144	120	103	103	89.8	79.8	71.8	65.3	55.3

Reduction factors η_2 with eccentric stress at a right angle to the insertion direction (independent of the gross density of solid wood or glulam)

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Eccentric	e = 30 mm	0.997	0.995	0.992	0.992	0.988	0.983	0.977	0.970	0.952
	e = 40 mm	0.993	0.988	0.981	0.981	0.972	0.961	0.948	0.933	0.899
	e = 50 mm	0.986	0.977	0.965	0.965	0.948	0.929	0.908	0.884	0.832
	e = 60 mm	0.977	0.961	0.942	0.942	0.917	0.889	0.858	0.826	0.760
	e = 70 mm	0.964	0.941	0.913	0.913	0.879	0.842	0.804	0.765	0.691
	e = 80 mm	0.949	0.917	0.880	0.880	0.837	0.793	0.749	0.706	0.629
	e = 90 mm	0.930	0.889	0.843	0.843	0.793	0.743	0.696	0.651	0.573
	e = 100 mm	0.908	0.859	0.805	0.805	0.749	0.696	0.646	0.602	0.525
	e = 110 mm	0.884	0.827	0.767	0.767	0.706	0.651	0.601	0.557	0.483
	e = 120 mm	0.859	0.794	0.729	0.729	0.666	0.610	0.561	0.518	0.447
	e = 130 mm	0.832	0.761	0.693	0.693	0.628	0.573	0.524	0.483	0.415
	e = 140 mm	0.805	0.728	0.658	0.658	0.593	0.539	0.492	0.452	0.387
	e = 150 mm	0.777	0.697	0.625	0.625	0.561	0.508	0.462	0.424	0.363
	e = 160 mm	0.750	0.667	0.595	0.595	0.532	0.480	0.436	0.399	0.341
	e = 170 mm	0.723	0.638	0.567	0.567	0.505	0.454	0.412	0.377	0.322
	e = 180 mm	0.697	0.611	0.540	0.540	0.480	0.431	0.391	0.357	0.304
	e = 190 mm	0.672	0.586	0.516	0.516	0.457	0.410	0.371	0.339	0.289
	e = 200 mm	0.648	0.562	0.493	0.493	0.436	0.391	0.354	0.323	0.275

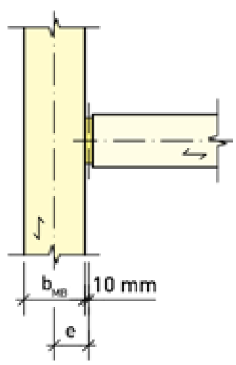
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side around the z axis flexible to bending main support for GL 24h and SHERPA XL 55
b_{MB} = 160 mm

$e = b_{MB} / 2 + 10\text{ mm} = 160 / 2 + 10 = 90\text{ mm}$
e = 90 mm

→ $\eta_2 = 0.930$
$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0.930 \cdot 27.6 = 25.7\text{ kN}$



Charts for visual assessment

Please scan the QR code to access charts for the chosen connector.

$K_{45,ser}$ Calculated value of the slip modulus $K_{45,ser}$ as proof of usability with centre or eccentric stress at a right angle to the insertion direction in kN/mm

$$K_{45,ser} = \frac{R_{45,k}}{5{,}00\ \text{mm}}$$

$R_{45,k}$.... Characteristic value of the carrying capacity of a SHERPA XL connector with centre or eccentric stress at a right angle to the insertion direction in kN

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	5.3	6.1	7.0	7.0	7.8	8.7	9.5	10.4	12.1
C30	ρ_k = 380 kg/m³	5.5	6.4	7.3	7.3	8.2	9.0	9.9	10.8	12.6

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	5.5	6.4	7.3	7.3	8.2	9.0	9.9	10.8	12.6
GL 28h	ρ_k = 410 kg/m³	5.7	6.6	7.6	7.6	8.5	9.4	10.3	11.2	13.1
GL 32h	ρ_k = 430 kg/m³	5.9	6.8	7.7	7.7	8.7	9.6	10.6	11.5	13.4
GL 36h	ρ_k = 450 kg/m³	6.0	7.0	7.9	7.9	8.9	9.8	10.8	11.8	13.7
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	5.3	6.1	7.0	7.0	7.8	8.7	9.5	10.4	12.1
GL 28c	ρ_k = 380 kg/m³	5.5	6.4	7.3	7.3	8.2	9.0	9.9	10.8	12.6
GL 32c	ρ_k = 410 kg/m³	5.7	6.6	7.6	7.6	8.5	9.4	10.3	11.2	13.1
GL 36c	ρ_k = 430 kg/m³	5.9	6.8	7.7	7.7	8.7	9.6	10.6	11.5	13.4

$K_{45,u}$ Calculated value of the slip modulus $K_{45,u}$ as proof of carrying capacity with centre or eccentric stress at a right angle to the insertion direction in kN/mm

$$K_{45,u} = \frac{2}{3} \cdot K_{45,ser}$$

$K_{45,ser}$... Calculated value of a slip modulus for a SHERPA XL connector as proof of usability with centre or eccentric stress at a right angle to the insertion direction in kN/mm

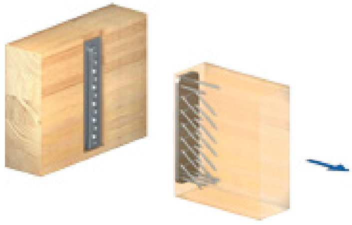
For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	3.5	4.1	4.7	4.7	5.2	5.8	6.3	6.9	8.1
C30	ρ_k = 380 kg/m³	3.7	4.3	4.8	4.8	5.4	6.0	6.6	7.2	8.4

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	3.7	4.3	4.9	4.9	5.4	6.0	6.6	7.2	8.4
GL 28h	ρ_k = 410 kg/m³	3.8	4.4	5.0	5.0	5.7	6.3	6.9	7.5	8.7
GL 32h	ρ_k = 430 kg/m³	3.9	4.5	5.2	5.2	5.8	6.4	7.0	7.7	8.9
GL 36h	ρ_k = 450 kg/m³	4.0	4.6	5.3	5.3	5.9	6.6	7.2	7.8	9.1
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	3.5	4.1	4.7	4.7	5.2	5.8	6.3	6.9	8.1
GL 28c	ρ_k = 380 kg/m³	3.7	4.3	4.8	4.8	5.4	6.0	6.6	7.2	8.4
GL 32c	ρ_k = 410 kg/m³	3.8	4.4	5.0	5.0	5.7	6.3	6.9	7.5	8.7
GL 36c	ρ_k = 430 kg/m³	3.9	4.5	5.2	5.2	5.8	6.4	7.0	7.7	8.9

$R_{1,k}$ Characteristic value of carrying capacity $R_{1,k}$ with stress in the direction of the auxiliary support longitudinal axis in kN



» SHERPA special screws: 8.0 x 160 mm

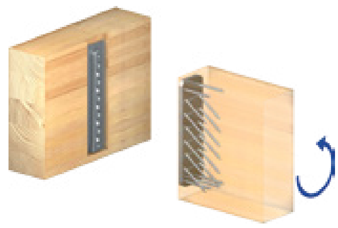
For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	57.4								
C30	ρ_k = 380 kg/m³	62.3								

For glulam in kN
as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	62.3								
GL 28h	ρ_k = 410 kg/m³	67.2								
GL 32h	ρ_k = 430 kg/m³	70.5								
GL 36h	ρ_k = 450 kg/m³	73.8								
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	57.4								
GL 28c	ρ_k = 380 kg/m³	62.3								
GL 32c	ρ_k = 410 kg/m³	67.2								
GL 36c	ρ_k = 430 kg/m³	70.5								

$R_{tor,k}$ Characteristic values for carrying capacity $R_{tor,k}$ with torsion stress around the auxiliary support longitudinal axis in kNmm



» SHERPA special screws: 8.0 x 160 mm

For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
C24	ρ_k = 350 kg/m³	2231	2971	3806	4750	5769	6882	8108	9450	12478
C30	ρ_k = 380 kg/m³	2325	3096	3966	4949	6011	7171	8448	9847	13002

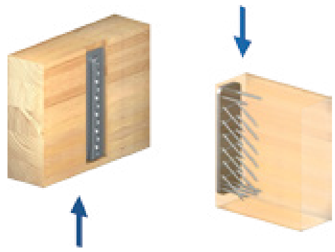
For glulam in kNmm
as per EN 1194 or EN 14080

Connector type		XL 55	XL 70	XL 80	XL 100	XL 120	XL 140	XL 170	XL 190	XL 250
Uniform cross-sectional configuration										
GL 24h	ρ_k = 380 kg/m³	2619	3488	4421	4984	6039	7204	8487	9892	13061
GL 28h	ρ_k = 410 kg/m³	2777	3698	4737	5141	6244	7449	8775	10228	13505
GL 32h	ρ_k = 430 kg/m³	2844	3787	4851	5265	6394	7628	8987	10474	13831
GL 36h	ρ_k = 450 kg/m³	2909	3874	4963	5386	6541	7803	9194	10715	14149
Combined cross-sectional configuration										
GL 24c	ρ_k = 350 kg/m³	2566	3417	4377	4750	5769	6882	8108	9450	12478
GL 28c	ρ_k = 380 kg/m³	2673	3560	4561	4949	6011	7171	8448	9847	13002
GL 32c	ρ_k = 410 kg/m³	2777	3698	4737	5141	6244	7449	8775	10228	13505
GL 36c	ρ_k = 430 kg/m³	2844	3787	4851	5265	6394	7628	8987	10474	13831

3.5 Standard characteristics for SHERPA Series XXL

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Geometric data QR code for PDF							
Width	[mm]	140					
Height	[mm]	410	450	490	530	570	610
Thickness	[mm]	20					
Minimum wood cross-section							
Main support	[mm]	160/440	160/480	160/520	160/560	160/600	160/640
Auxiliary support	[mm]	160/440	160/480	160/520	160/560	160/600	160/640
Screw type 8 x 160 mm or optionally 8 x 120/140/180 mm							
Helical screws							
Main support		12	14	16	18	20	22
Auxiliary support		15	18	21	24	24	27
Torque screws							
Main support		4					
Auxiliary support		6					
Total		37	42	47	52	54	59

Please scan the QR code to access charts for the chosen connector.



$R_{2,k}$ Characteristic values for carrying capacity $R_{2,k}$ with centre stress in the insertion direction in kN

» SHERPA special screws: 8.0 x 160 mm

For solid wood in kN
as per EN 338 or EN 14081-1

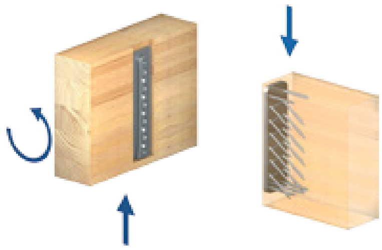
Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	143.3	164.6	185.7	206.4	226.9	247.3
C30	ρ_k = 380 kg/m³	153.0	175.8	198.3	220.4	242.3	264.1

For glulam in kN
as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	176.0	202.2	228.0	253.5	278.7	303.7
GL 28h	ρ_k = 410 kg/m³	187.0	214.8	242.4	269.4	296.1	322.8
GL 32h	ρ_k = 430 kg/m³	194.3	223.2	251.8	279.9	307.6	335.3
GL 36h	ρ_k = 450 kg/m³	201.5	231.4	261.1	290.2	319.0	347.7
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	164.8	189.3	213.6	237.4	260.9	284.4
GL 28c	ρ_k = 380 kg/m³	176.0	202.2	228.1	253.5	278.7	303.7
GL 32c	ρ_k = 410 kg/m³	187.0	214.8	242.4	269.4	296.1	322.8
GL 36c	ρ_k = 430 kg/m³	194.3	223.2	251.8	279.9	307.6	335.3

$R'_{2,k}$ Characteristic values of carrying capacity $R'_{2,k}$ with eccentric stress in the insertion direction in kN

» SHERPA special screws: 8.0 x 160 mm



Eccentric or eccentricity dimensions

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
$e_{grenz\ [limit]}$	[mm]	53.7	60	66.4	72.9	79.4	86
e_2	[mm]	70.4	61.6	54.7	49.3	49.3	44.8

Reduction factors η_2 with eccentric stress in the insertion direction
(independent of the gross density of the solid wood or glulam)

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Eccentric	e = 30 mm	1	1	1	1	1	1
	e = 40 mm	1	1	1	1	1	1
	e = 50 mm	1	1	1	1	1	1
	e = 60 mm	1	1	1	1	1	1
	e = 70 mm	0.995	0.998	1	1	1	1
	e = 80 mm	0.979	0.988	0.996	1	1	1
	e = 90 mm	0.948	0.962	0.978	0.990	1	1
	e = 100 mm	0.902	0.918	0.940	0.962	0.986	1
	e = 110 mm	0.846	0.860	0.884	0.913	0.958	0.976
	e = 120 mm	0.785	0.796	0.818	0.848	0.911	0.938
	e = 130 mm	0.725	0.731	0.749	0.776	0.851	0.881
	e = 140 mm	0.668	0.669	0.683	0.705	0.785	0.814
	e = 150 mm	0.617	0.614	0.623	0.640	0.719	0.745
	e = 160 mm	0.570	0.564	0.570	0.583	0.658	0.679
	e = 170 mm	0.529	0.521	0.523	0.532	0.603	0.619
	e = 180 mm	0.493	0.483	0.483	0.489	0.554	0.566
	e = 190 mm	0.460	0.449	0.448	0.452	0.511	0.520
	e = 200 mm	0.431	0.420	0.417	0.419	0.474	0.480

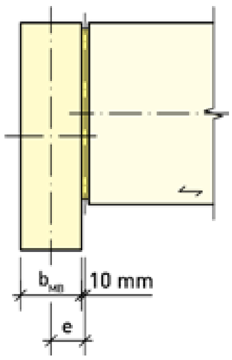
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side, flexible to torsion
Main support for GL 24h and SHERPA
XXL 170

b_{MB} = 180 mm
e = b_{MB} / 2 + 10 mm = 180 / 2 + 10 = 100 mm
e = 100 mm

→ $h_2 = 0.902$
$R'_{2,k} = h_2 \cdot R_{2,k} = 0.902 \cdot 176 = 158.8$ kN



Charts for visual assessment

Please scan the QR code to access charts for the chosen connector.

$K_{2,ser}$ Calculated value of a slip modulus $K_{2,ser}$ as proof of usability with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,ser} = \frac{R_{2,k}}{3{,}00\ mm}$$

$R_{2,k}$...... Characteristic value of carrying capacity for a SHERPA XXL connector with stress in the insertion direction in kN

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	47.8	54.9	61.9	68.8	75.6	82.4
C30	ρ_k = 380 kg/m³	51.0	58.6	66.1	73.5	80.8	88.0

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	58.7	67.4	76.0	84.5	92.9	101.2
GL 28h	ρ_k = 410 kg/m³	62.3	71.6	80.8	89.8	98.7	107.6
GL 32h	ρ_k = 430 kg/m³	64.8	74.4	83.9	93.3	102.5	111.8
GL 36h	ρ_k = 450 kg/m³	67.2	77.1	87.0	96.7	106.3	115.9
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	54.9	63.1	71.2	79.1	87.0	94.8
GL 28c	ρ_k = 380 kg/m³	58.7	67.4	76.0	84.5	92.9	101.2
GL 32c	ρ_k = 410 kg/m³	62.3	71.6	80.8	89.8	98.7	107.6
GL 36c	ρ_k = 430 kg/m³	64.8	74.4	83.9	93.3	102.5	111.8

$K_{2,u}$ Calculated value of a slip modulus $K_{2,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kN/mm

$$K_{2,u} = \frac{2}{3} \cdot K_{2,ser}$$

$K_{2,ser}$.... Calculated value of a slip modulus of a SHERPA XXL connector for usability evidence with centre or eccentric stress in the insertion direction in kN/mm

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	31.8	36.6	41.3	45.9	50.4	55.0
C30	ρ_k = 380 kg/m³	34.0	39.1	44.1	49.0	53.9	58.7

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	39.1	44.9	50.7	56.3	61.9	67.5
GL 28h	ρ_k = 410 kg/m³	41.6	47.7	53.9	59.9	65.8	71.7
GL 32h	ρ_k = 430 kg/m³	43.2	49.6	56.0	62.2	68.4	74.5
GL 36h	ρ_k = 450 kg/m³	44.8	51.4	58.0	64.5	70.9	77.3
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	36.6	42.1	47.5	52.7	58.0	63.2
GL 28c	ρ_k = 380 kg/m³	39.1	44.9	50.7	56.3	61.9	67.5
GL 32c	ρ_k = 410 kg/m³	41.6	47.7	53.9	59.9	65.8	71.7
GL 36c	ρ_k = 430 kg/m³	43.2	49.6	56.0	62.2	68.4	74.5

$K_{2,\varphi,ser}$ Calculated value of the torsion modulus $K_{2,\varphi,ser}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,ser} = 100 \cdot R_{2,k} \cdot e_2$$

$R_{2,k}$...... Characteristic value of carrying capacity for a SHERPA XXL connector with stress in the insertion direction in kN

e_2........ Eccentric SHERPA XXL connector at maximum torque stress around the axis at a right angle to the insertion direction in m

For solid wood in kNm/rad as per EN 338 or EN 14081-1

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	1008.8	1013.9	1015.8	1017.6	1118.6	1107.9
C30	ρ_k = 380 kg/m³	1077.4	1082.9	1084.9	1086.7	1194.7	1183.2

For glulam in kNm/rad as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	1239.0	1245.6	1247.2	1249.8	1374.0	1360.6
GL 28h	ρ_k = 410 kg/m³	1316.7	1323.4	1325.8	1328.1	1460.0	1446.0
GL 32h	ρ_k = 430 kg/m³	1367.8	1374.8	1377.3	1379.7	1516.7	1502.2
GL 36h	ρ_k = 450 kg/m³	1418.5	1425.7	1428.3	1430.8	1572.9	1557.8
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	1160.2	1166.0	1168.1	1170.2	1286.4	1274.1
GL 28c	ρ_k = 380 kg/m³	1239.1	1245.3	1247.6	1249.8	1373.9	1360.7
GL 32c	ρ_k = 410 kg/m³	1316.7	1323.4	1325.8	1328.1	1460.0	1446.0
GL 36c	ρ_k = 430 kg/m³	1367.8	1374.8	1377.3	1379.7	1516.7	1502.2

$K_{2,\varphi,u}$ Calculated value of a torsion modulus $K_{2,\varphi,u}$ as proof of carrying capacity with centre or eccentric stress in the insertion direction in kNm/rad

$$K_{2,\varphi,u} = \frac{2}{3} \cdot K_{2,\varphi,ser}$$

$K_{2,\varphi,ser}$.. Calculated value of a torsion modulus of a SHERPA XL connector as proof of usability with centre or eccentric stress in the insertion direction in kNm/rad

For solid wood in kNm/rad as per EN 338 or EN 14081-1

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	672.6	676.0	677.2	678.4	745.7	738.6
C30	ρ_k = 380 kg/m³	718.3	721.9	723.2	724.5	796.5	788.8

For glulam in kNm/rad as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	826.0	830.4	831.4	833.2	916.0	907.1
GL 28h	ρ_k = 410 kg/m³	877.8	882.2	883.8	885.4	973.3	964.0
GL 32h	ρ_k = 430 kg/m³	911.9	916.5	918.2	919.8	1011.1	1001.4
GL 36h	ρ_k = 450 kg/m³	945.7	950.5	952.2	953.8	1048.6	1038.5
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	773.4	777.4	778.8	780.1	857.6	849.4
GL 28c	ρ_k = 380 kg/m³	826.0	830.2	831.7	833.2	915.9	907.2
GL 32c	ρ_k = 410 kg/m³	877.8	882.2	883.8	885.4	973.3	964.0
GL 36c	ρ_k = 430 kg/m³	911.9	916.5	918.2	919.8	1011.1	1001.4

The following information is valid for:

- » Full wood made of pine with a minimum solidity class C24 as per EN 338 or EN 14081-1
- » all glulam solidity classes as per EN 1194 or EN 14080
- » Plywood (LVL) as PER EN 14374
- » Construction materials similar to glulam in solid wood (double and triple columns) as per prEN 14080
- » Laminated wood in accordance with European technical approvals or national regulations
- » Strand wood (e.g. wood trim strips – intralam, parallel strand wood – Paralam) as per European technical approvals or national regulations

Solid wood must have a moisture content of at most 18 % when manufactured, and must have a minimum core separation at grain connections.

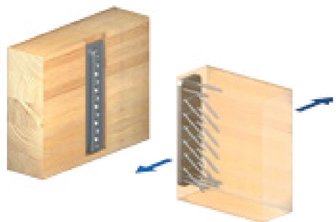
Sherpa may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1 and screws must withstand the following corrosion loads.

- » Yellow zinc plated
  Moderate load – corrosive categories C1, C2 and C3 as per EN ISO 12944-2

- » Zinc-nickel
  Very high load – corrosive categories C1 to C5-M length as per EN ISO 12944-2

Moisture penetration and regular condensate build-up must be prevented.

$R_{45,k}$ **Characteristic values of carrying capacity $R_{45,k}$ with centre stress at a right angle to the insertion direction in kN**



- » SHERPA special screws: 8.0 x 160 mm

For solid wood in kN
as per EN 338 or EN 14081-1

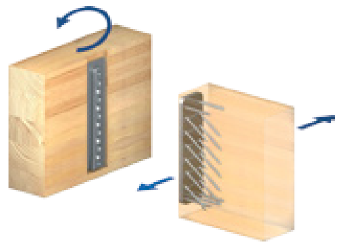
Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	49.8	56.1	62.5	68.8	68.8	75.2
C30	ρ_k = 380 kg/m³	51.9	58.5	65.1	71.7	71.7	78.4

For glulam in kN
as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	51.9	58.5	65.1	71.7	71.7	78.3
GL 28h	ρ_k = 410 kg/m³	53.9	60.7	67.6	74.5	74.5	81.4
GL 32h	ρ_k = 430 kg/m³	55.2	62.2	69.3	76.3	76.3	83.4
GL 36h	ρ_k = 450 kg/m³	56.5	63.6	70.9	78.0	78.0	85.3
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	49.8	56.1	62.5	68.8	68.8	75.2
GL 28c	ρ_k = 380 kg/m³	51.9	58.5	65.1	71.7	71.7	78.4
GL 32c	ρ_k = 410 kg/m³	53.9	60.7	67.6	74.5	74.5	81.4
GL 36c	ρ_k = 430 kg/m³	55.2	62.2	69.3	76.3	76.3	83.4

$R'_{45,k}$ Characteristic values of carrying capacity $R'_{45,k}$ with eccentric stress at a right angle to the insertion direction in kN

» SHERPA special screws: 8.0 x 160 mm



Eccentric or eccentricity dimensions

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
e_{45}	[mm]	70.4	61.6	54.7	49.3	49.3	44.8

Reduction factors η_2 with eccentric stress at a right angle to the insertion direction (independent of the gross density of solid wood or glulam)

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Eccentric	e = 30 mm	0.975	0.964	0.950	0.935	0.935	0.916
	e = 40 mm	0.945	0.922	0.896	0.867	0.867	0.836
	e = 50 mm	0.903	0.867	0.828	0.788	0.788	0.748
	e = 60 mm	0.852	0.804	0.755	0.709	0.709	0.665
	e = 70 mm	0.796	0.740	0.686	0.637	0.637	0.592
	e = 80 mm	0.740	0.679	0.623	0.575	0.575	0.531
	e = 90 mm	0.687	0.624	0.568	0.521	0.521	0.479
	e = 100 mm	0.637	0.574	0.520	0.475	0.475	0.435
	e = 110 mm	0.592	0.531	0.478	0.435	0.435	0.398
	e = 120 mm	0.552	0.492	0.442	0.402	0.402	0.367
	e = 130 mm	0.516	0.458	0.411	0.373	0.373	0.340
	e = 140 mm	0.483	0.428	0.383	0.347	0.347	0.317
	e = 150 mm	0.454	0.402	0.359	0.325	0.325	0.296
	e = 160 mm	0.428	0.378	0.337	0.305	0.305	0.278
	e = 170 mm	0.405	0.357	0.318	0.288	0.288	0.262
	e = 180 mm	0.384	0.338	0.301	0.272	0.272	0.248
	e = 190 mm	0.364	0.321	0.286	0.258	0.258	0.235
	e = 200 mm	0.347	0.305	0.272	0.245	0.245	0.223

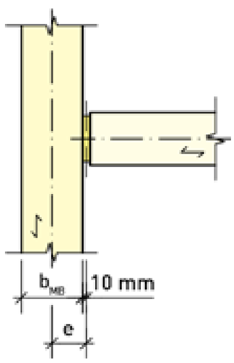
Intermediate values must be linearly interpolated

Calculation example:

Stress on one side around the z axis flexible to bending main support for GL 24h and SHERPA XXL 170

b_{MB} = 180 mm
e = b_{MB} / 2 + 10 mm = 180 / 2 + 10 = 100 mm
e = 100 mm

→ $\eta_2 = 0.930$
$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0.637 \cdot 51.9 = 33.1$ kN



Charts for visual assessment

Please scan the QR code to access charts for the chosen connector.

$K_{45,ser}$ Calculated value of the slip modulus $K_{45,ser}$ as proof of usability with centre or eccentric stress at a right angle to the insertion direction in kN/mm

$$K_{45,ser} = \frac{R_{45,k}}{5{,}00\ \text{mm}}$$

$R_{45,k}$.... Characteristic value of carrying capacity for a SHERPA XXL connector with centre or eccentric stress at a right angle to the insertion direction in kN

For solid wood in kN/mm as per EN 338 or EN 14081-1

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	10.0	11.2	12.5	13.8	13.8	15.0
C30	ρ_k = 380 kg/m³	10.4	11.7	13.0	14.3	14.3	15.7

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	10.4	11.7	13.0	14.3	14.3	15.7
GL 28h	ρ_k = 410 kg/m³	10.8	12.1	13.5	14.9	14.9	16.3
GL 32h	ρ_k = 430 kg/m³	11.0	12.4	13.9	15.3	15.3	16.7
GL 36h	ρ_k = 450 kg/m³	11.3	12.7	14.2	15.6	15.6	17.1
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	10.0	11.2	12.5	13.8	13.8	15.0
GL 28c	ρ_k = 380 kg/m³	10.4	11.7	13.0	14.3	14.3	15.7
GL 32c	ρ_k = 410 kg/m³	10.8	12.1	13.5	14.9	14.9	16.3
GL 36c	ρ_k = 430 kg/m³	11.0	12.4	13.9	15.3	15.3	16.7

$K_{45,u}$ Calculated value of a slip modulus $K_{45,u}$ as proof of carrying capacity with centre or eccentric stress at a right angle to the insertion value in kN/mm

$$K_{45,u} = \frac{2}{3} \cdot K_{45,ser}$$

$K_{45,ser}$... Calculated value of a slip modulus of a SHERPA XXL connector as proof of usability with centre or eccentric stress at a right angle to the insertion direction in kN/mm

For solid wood in kN/mm as per EN 338 or EN 14081-1

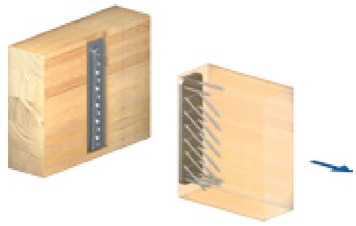
Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	6.6	7.5	8.3	9.2	9.2	10.0
C30	ρ_k = 380 kg/m³	6.9	7.8	8.7	9.6	9.6	10.4

For glulam in kN/mm as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	6.9	7.8	8.7	9.6	9.6	10.4
GL 28h	ρ_k = 410 kg/m³	7.2	8.1	9.0	9.9	9.9	10.9
GL 32h	ρ_k = 430 kg/m³	7.4	8.3	9.2	10.2	10.2	11.1
GL 36h	ρ_k = 450 kg/m³	7.5	8.5	9.4	10.4	10.4	11.4
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	6.6	7.5	8.3	9.2	9.2	10.0
GL 28c	ρ_k = 380 kg/m³	6.9	7.8	8.7	9.6	9.6	10.4
GL 32c	ρ_k = 410 kg/m³	7.2	8.1	9.0	9.9	9.9	10.9
GL 36c	ρ_k = 430 kg/m³	7.4	8.3	9.2	10.2	10.2	11.1

$R_{1,k}$ Characteristic value of carrying capacity $R_{1,k}$ with stress in the direction of the auxiliary support longitudinal axis in kN

» SHERPA special screws: 8.0 x 160 mm



For solid wood in kN
as per EN 338 or EN 14081-1

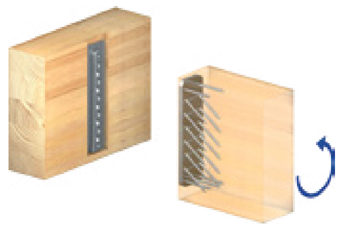
Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	57.4					
C30	ρ_k = 380 kg/m³	62.3					

For glulam in kNmm
as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	62.3					
GL 28h	ρ_k = 410 kg/m³	67.2					
GL 32h	ρ_k = 430 kg/m³	70.5					
GL 36h	ρ_k = 450 kg/m³	73.8					
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	57.4					
GL 28c	ρ_k = 380 kg/m³	62.3					
GL 32c	ρ_k = 410 kg/m³	67.2					
GL 36c	ρ_k = 430 kg/m³	70.5					

$R_{tor,k}$ Characteristic values for carrying capacity $R_{tor,k}$ with torsion stress around the auxiliary support longitudinal axis in kNmm

» SHERPA special screws: 8.0 x 160 mm



For solid wood in kN
as per EN 338 or EN 14081-1

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
C24	ρ_k = 350 kg/m³	7079	8660	10381	12308	13415	15568
C30	ρ_k = 380 kg/m³	7376	9024	10817	12825	13978	16221

For glulam in kNmm
as per EN 1194 or EN 14080

Connector type		XXL 170	XXL 190	XXL 220	XXL 250	XXL 280	XXL 300
Uniform cross-sectional configuration							
GL 24h	ρ_k = 380 kg/m³	7410	9065	10866	12883	14042	16296
GL 28h	ρ_k = 410 kg/m³	7662	9373	11236	13321	14519	16850
GL 32h	ρ_k = 430 kg/m³	7846	9599	11506	13642	14869	17256
GL 36h	ρ_k = 450 kg/m³	8027	9820	11771	13956	15211	17652
Combined cross-sectional configuration							
GL 24c	ρ_k = 350 kg/m³	7079	8660	10381	12308	13415	15568
GL 28c	ρ_k = 380 kg/m³	7376	9024	10817	12825	13978	16221
GL 32c	ρ_k = 410 kg/m³	7662	9373	11236	13321	14519	16850
GL 36c	ρ_k = 430 kg/m³	7846	9599	11506	13642	14869	17256

3.6 Variable screw lengths of SHERPA XL and XXL series

The following screw lengths can be used for connector series XL and XXL:

» 120 mm

» 140 mm

» 160 mm

» 180 mm

The carrying capacity values are given as a standard for the 160 mm screw lengths Other lengths are calculated using the η_s factor:

$$\eta_s = \frac{(l - 21\,\text{mm})}{139\,\text{mm}}$$

η_s....... Calculation factor for screw lengths 120, 140 and 180 mm
l......... Screw lengths used in mm

Screw lengths [mm]	120	140	160	180
η_s [μμ]	0.712	0.856	1.00	1.144

Carrying capacity in relation to the screw lengths used is calculated as follows:

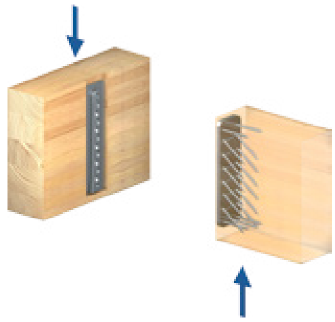
$$R_{k;s} = R_k \cdot \eta_s$$

R_k....... Characteristic value of the carrying capacity of a SHERPA XL or XXL connector
$R_{k;s}$..... Characteristic value for carrying capacity for the screw length used

3.7 Standard characteristics for SHERPA special screws

Connector series		XS series	S series	M series	L series	XL series	XXL series
Screw type		4.5 x 50		6.5 x 65	8.0 x 100	8.0 x 120/140/160/180	
Length	[mm]	50		60	100	120/140/160/180	
Thread diameter							
Outside	[mm]	4.5		6.50	8.0	8.0	
Inside	[mm]	2.6		3.25	5.3	5.3	
Torx drive		T20		T25	T30	T40	

3.8 Standard characteristics for SHERPA locking screws



$R_{3,k}$ **Characteristic value of carrying capacity $R_{3,k}$ with centre stress against the insertion direction in kN**

Connector series	XS series	S series	M series	L series	XL series	XXL series
Screw type	3 x 12	3 x 20/9	4 x 20/12	5 x 47.8/20	6 x 100/55	6 x 100/55
Number per connection	1	1	1	2	2	2
Torx drive	T10		T20	T25	T40	
$R_{3,k}$ [kN]	3.76	5.67	8.95	17.5	40.6	40.6

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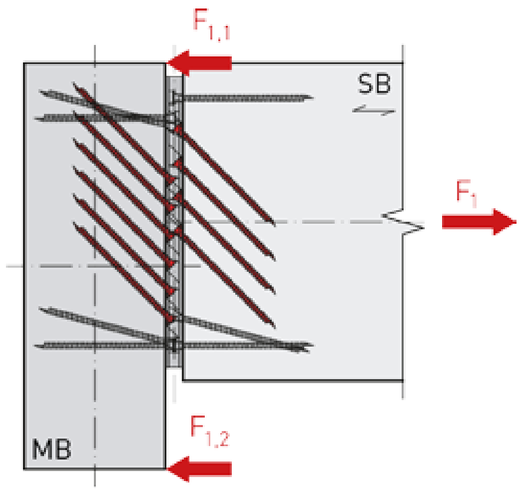
(Arch. Holzbauer und Partner,
WIEHAG photo) Created by: WIEHAG

4 Modelling

4 Modelling for SHERPA connectors

4.1 Determining characteristic carrying capacity with tensile stress in the direction of the secondary beam lengthwise axis.

4.1.1 Modelling for SHERPA series XS to L

Schematic diagram	Force transfer mechanism
	Force transfer in series XS to L with tensile stress in the direction of the secondary beam lengthwise axis is done with the force components of the helical screws in parallel to the secondary beam lengthwise axis. The torque screw contribution to force transfer is ignored.

» **Characteristic carrying capacity value for special screws against extraction**

$$R_{ax,k} = f_{ax,k} \cdot l_{ef} \cdot d \ [N]$$

with

$f_{ax,k}$... Characteristic value of the extraction parameter (reference density 350 kg/m³) in N/mm² [8]

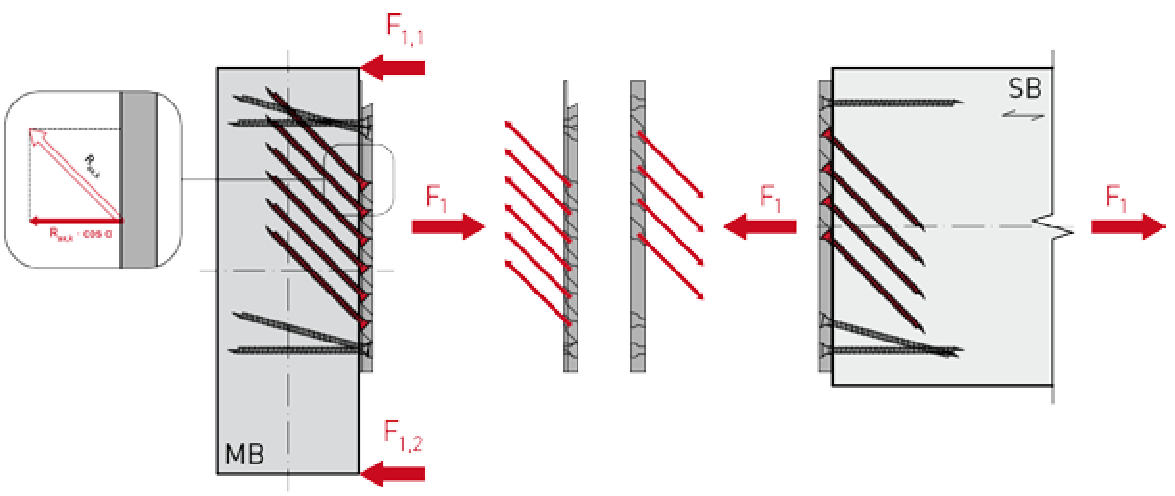
$f_{ax,k} = 0{,}087 \cdot 350 \cdot d^{-0{,}41}$ [N/mm²]

l_{ef}..... Screw-in depth of the special screw in mm

d...... Outside diameter of the special screw in mm

		XS-S	M	L
l_{ef}	[mm]	33.0	43.5	72.0
d	[mm]	4.5	6.5	8.0
$f_{ax,k}$	[N/mm²]	16.44	14.14	12.98
$R_{ax,k}$	[N]	2441.34	3998.10	7476.48

The share of torque screws in force support is not considered in the modelling of tensile stress in the direction of the secondary beam lengthwise axis.



» **Characteristic value of carrying capacity with tensile stress in the direction of the secondary beam lengthwise axis for the SHERPA series XS to L**

$$F_{1,k} = k_{sys;VH\ oder\ BSH} \cdot \left(\frac{\rho_k}{350}\right)^{0,8} R_{ax,k} \cdot \cos\alpha\ [N]$$

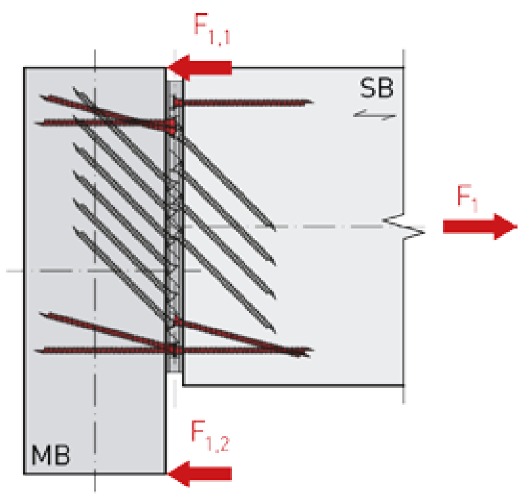
with

$F_{1,k}$... Force component of a special screw in the secondary beam lengthwise axis in N
n_{SchS} Number of helical screws
k_{sys}... Factor for consideration of system effects: solid wood k_{sys}= 1.00 and BSH k_{sys}= 1.15
ρ_k..... Characteristic value for the gross density of the wood used in kg/m³
$R_{ax,k}$ Characteristic value of a screw against extraction in N
α...... Angle between the screw axis and the grain direction of the wood in degrees [°]; XS-L= 37.50°

for the main beam	for the secondary beam
$R_{1,k;HT} = n_{SchS;HT}^{0,9} \cdot F_{1,k}\ [N]$	$R_{1,k;NT} = n_{SchS;NT}^{0,9} \cdot F_{1,k}\ [N]$

For SHERPA connectors in series XS to L, the main beam connection is always authoritative for tensile stress in the direction of the secondary beam lengthwise axis!

4.1.2 Modelling for the SHERPA series XL and XXL

Schematic diagram	Force transfer mechanism
	Force transfer for series XL and XXL with a tensile stress in the direction of the secondary beam lengthwise axis is exclusively done through the torque screws. In this load form they are always subjected to extraction load forces The contribution of helical screws to force transfer is ignored.

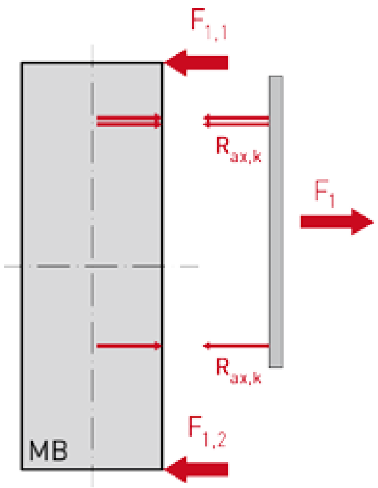
» **Characteristic value for carrying capacity of a special screw against extraction**

$$R_{ax,k} = f_{ax,k} \cdot l_{ef} \cdot d = 0,0371 \cdot \rho_k \cdot 139 \cdot 8 = 41 \cdot \rho_k\ [N] = 0,041 \cdot \rho_k\ [kN]$$

with

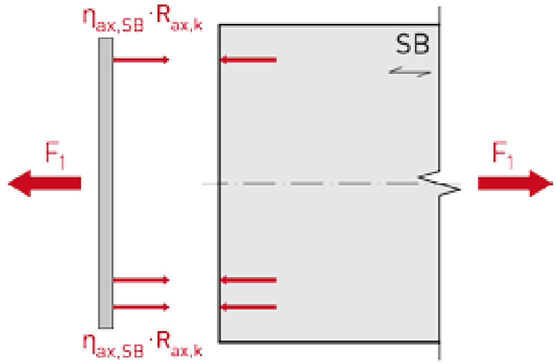
$f_{ax,k}$... Characteristic value of the extraction parameter in N/mm² [8]
$f_{ax,k} = 0,087 \cdot \rho_k \cdot d^{-0,41} = 0,087 \cdot 8^{-0,41} \cdot \rho_k = 0,0371 \cdot \rho_k$ [N/mm²]
l_{ef}..... Screw-in depth of the special screw in mm
d...... Outer diameter of the special screw in mm
ρ...... Characteristic value of the gross density of the wood used in kg/m³

In order to determine the characteristic vale of a full threaded screw against extraction in the end grain of a secondary beam, the characteristic value for the main beam should be reduced as per [2] by a factor $\eta_{ax,SB}$= 1/1.20



The contribution of helical screws in force support is not considered in modelling for tensile stress in the direction of the secondary beam lengthwise axis.

The load eccentricity is ignored due to the eccentric screw arrangement in the connector



» **Characteristic value of carrying capacity with tensile stress in the direction of the secondary beam lengthwise axis for SHERPA series XL and XXL**

for the main beam	for the auxiliary beam
$R_{1,k;MB} = n_{MS,MB} \cdot R_{ax,k} =$ $= 4 \cdot 0{,}041 \cdot \rho_k = 0{,}164 \cdot \rho_k \;\; [kN]$	$R_{1,k;SB} = n_{MS,SB} \cdot \eta_{ax,SB} \cdot R_{ax,k} =$ $= 6 \cdot (1/1{,}20) \cdot 0{,}041 \cdot \rho_k = 0{,}205 \cdot \rho_k \;\; [kN]$

The main beam connection applies for series XL and L SHERPA connectors with a tensile stress in the direction of the secondary beam lengthwise axis.

The following applies for the characteristic carrying capacity with a tensile stress in the direction of the secondary beam lengthwise axis with a reference gross density of ρ_k= 380 kg/m³ (C30 or GL 24h):

$$R_{1,k} = R_{1,k;MB} = 0{,}164 \cdot \rho_k = 0{,}164 \cdot 380 = 62{,}3 \;\; [kN]$$

For other gross densities, the characteristic values for carrying capacity are determined by the ratio of the respective characteristic gross density to the reference gross density:

$$R_{1,k} = \left(\frac{\rho_k}{380}\right) \cdot 62{,}3 \;\; [kN]$$

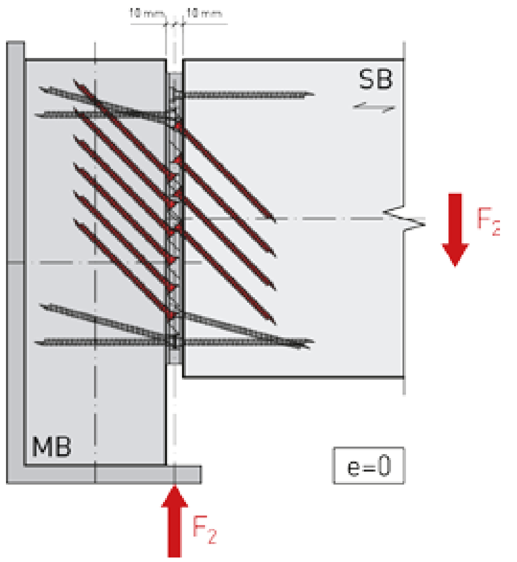
with

ρ...... Characteristic value of the gross density of the wood used in kg/m³

4.2 Determination of the characteristic carrying capacity with stress in the insertion direction

4.2.1 Centre stress in the insertion direction

Schematic diagram	Force transfer mechanism

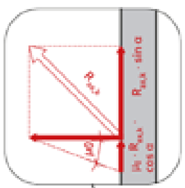


Force transfer with a centre stress in the insertion direction

Force transfer with a centre stress in the insertion direction takes place through loading the helical screws with extraction force.

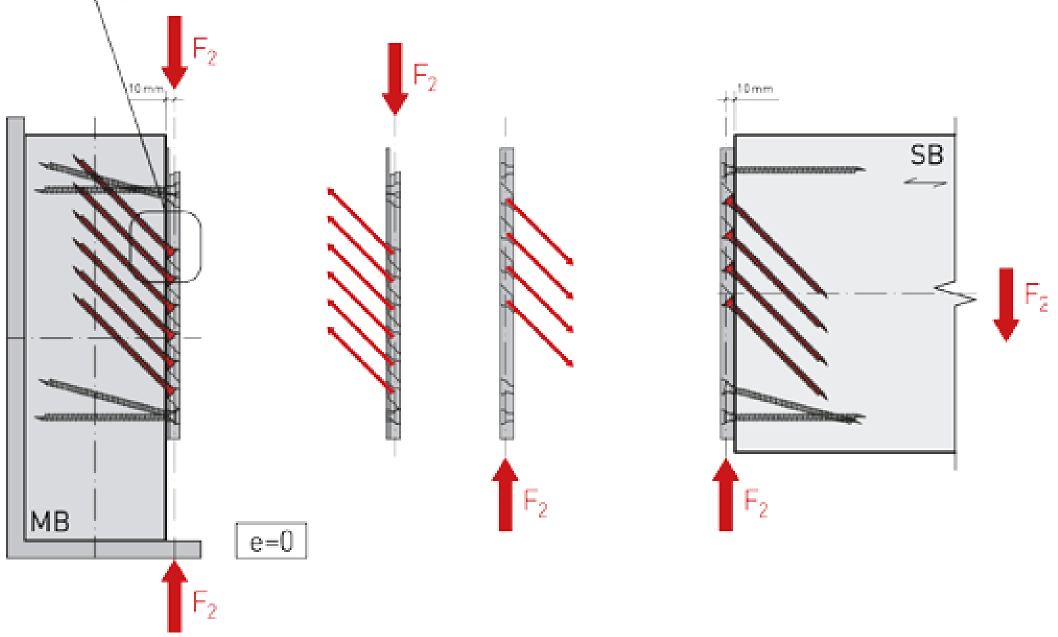
The contribution of torque screws involved in force transfer with centre stress in the insertion direction is ignored.

» **Characteristic value of the carrying capacity of a helical screw**



Detail
Force map of a helical screw

The contribution of torque screws involved in force reduction is not considered in modelling for centre stress in the insertion direction.



If a screw axis is inserted at an angle α against the grain direction of the wood part, the following is obtained for the force component in the insertion direction:

$$R_{2,k;1} = R_{ax,k} \cdot \sin\alpha \ [N]$$

with

α...... Angle between the screw axis and the grain direction in the wood in degrees [°]
XS to L series = 37.50°
XL to XXL series = 45.00°

In addition, due to the friction between the connection plate and the wood surface, a force component with the coefficient of static friction μ_0 = 0.25 is used, that is, there is an additional proportion in carrying capacity in the insertion direction:

$$R_{2,k;2} = \mu_0 \cdot R_{ax,k} \cdot \cos\alpha \text{ [N]}$$

The following applies for a maximum characteristic carrying capacity of a helical screw with a centre stress for a SHERPA connector:

$$R_{2,k} = R_{2,k;1} + R_{2,k;2} = R_{ax,k} \left(\sin\alpha + \mu_0 \cdot \cos\alpha\right) \text{ [N]}$$

» **Gross density correction**

For a wooden component which varies from the characteristic reference gross density $\rho_{ref,k}$ (350 kg/m³), the gross density correction can be carried out approximately using the factor kr.

$$k_\rho = \left(\frac{\rho_k}{\rho_{ref,k}}\right)^{c_w}$$

with

ρ_k..... Characteristic value of the gross density of the wood used in kg/m³
$\rho_{ref,k}$ Characteristic value of the reference gross density (C24 - 350 kg/m³)
c_w..... Exponent to consider the influence of gross density on screws with extraction stress as per TR016: c_w = 0.8

» **Characteristic value of carrying capacity of a SHERPA connector in series XS to XXL with a centre stress in the insertion direction**

$$R_{2,k} = VF \cdot n_{SchS;HT}{}^{0{,}90} \cdot k_{sys;VH\ oder\ BSH/BSP} \cdot \left(\frac{\rho_k}{350}\right)^{0{,}80} \cdot R_{ax,k} \cdot \left(\sin\alpha + \mu_0 \cdot \cos\alpha\right) \text{ [N]}$$

with

VF.... Prefactor to account for the size ratios between the individual SHERPA series

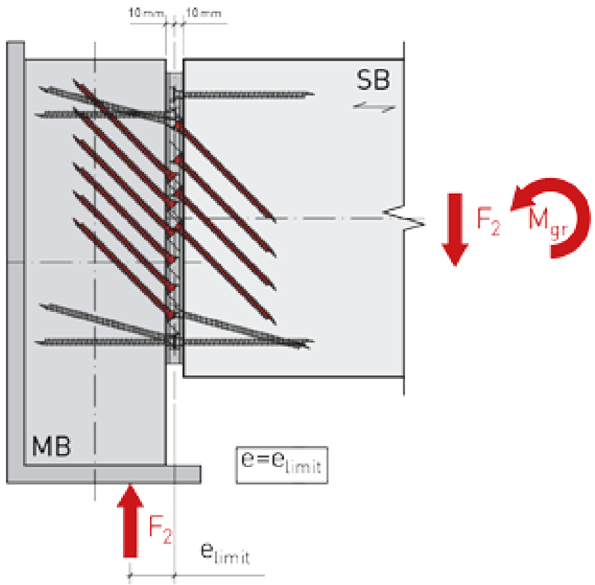
XS to L series:	1.40
XL to XXL series:	1.20

$n_{SchS;HT}$ Number of helical screws in the main beam
k_{sys}... Factor to consider system effects; solid wood k_{sys}= 1.00 and BSH k_{sys}= 1.15
ρ_k..... Characteristic value of gross density of the wood used in kg/m³
$R_{ax,k}$ Characteristic value of a screw against extraction in N
α...... Angle between the screw axis and the grain direction of the wood in degrees [°]

XS to L series=	37.50°
XL to XXL series=	45.00°

4.2.2 Determining the eccentricity e_{limit}

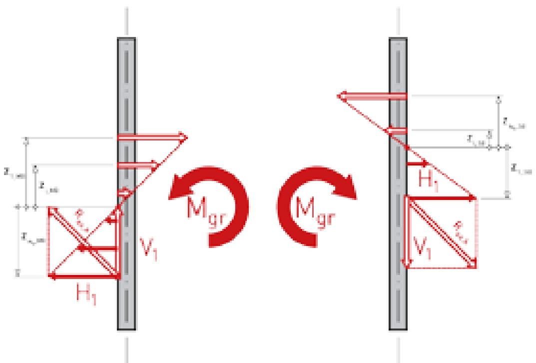
Schematic diagram	Static construction model



Determining the eccentricity e_{limit}

The screwed-in helical screws at angle α at the connection level are primarily experience tensile stress in SHERPA connectors by the force in the insertion direction, while the torque screws contribute nearly no load support in this stress, and can therefore be ignored.

The activation of extraction forces on the helical screws produces contact pressure in the connecting joint between the wood and the aluminium surface, which increases the transferable carrying capacity via the frictional forces.



Due to the eccentricity of the SHERPA central axis (e.g. XL and XXL series e = 10 mm) there is a torque exerted on the connecting joint in addition to the shear force, whereby pull forces from below and pressing forces from above are generated on the connecting level in both the main (HT) and secondary (NT) beams.
These forces diminish the contact pressure placed on the helical screws.

At the eccentric centre e_{limit}, the contact pressure on the top helical screw on the main beam or on the lowest helical screw on the secondary beam is cancelled directly by the horizontal force of the eccentricity torque. In a helical screw screwed in at an angle of less than 45°, this is corresponds to a horizontal force in the torque equalling the vertical component from the shear force.

This applies to the main and secondary beam connections of a SHERPA XL or XXL fastener:

$$H_1 = V_1 \text{ [kN]} \qquad \text{and} \qquad V_1 = \frac{F_2}{n_{SchS}} \text{ [kN]}$$

i.e.

$$H_1 = M \cdot \frac{z_{max}}{\sum_{i=1}^{n_{SchS}} z_i^2} = F_2 \cdot e \cdot \frac{z_{max}}{\sum_{i=1}^{n_{SchS}} z_i^2} \text{ [kN]}$$

Insertion produces:

$$F_2 \cdot e \cdot \frac{z_{max}}{\sum_{i=1}^{n_{SchS}} z_i^2} = \frac{F_2}{n_{SchS}} \text{ [kN]}$$

by moving towards e, in the limit case:

$$e_{limit} = \frac{\sum_{i=1}^{n_{SchS}} z_i^2}{n_{SchS} \cdot z_{max}} \text{ [m]}$$

Meanings of symbols:

H_1..... Horizontal component of the force in the helical screw with a pulling strain in kN
V_1...... Vertical component of the force in the helical screw with a pulling strain in kN
n_{SchS} Number of helical screws in the main beam or the secondary beam connection
z_{max}... Interval of the lowest screw in the main beam or the secondary beam connection
$\Sigma\zeta_i^2$... Sum of the squares of the intervals from the centre of the helical screw to the centre of gravity of the screw pattern in m²

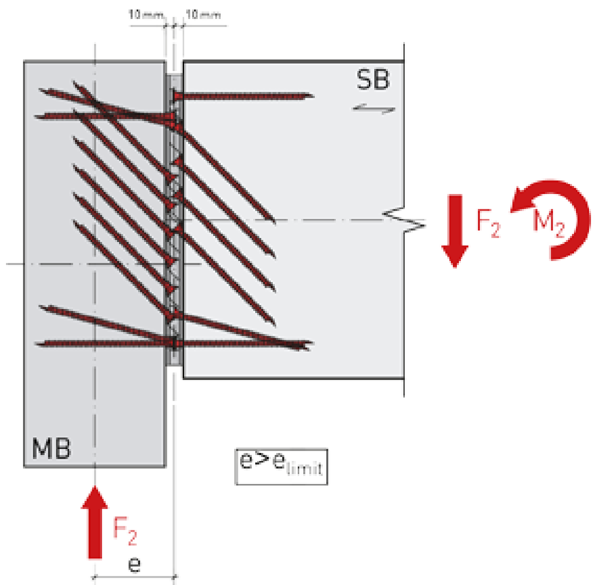
» **Characteristic value of carrying capacity of a SHERPA fastener in XS to XXL series with an eccentric force $e \le e_{limit}$ in the insertion direction**

$$R'_{2,k} = R_{2,k} \text{ [kN]}$$

with

$R_{2,k}$.... Characteristic value of the carrying capacity with central stress in the insertion direction

4.2.3 Eccentric stress in the insertion direction

Schematic diagram	Static construction model
	**Force transfer with eccentric stress in the insertion direction** If an eccentricity e_{limit} or the limit torque M_{limit} is exceeded by a stress acting upon it, the contact with the connecting joint is lost between the connector and the torque screws are exposed to extraction stress. The carrying capacity in a theoretically pure torque stress is: $M_2 = R_{ax,k} \cdot \frac{\sum_{j=1}^{n_M} z_j^2}{z} + F_2 \cdot e_{limit}$ [kNm]

In order to develop a simple computational model for a SHERPA fastener with an eccentric stress in the insertion direction, the carrying capacity is referenced based on the central stress and reduced dependent on the torque stress.

In practice, this is produced by applying the empirically confirmed interaction formula contained in the European Technical Approval, ETA-12/0067, and defined in the following.

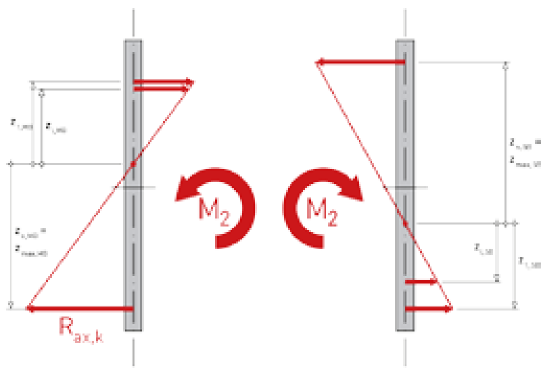
$$R'_{2,k} = \frac{R_{2,k}}{\sqrt[3]{1 + \left(\frac{e - e_{limit}}{e_2}\right)^3}} \text{ [kN]}$$

in which

$R_{2,k}$.... Characteristic value of carrying capacity with central stress in the insertion direction
e....... Eccentricity of the force exerted in m
e_{limit}... Eccentric limit of the SHERPA fastener in m
e_2...... Unfavourable eccentricity of the main and secondary beam connection for the maximum torque absorption

4.2.4 Determining eccentricity e_2

Schematic diagram	Static construction model



Determining the eccentricity, e_2

One must consider when determining the eccentricity e_2 that the exerted stress must be carried via the partial connection on the main and secondary beams. Hence they must be considered separately.

Further, the torque stresses of each partial connection must be evaluated for positive and negative torque.

Taken conservatively, the smallest value of the entire connection is authoritative.

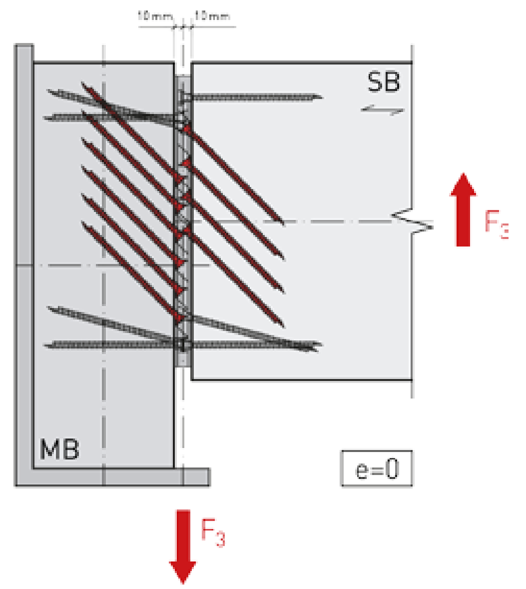
for the main beam	for the secondary beam
$M_{2,MB,k} = R_{ax,k} \cdot \frac{\sum_{j=1}^{n_M} z_j^2}{z}$ [kNm]	$M_{2,SB,k} = \eta_{ax,SB} \cdot R_{ax,k} \cdot \frac{\sum_{j=1}^{n_M} z_j^2}{z}$ [kNm]
$e_{2,MB} = \frac{\pm M_{2,MB,k}}{R_{2,MB,k}}$ [m]	$e_{2,SB} = \frac{\pm M_{2,SB,k}}{R_{2,SB,k}}$ [m]

$$e_2 = \min\left\{\begin{matrix} e_{2,MB} \\ e_{2,MB} \end{matrix}\right\} \text{ [m]}$$

4.3 Determination of characteristic carrying capability with stress against the insertion direction

4.3.1 Central stress against the insertion direction

Schematic diagram	Force transfer mechanism



Force transfer with central stress against the insertion direction

Force transfer with central stress against the insertion direction is done by turning the locking screws.

In the XS to M series, one locking screw is screwed into the spring through the upper edge of the slot plate. For the L to XXL series, two locking screws are screwed into the joint area in both connection plates through the upper edge of the slot plate. The forces are further transmitted over the helicalscrews exposed to tensile forces, i.e. the frictional forces acting on the aluminium surface.

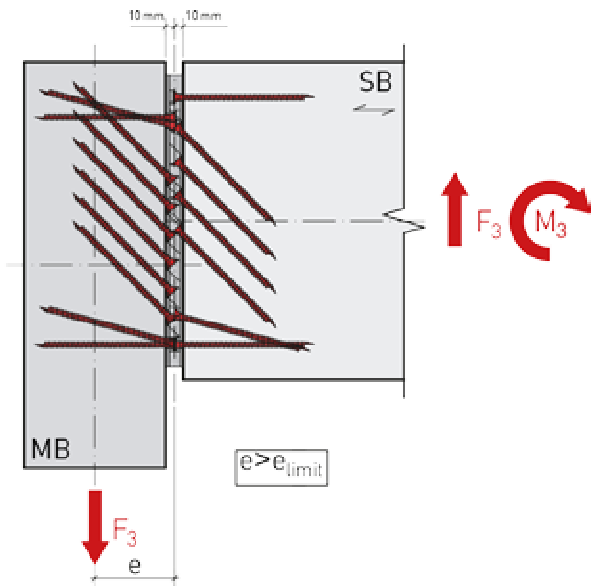
The characteristic values for SHERPA fasteners' carrying capacity with central stress against the insertion direction were determined empirically:

		XS	S	M	L	XL-XXL
$R_{3,k}$	[kN]	3.76	5.67	8.95	17.5	40.6

$R_{3,k}$.... Characteristic carrying capacity value with central stress against the insertion direction

4.3.2 Eccentric stress against the insertion direction

Schematic diagram	Force transfer mechanism



Force transfer with an eccentric stress against the insertion direction

The torque screws on the connector are activated equivalent to the effect in the insertion direction when eccentric stress is applied against the insertion direction. They are exposed to extraction forces. In practice, this is produced by applying the empirically confirmed interaction formula contained in the European Technical Approval, ETA-12/0067, and defined in the following.

$$R'_{3,k} = \frac{R_{3,k}}{\sqrt[3]{1+\left(\frac{e-e_{limit}}{e_2}\right)^3}} \text{ [kN]}$$

with

$R_{3,k}$.... Characteristic carrying capacity value with central stress against the insertion direction

e....... Eccentricity of exerted force in m

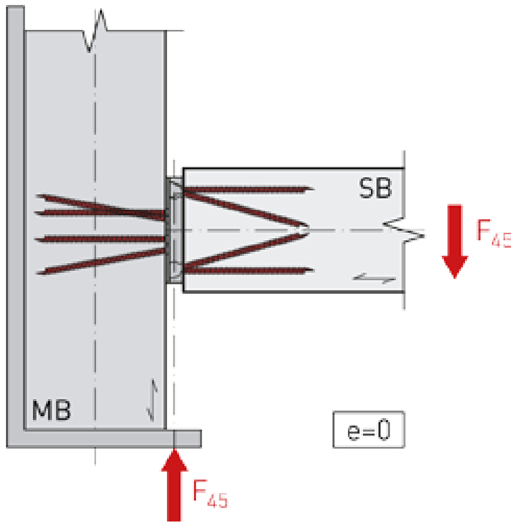
e_{limit} Eccentric centre of the SHERPA fastener in m

e_2...... Unfavourable eccentric centre of the main and secondary connection for the maximum torque absorption

4.4 Determining characteristic carrying capacity with stress at a right angle to the insertion direction

4.4.1 Central stress at a right angle to the insertion direction

Schematic diagram	Force transfer mechanism



Force transfer with central stress at a right angle to the insertion direction

The force transfer with central stress at a right angle to the insertion direction takes place through application of shearing stress on the helical as well as the torque screws.

The characteristic carrying capacity of a SHERPA special screw against shearing can be determined using a formula contained in Johansen's theory for a single-shear wood-steel sheet or wood-aluminium connection with thin sheet.

» **Emebedment strength for the reference gross density of 350 kg/m³**

$$f_{h,0,k} = 0{,}082 \cdot 350 \cdot d^{-0{,}3} \text{ [N/mm²]}$$

with

$f_{h,0,k}$... Characteristic value of the embedment strength with a shear stress in the grain direction of the wood component and reference gross density of 350 kg/m³ in N/mm²

d....... (rated) diameter of the screw in mm

The characteristic value for the embedment strength can only be assumed to be 40% when shear stress is applied, whereby the central axis of the fastener is parallel to the grain direction of the wood component (in the end grain).

$$f_{h,HH,k} = 0{,}40 \cdot f_{h,0,k} = 0{,}40 \cdot 0{,}082 \cdot 350 \cdot d^{-0{,}3} = 0{,}0328 \cdot 350 \cdot d^{-0{,}3} \text{ [N/mm²]}$$

with

$f_{h,HH,k}$. Characteristic value for embedment strength with a shear stress in the grain direction of the wood component and reference gross density of 350 kg/m³ in N/mm²

» **Yield moment**

Rated diameter Ø SHERPA special screws	**[mm]**	**4.5**	**6.5**	**8.0**
Characteristic yield moment $M_{y,Rk}$	[Nmm]	4,900	12,000	22,600

» **Carrying capacity per fastener – Johansen's formula**

The carrying capacity per fastener and shear plane for SHERPA fasteners is equal to the smallest value of the following formulae:

Mode (a)	Mode (b)
$F_{v,Rk;a} = \left(\sqrt{2} - 1\right) \cdot f_{h,k} \cdot k_\rho \cdot t_1 \cdot d$ [N]	$F_{v,Rk;b} = \sqrt{2 \cdot M_{y,k} \cdot f_{h,k} \cdot k_\rho \cdot d} + \Delta F_{v,Rk}$ [N]

Meaning of the symbols:

$F_{V,Rk;a}$ Characteristic value of a screw against shearing for failure mode (a) in N

$F_{V,Rk;b}$ Characteristic value of a screw against shearing for failure mode (b) in N

$f_{h,0,k}$... Characteristic value of the embedment strength in N/mm²

The following applies for screws in the secondary beam:

for the helical screws (SchS): $f_{h,k} = f_{h,0,k}$
for the torque screws (MomS): $f_{h,k} = f_{h,HH,k}$

The following applies for screws in the main beam:

for helical screws (SchS): $f_{h,k} = f_{h,0,k}$
for the torque screws (MomS): $f_{h,k} = f_{h,0,k}$

k_ρ...... Factor for the gross density correction deviating from 350 kg./m³

t_1...... Embedment depth of the screw in mm

The lateral expansion of the helical and torque screws may be neglected.

d....... (Rated) diameter of the screws in mm

$\Delta_{FV,Rk}$ Characteristic value of the carrying capacity portion of the "rope effect" in N

» **Determining the characteristic value of the carrying capacity portion of the "rope effect"**

$$\Delta F_{V,Rk} = \min \begin{Bmatrix} \min\ F_{V,Rk;ab,} \\ 0{,}25 \cdot R_{ax,k} \end{Bmatrix} \ [N]$$

with

$R_{ax,k}$... Characteristic value of a screw against extraction in N (see 4.1.1)

» **Gross density correction**

The gross density correction can be carried out approximately with a factor of kρ for the wood components with a gross density of ρ_k that deviate from the characteristic reference gross density $\rho_{ref,k}$ (350 kg/m³).

$$k_\rho = \left(\frac{\rho_k}{\rho_{ref,k}} \right)^{c_s}$$

with

ρ_k..... Characteristic value of the gross density of the wood used in kg/m³

$\rho_{ref,k}$.. Characteristic value of the reference gross density (C24 - 350 kg/m³)

c_s..... Exponent to consider the gross density influence on screws with extraction stress as per TR016: $c_s = 0.5$

» **Connection depth of the screws**

		SHERPA special screws							
		4.5 x 50		6.5 x 65		8.0 x 100		8.0 x 160	
		SchS	MomS	SchS	MomS	SchS	MomS	SchS	MomS
Connection depth t_1	**[mm]**	33.32	42.00	44.43	56.00	69.82	88.00	103.94	147.00

» **Characteristic value of the carrying capacity of a XS to XXL series SHERPA fastener with central stress at a right angle to the insertion direction**

The carrying capacity of a SHERPA fastener with central shear stress at a right angle to the insertion direction is calculated as follows:

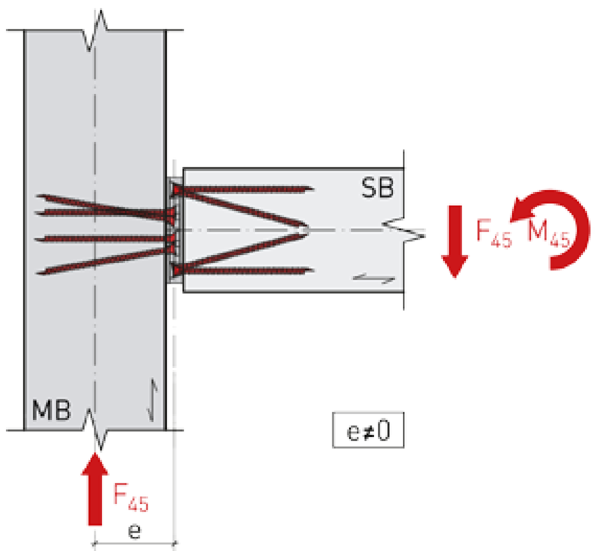
for the secondary beam connection
$R_{45,k;NT} = n_{SchS;NT} \cdot \min\ F_{v,SchS;NT;Rk;a,b} + n_{MomS;NT} \cdot \min\ F_{v,MomS;NT;Rk;a,b}$ [N]

for the main beam connection
$R_{45,k;HT} = n_{SchS;HT} \cdot \min\ F_{v,SchS;HT;Rk;a,b} + n_{MomS;HT} \cdot \min\ F_{v,MomS;HT;Rk;a,b}$ [N]

The smaller value of the secondary or main beam connection is used.

$$R_{45,k} = \min \begin{Bmatrix} R_{45,k;NT} \\ R_{45,k;HT} \end{Bmatrix} \text{ [N]}$$

4.4.2 Eccentric force at a right angle to the insertion direction

Schematic diagram	Force transfer mechanism
	**Force transfer with eccentric stress at a right angle to the insertion direction** This is absorbed by the helical as well as the torque screws when eccentric stress or a shear force stress and torque are applied. The torque stress is thus exclusively transmitted by the torque screws, while the rotation centre of the connection is at the edge of the fastener.

In order to develop a simple calculation model for the SHERPA fastener with an eccentric force at a right angle to the insertion direction, the carrying capacity is referenced to the central stress, and reduced depending upon the torque stress.

In practice, this is produced by applying the empirically confirmed interaction formula contained in the European Technical Approval, ETA-12/0067, and defined in the following.

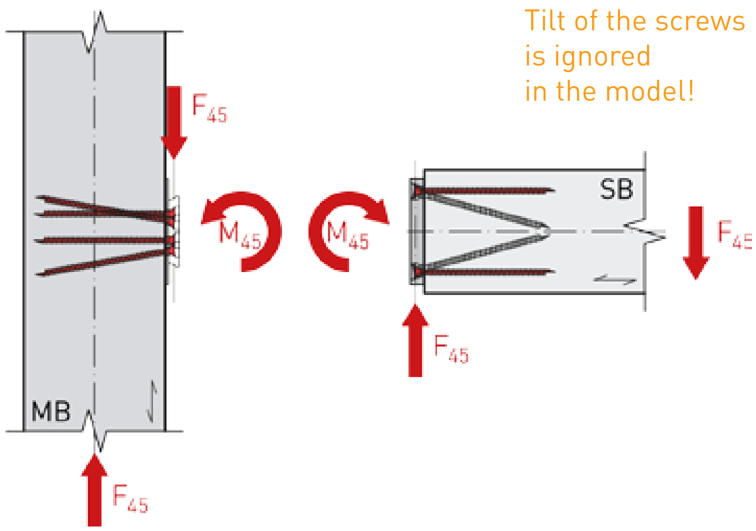
$$R'_{45,k} = \frac{R_{45,k}}{\sqrt[3]{1+\left(\frac{e}{e_{45}}\right)^3}} \text{ [N]}$$

with

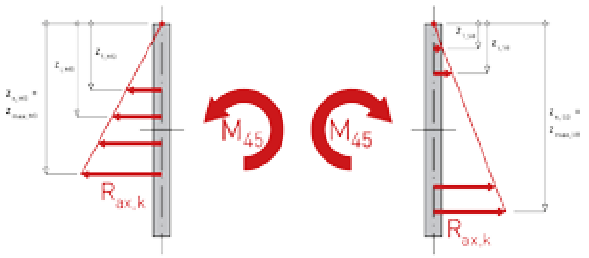
- $R_{45,k}$... Characteristic carrying capacity value with central stress at a right angle to the insertion direction
- e....... Eccentricity of the force exerted at a right angle to the insertion direction in m
- e_{45}..... Unfavourable eccentricity of the main and secondary beam connection for the maximum extraction torque

4.4.3 Determining the eccentricity, e_{45}

Schematic diagram



Static construction model



Determining the eccentricity e_{45}

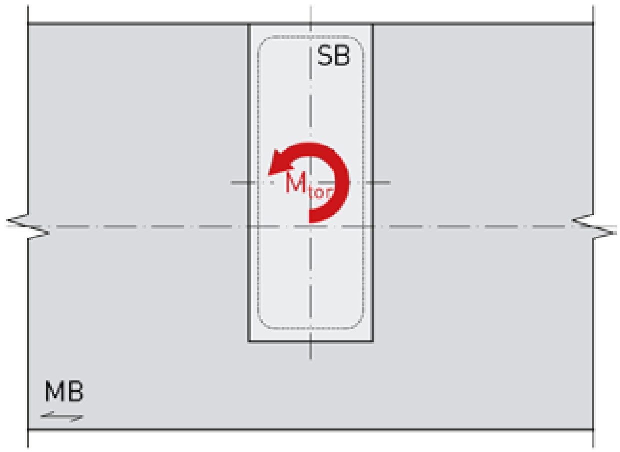
When determining eccentricity, e_{45} one must consider that the exerted stress must be carried via the partial connections of the main and secondary beams. Hence they must be considered separately.

The smallest value of the total connection must be used - in order to be conservative.

for the main beam	for the secondary beam
$M_{45,MB,k} = R_{ax,k} \cdot \frac{\sum_{i=1}^{n_M} z_i^2}{z_{max,MB}}$ [kNm]	$M_{45,SB,k} = \eta_{ax,SB} \cdot R_{ax,k} \cdot \frac{\sum_{i=1}^{n_M} z_i^2}{z_{max,SB}}$ [kNm]
$e_{45,MB} = \frac{M_{45,MB,k}}{R_{45,MB,k}}$ [m]	$e_{45,SB} = \frac{M_{45,SB,k}}{R_{45,SB,k}}$ [m]

$$e_{45} = \min \begin{Bmatrix} e_{45,MB} \\ e_{45,SB} \end{Bmatrix} \text{ [m]}$$

4.5 Determining characteristic carrying capacity with torsion stress

Schematic diagram	Static construction model
	**Force transfer with a torsion stress** Modelling SHERPA fasteners for torsion may take place based on an "ideally three-dimensional" model; i.e. the characteristic torsion carrying capacity of SHERPA fasteners can be calculated using the following formulae

for the main beam	for the secondary beam
$R_{tor,k;MB} = \sum_{i=1}^{n_{MB}} r_i \cdot \min R_{k,MB;a,b}$ [kNmm]	$R_{tor,k;SB} = \sum_{i=1}^{n_{SB}} r_i \cdot \min R_{k,SB;a,b}$ [kNmm]

$$R_{tor,k} = \min \begin{Bmatrix} R_{tor,k;MB} \\ R_{tor,k;SB} \end{Bmatrix} \text{ [kNmm]}$$

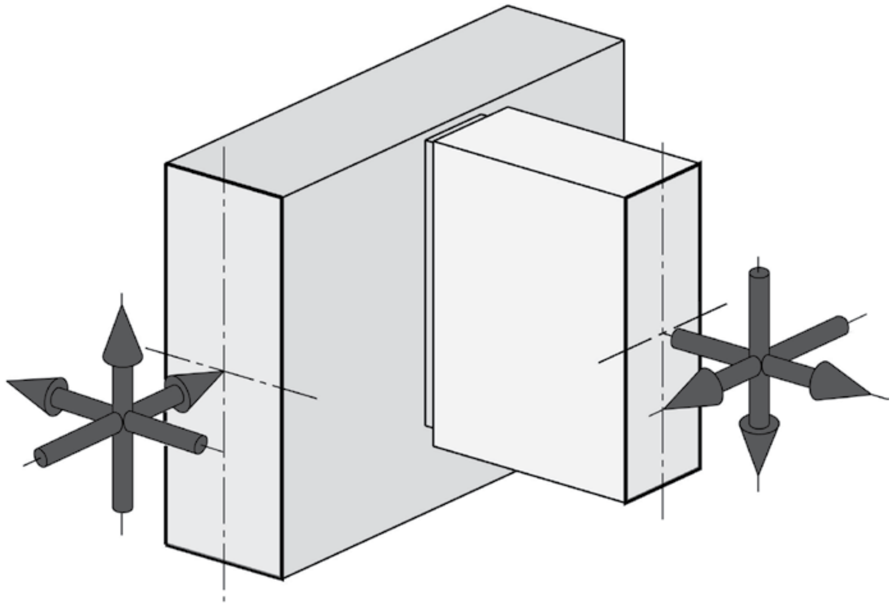
with

$R_{tor,k}$	Characteristic value of the torsion carrying capacity in Kn/mm
$\sum_{i\ 1}$	Sum of the radii around the centre of the screw group (helical and torque screws) in mm
$R_{k,MB/SB;a,b}$	Characteristic value of a shear force on a wood screw as per Johansen – smallest value for the failure mode (a) or (b) for the respective main or secondary beam connection in kN (see 4.4.1)

In order to simplify, the characteristic shear value for a helical wood screw with the same embedment depth t_1 is carried out in the same way as for the torque screws. When determining the characteristic carrying capacity of a wood screw, it is admissible to use the formulae used when stress is applied at right-angles to the insertion direction (see 4.4.1).

4.6 Modelling for combined stress

Schematic diagram



Short description of verification

Upon application of combined stress and when providing individual verification for loads in and at right angles to the insertion direction, also parallel to the secondary beam lengthwise axis, the the sum of utilisation squared and the utilisation of torsion load squared must be less than or equal to 1.

» **Verification for combined stresses**

$$\left(\frac{F_{1,d}}{R_{1,d}}\right)^2+\left(\frac{F_{2/3,d}}{R'_{2/3,d}}\right)^2+\left(\frac{F_{45,d}}{R'_{45,d}}\right)^2+\frac{M_{tor,d}}{R_{tor,d}}\leq 1$$

with

$F_{1,d}$.... Rated value of the effects with stress in the direction of the secondary beam lengthwise axis in kN

$F_{2/3,d}$.. Rated value of the effects with stress in/against the insertion direction in kN

$F_{45,d}$... Rated value of the effects with stress at a right angle to the insertion direction in kN

$M_{tor,d}$.. Rated value of the torsion effects around the secondary beam lengthwise axis in kN/mm

$R_{1,d}$.... Rated value for carrying capacity when exposed to a single stress in the direction of the secondary beam lengthwise axis, calculated based on the characteristic value $R_{1,k}$ in kN

$R'_{2/3,d}$ Rated value of carrying capacity with application of additional torque in or against the insertion direction, determined from the characteristic value $R'_{2,k}$ or $R'_{3,k}$ in kN

$R_{2/3,d}$ Rated value of carrying capacity when exposed to single torque in or against the insertion direction, calculated based on the characteristic value $R'_{2,k}$ or $R'_{3,k}$ in kN

$R'_{45,d}$.. Rated value of carrying capacity with application of additional torque at a right angle to the insertion direction, calculated based on the characteristic value $R'_{45,k}$ in kN.

$R_{45,d}$... Rated value of carrying capacity when exposed to single stress at a right angle to the insertion direction, calculated based on the characteristic value $R_{45,k}$ in kN.

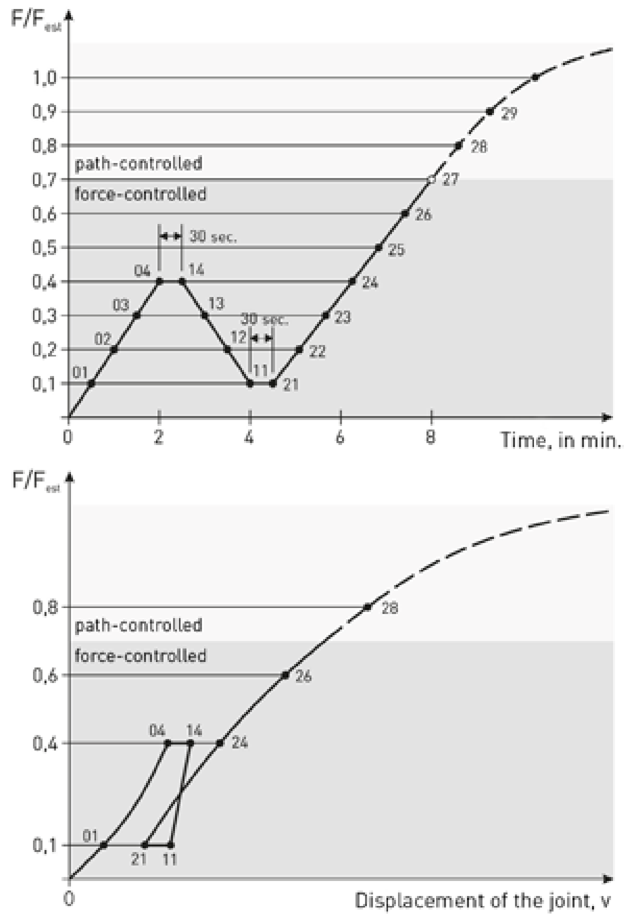
$R_{tor,d}$.. Rated value of torsion carrying capacity along the secondary beam lengthwise axis, calculated based on the characteristic value $R_{tor,k}$ in kNmm.

4.7 Displacement and torsion moduli

4.7.1 Testing procedure as per EN 26891:1991

Determining displacement and torsion moduli for SHERPA fasteners is done on the basis of tests carried out using the procedures and their definitions specified in the European testing standard EN 26891:1991.

Test procedures



The specifications to perform testing as per EN 26891:1991 form the general basis to determine the carrying capacity and the deformation behaviour of a fastener.

Before testing a fastener, one must first estimate the breaking load for a fastener (F_{est}). During testing, a hysteresis with 40% of F_{est} is applied in such a way that the value is reached in two minutes. This force is maintained for 30 seconds, then lowered with the same loading rate to 10% of F_{est} and held constant at this level for a further 30 seconds.
Then – retaining the same load rate – the force is increased to 70 % of F_{est} and the test continues path-controlled from this force level until either the fastener breaks after 10 to 15 minutes of total test time, or the fastener material moves by 15 mm.

The breaking force as well as the displacement and torsion moduli are then calculated based on the test data recorded.

4.7.2 Determining the displacement moduli K_{ser} and K_u

As per EN 26891:1991, several displacement moduli are calculated based on the fastener testing data.
At this point only the definition of the displacement modulus K_{ser} (or k_s as per EN 26891:1991) is provided, as it is possesses greatest relevance to rating practice.
The test data is used to make this calculation for a test specimen:

$$k_s = \frac{0{,}4 \cdot F_{est}}{v_{i,mod}} \text{ [N/mm]} \qquad \text{with} \qquad v_{i,mod} = \frac{4}{3} \cdot \left(v_{04} - v_{01}\right) \text{ [mm]}$$

with

F_{est}.... Maximum load in N, as estimated "before carrying out the test"
$v_{i,mod}$.. Modified starting displacement in mm
v_{04}..... Measurement value of the displacement at 40 % of the estimated maximum load F_{est} in mm
v_{01}..... Measurement value of the displacement at 10 % of the estimated maximum load F_{est} in mm

Thereafter, the individual data k_s are used to determine the displacement modulus to set the limit status of the serviceability by calculating the average of the displacement modulus K_{ser}.

The relevant measurement and design standards (e.g. EN 1995-1-1) contain the following definition to produce verification in a limit state of carrying capacity:

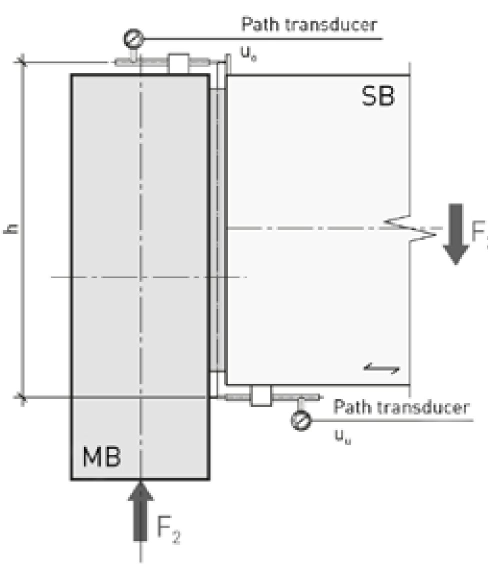
$$K_u = \frac{2}{3} \cdot K_{ser} \text{ [N/mm]}$$

with

K_{ser}... Displacement modulus in the limit state for serviceability in N/mm

4.7.3 Determination of the torsion moduli $K_{\varphi,ser}$ and $K_{\varphi,u}$

Test procedure



EN 26891:1991 contains no explicit definitions to determine the torsion moduli for a fastener. The calculated values for torsion moduli are therefore determined in a similar way to that of the displacement moduli with reference to the associated force (M torque) and displacement variables (torsion φ) from the test data.

Based on the individual data and equivalent to the corresponding displacement moduli, it is then possible to calculate the torsion modulus $K_{\varphi,ser}$ in Nm/rad for calculations in the limit state of serviceability, i.e. the torsion modulus $K_{\varphi,u}$ in Nm/rad for calculations in the limit state of carrying capacity..

The torsion variable φ, which is the respective force level, can be calculated as follows based on the test data:

$$\varphi_i = \frac{u_{u,i} - u_{o,i}}{h} \text{ [rad]}$$

with

φ_i...... Torsion between the main and the secondary beam on the considered load level i in rad
$u_{u,i}$..... Horizontal displacement on the lower edge of the connector at the considered load level i in mm
$u_{o,i}$..... Horizontal displacement at the upper edge of the connector at the considered load level i in mm
h....... Vertical distance between the upper and lower path transducer in mm

Thus the following is derived for the torsion modulus $k_{s,\varphi}$:

$$k_{s,\varphi} = \frac{0{,}4 \cdot M_{est}}{\varphi_{i,mod}} \text{ [Nm/rad]} \qquad \text{with} \qquad \varphi_{i,mod} = \frac{4}{3} \cdot \left(\varphi_{04} - \varphi_{01}\right) \text{ [rad]}$$

with

M_{est}... As a consequence of the estimated highest load on the fastener's exerted torque in Nm
$\varphi_{i,mod}$ Modified starting torsion in rad
$\varphi_{i,04}$... Torsion between the main and secondary beam at 40 % of the estimated highest load in rad
$\varphi_{i,01}$... Torsion between the main and secondary beam at 10 % of the estimated highest load in rad

5 Steel and steel-reinforced concrete

5 Steel and steel-reinforced concrete connection

Comments on 5.1 and 5.2:
These points contain a textual summary of the current rules to rate head bolts and anchor bolts in concrete, and of course make no claim to be complete. They do not replace in any way the detailed definitions of ETAG 001, which must be referred to in any case, and are binding.

5.1 Principles to rate anchor bolts and head bolts in concrete

5.1. Standards backgrounds for fastening in concrete

Construction products for fastening technology, such as anchor bolts and head bolts, are not as yet regulated by harmonised European standards (hENs), but rather through European Technical Approvals or, since July 31, 2013, through European Technical Assessments by EOTA (since July 31, 2013: European Organisation for Technical Assessment).

The EOTA is a European organisation whose work area includes the development and issuance of guidelines for European Technical Approvals or Assessments (European Technical Approval Guidelines - ETAG / since July 31, 2013: European Assessment Document - EAD), the technical reports (TR) supporting the respective ETAGs as well as the bases for issuing ETAs and individual approvals or individual assessments without the presentation of a guideline on the basis of a consensual statement of all European approval offices (CUAP: Common Understanding of Assessment Procedure).

For fasteners in concrete related to safety (the possibility of personal or major commercial damage), only anchor bolts may be used which meet the requirements of Guideline 001 for European Technical Approval/Assessment (ETAG 001), "Metal anchor bolts for attachment in concrete". ETAG 001 defines rules for various types of anchor bolts, their underlying requirements and the tests to be conducted as part of approval or assessment procedures, also a rating procedure to determine characteristic carrying capabilities.

The approval/assessment of an anchor as per ETAG 001 is a condition for a CE Mark, and therefore marketing and sales of the respective anchor bolts in Europe.

The ETAG 001 consists of the following parts:

- Part 1: "Anchor - General"
- Part 2: "Force-controlled spreading anchor bolts"
- Part 3: "Undercut anchor"
- Part 4: "Path-controlled spreading anchor bolts"
- Part 5: "Compound anchor bolts"
- Part 6: "Anchor bolts for use in multiple attachment by non-supporting systems"

ETAG 001 consists of the following appendices:

- Appendix A: "Testing details"
- Appendix B: "Testing to determine the approval application conditions, detailed information:
- Appendix C: "Rating procedures for anchors"

Rating of head bolts is done in adherence to Appendix C of the ETAG 001 Rating is described in examples in he respective approvals One can find a product-independent presentation of the rating of head bolts in the CUAP for "Steel plates with concrete-surrounded anchor bolts." This CUAP is valid only in connection with ETAG 001.

The EOTA presents the approval and assessment guidelines for construction products. Publication of European rating rules is, however, reserved to the European Standards Committee (CEN). Since there is no existing European rating regulation for fasteners as of the time of the publishing of ETAG 001, the rules for rating guidelines are provided in Appendix C. This is only a provisional solution, however.

The current rating rules (Appendix C of ETAG 001, TR 020, TR 029 as well as the CUAP for head bolts) will therefore be summarised and replaced in the near future in the technical specification CEN/TS 1992-4, "Design of fastenings for use in concrete" which has existed since 2009. CEN/TS follows the rating procedure in Appendix C in ETAG 001, but is not identical for all products, and is in some areas significantly broader, including among other things rating under fatigue conditions and seismic effects. Rating of head bolts and anchor rails is covered in its own section.

The "pre-standard," CEN/TS 1992-4 consists of the following parts:

- » CEN/TS 1992-4-1:2009: Part 1: "General"
- » CEN/TS 1992-4-2:2009: Part 2: "Head bolts"
- » CEN/TS 1992-4-3:2009: Part 3: "Anchor rails"
- » CEN/TS 1992-4-4:2009: Part 4: "Anchor bolts - mechanical systems"
- » CEN/TS 1992-4-5:2009: Part 5: "Anchor bolts - Chemical systems (fastening systems)"

The applicant for approval can choose at present between the procedure in Appendix C of ETAG 001 or that in CEN/TS 1992-4. Since the rating rules are not entirely equivalent, validation of an anchor bolt/head bolt must be carried out consistently according to one of these guidelines.

5.12 Fasteners in concrete

Fasteners have the task of introducing externally applied forces into the anchorage area of the concrete. ETAG distinguishes between the following types:

- » force-controlled spreading anchor bolts
- » path-controlled spreading anchor bolts
- » undercut anchor bolts
- » compound anchor bolts

Anchoring of these fasteners into concrete thus touches the basic working principles of "form-fitting," "frictional connection" or "material-fitting." Depending upon the type of fastener, one of the three or a combination of the three working principles is used.

In the "form-fitting" working principle (see Fig. 5.1, left), anchoring of the fastener in the concrete is done through mechanical indentation (undercut) in the fastening material with the anchor base. A "form-fit" is used in undercut anchor bolts, head bolts and compound undercut anchor bolts.

The "frictional connection" working principle (see Fig. 5.1, right) is applied in spreading anchor bolts (force and path-controlled). When the anchor bolt is set, spreading creates tension on the drill hole wall. This tension causes friction between the anchor bolt and the drill hole wall which prevents the anchor bolt detaching.

The "material-fitting" working principle (see Fig. 5.1, middle) is produced by a compound formed by a mortar-resin mixture between the threads and the drill hole wall. This compound can direct external forces over the drill hole wall to the anchoring foundation. Material filling is the working principle applied to compound anchor bolts.

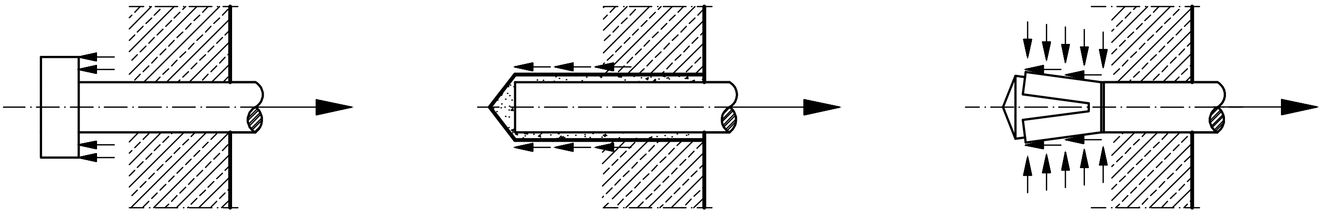


Fig. 5.1: Working principle of anchoring in concrete: Form fitting (left); material fitting (middle); friction fitting (right)

5.1.3 CC procedure – rating fasteners in concrete

5.1.3.1 General

The rating of fasteners in concrete as per Appendix C of ETAG 001 and, in the future, in CEN/TS 1992-4 involves the so-called CC procedure of the DIBt from 1993. CC stands for "Concrete Capacity," as the fasteners use the local tension resistance of the concrete.
When rating reinforced steel concrete components, the general tension resistance of concrete is not considered. This is because, in comparison to pressure resistance, concrete has low tension resistance capacity. The tension resistance of concrete can be exceeded when calculating unrecognised inherent and restraint stresses (due to the hindrance of creep and contraction or temperature stresses). Hence restraint stresses alone can cause a concrete component to fail if there is no reinforcement. Restraint stresses have further effects in the same direction as the externally applied tensile stress. Steel reinforcement to absorb tensile stresses in the form of minimum reinforcement is therefore absolutely necessary for concrete components.

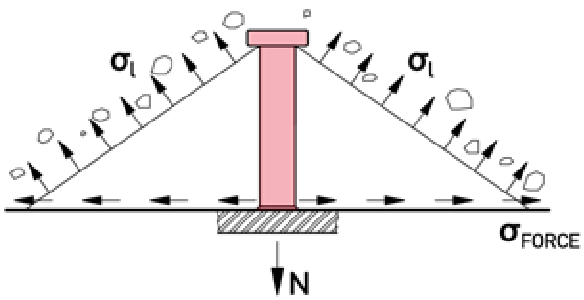


Fig. 5.2: Overlap of forced stresses with stresses created by the fasteners

The situation is different for anchor bolts and head bolts. A concrete fastener establishes a symmetrical rotational tension state. The fracture surface when a concrete body fractures around the fastener is inclined in relation to the concrete surface. The tensile stresses caused by the fastener overlap only to a small extent with the restraint stresses running parallel to the concrete surface (see Fig. 5.2).

Only a slight decrease in the concrete fracture load due to the stresses present in concrete should therefore be expected. An approach using a high partial safety coefficient can therefore be used in the CC procedure for concrete tension resistance.

Since the tension resistance of concrete develops more slowly than pressure resistance, fasteners should not be set in concrete which is fresher than 28 days.

The CC procedure differentiates between various possible failure types under cross- and tensile loads on the anchor bolts when rating metal anchor bolts and head bolts. All failure types are investigated during the verification process. The form of failure must be determined with the lowest resistance rate, i.e. the lowest possible carrying load.

5.1.3.2 Applications areas and conditions for the rating procedure

The CC procedure is limited to C20/25-C50/60 solidity class concrete as the anchoring foundation. Tension applied produces deformation recesses in the concrete in the area of the spreading shell when metal spreading anchor bolts are used. Metal spreading anchor bolts distribute external loads, therefore, through friction on the one hand, and to a small degree through the indentations in the deformation of the recesses in the concrete on the other hand. The depth of the deformation recesses as well as the spreading paths thus depend upon the torque applied as well as the solidity and therefore the deformation resistance of the concrete. Anchor bolts which are developed for use in normal concrete cannot be used in high-strength or very high-strength concrete, because there are insufficient deformation recesses, hence producing insufficient locking with the concrete.
In contrast to rating concrete components, cube compressive strength ($f_{ck,cube}$) and not the cylinder compressive strength is used in the rating formulae to rate anchor bolts and head bolts in concrete.

The procedure applies to individual anchor bolts and groups of anchor bolts. A condition, however, is that all anchor bolts in a group have the same type, manufacturer and diameter and exhibit the same anchoring depth in the concrete. Furthermore, the anchor bolts must be arranged square or at right angles, and be connected to one another using a rigid metal anchor plate. For anchors which are far from the edge (edge distance $c_{1,2}$ at least 10-times the anchoring depth or 60-times the nominal diameter of the anchor bolt), the CC procedure is limited to a maximum of eight anchor bolts per anchor bolt group under tensile and transverse loads (see Fig. 5.3).

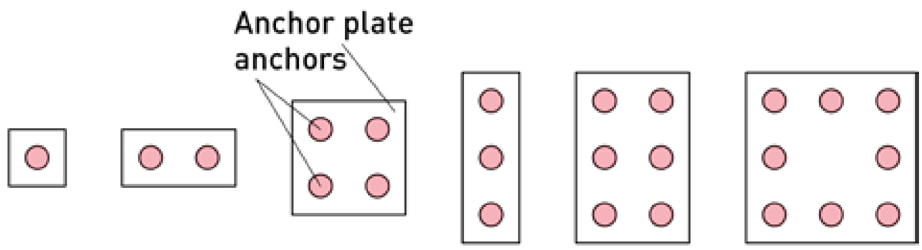


Fig. 5.3: Anchors distant to the edge covered by the rating procedure for all load directions and anchors near the edges

For anchors which are close to the edge (edge distance $c_{1,2}$ less than the 10-times the anchoring depth or 60-times the nominal diameter of the anchor bolt), the CC procedure is limited under pure tensile loads to a maximum of eight anchor bolts and a maximum of four anchor bolts per anchor bolt group (see Fig. 5.4).

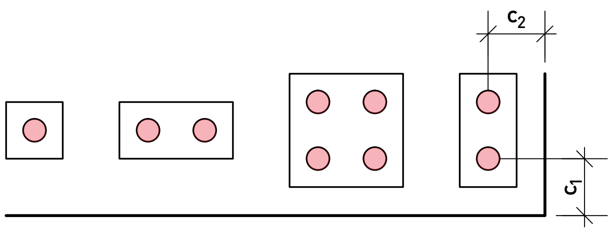


Fig. 5.4: Anchors close to the edge under transverse stress covered by the rating procedure

In the current CC procedure version (ETAG 001), only static forces are covered. The use of anchor bolts under compression and impact loads as well as for earthquakes or fatigue stresses is not possible yet; a suitable extension is given in CEN/TS, 1992-4.

5.1.3.3 Safety concept

The CC procedure is based on the safety concept with partial safety coefficients as per EN 1990. Verification must be provided that the rated value of the effect S_d does not exceed the rated resistance value R_d. The characteristic resistances Rk for the individual forms of failure are either calculated with formulae or are given directly in the anchor bolt approval.

The partial safety coefficient of the material resistance varies depending upon the type of failure, and which material fails (concrete or steel). For failure types in which the concrete is responsible for the failure (fracturing out of the concrete edge, gaps, extraction as well as fracturing out of the concrete on the side of the load), the partial safety coefficient is derived from the following formula:

$$\gamma_{Mc} = \gamma_{Ms} = \gamma_{Mp} = \gamma_{Mcp} = \gamma_c \cdot \gamma_2 \tag{5.1}$$

in which γ_2 is the installation safety coefficient. Suitability tests are applied to define the influence of deviations from the installation instructions or the properties of the anchor foundation on the carrying behaviour of the anchor bolt. The installation safety coefficient is 1.0 for systems with high installation safety under tensile loads, 1.2 for systems with normal installation safety, and 1.4 for systems with low, but sufficient, installation safety. Installation safety has no influence on the magnitude of the partial safety coefficient for concrete failure under transverse loads.

For steel failure types, the partial safety coefficient for material resistance is given dependent upon the ratio of the flow limit $f_{yk}$to tensile strength of the steel f_{uk}. When rating anchor bolts, the tensile strength is used, unlike the flow limit in steel. Therefore, when rating anchor bolts, larger partial safety coefficients must be used than in steel construction. Since the ratio f_{yk}/f_{uk} becomes smaller as steel ductility increases, the partial safety coefficient for steel failure also increases with increasing ductility of the steel used. This is because a sufficient safety against steel flow must be present.

The partial safety coefficient further differs by the load application, and under tensile load amounts to:

$$\gamma_{Ms} = \frac{1{,}20}{f_{yk} / f_{uk}} \geq 1{,}40 \tag{5.2}$$

and under transverse load:

$$\gamma_{Ms} = \frac{1{,}00}{f_{yk} / f_{uk}} \geq 1{,}25 \quad \text{für} \quad f_{uk} \leq 800 \ \frac{N}{mm^2} \quad \text{und} \quad f_{yk} / f_{uk} \leq 0{,}80 \tag{5.3}$$

$$\gamma_{Ms} = 1{,}25 \qquad \text{für} \quad f_{uk} > 800 \ \frac{N}{mm^2} \quad \text{und} \quad f_{yk} / f_{uk} > 0{,}80 \tag{5.4}$$

5.1.3.4 Validation of uncracked concrete

One assumes in the CC process that the anchoring foundation of the anchoring bolt in concrete is generally cracked. Concrete has only a low resistance to tension; crack formation under use states is therefore usually present. When cracks occur in concrete, there is a relatively high probability that these cracks refer to, or at least affect, the anchor bolts at the intersections of which they lie (cross-crack). In addition to the notch effect of the drill hole, this is due to the splitting forces around the drill hole caused by installation and loads.

Also, the anchor bolts may produce different types of crack in otherwise uncracked concrete. Crack formation reduces the maximum carrying load and the load displacement behaviour of the anchor bolt becomes less favourable. The reduction in carrying load in cracked concrete disrupts above all the tension status in the concrete through the crack. In uncracked concrete, the stresses in the concrete are distributed symmetrically around the anchor bolt, and balance is ensured through ring tensile forces. A crack destroys this tension field, and prevents the transmission of tensile forces orthogonal to the crack. Thus the force distribution is changed. In addition, the surface available to distribute the tensile forces is reduced. Additionally, the crack aperture effects a further reduction in spreading forces in metal spreading anchor bolts. Crack formation must therefore be considered during rating. If one assumes, however, that the concrete is uncracked, it is necessary to prove that there is excess pressure in the area of the anchoring depth (pressure zone). This validation of the component must be carried out in SLS. A further condition is that the rating of an anchor bolt in uncracked concrete must be limited to a maximum characteristic load of 60 kN. If the load is greater, then one must assume cracked concrete.

The validation of uncracked concrete is fulfilled if the sum of the stresses from the applied loads (including loads from the anchoring of the anchor bolt σ_L and the sum of the stresses from forced deformation σ_R (shrinkage, temperature variations) are altogether smaller or are equal to zero. In a simplified sense, σ_R can be assumed to be 3 N/mm² . The validation must show that the following condition is adhered to:

$$\sigma_L + \sigma_R \leq 0 \qquad (5.5)$$

5.1.3.5 Load distribution on the anchor bolt

The tensile force is distributed evenly on the individual anchor bolt or the group of anchor bolts under tensile loads. If the anchor bolts are unevenly loaded (e.g. through torque and normal forces), the eccentricity of the load on the group must be determined using the moment of inertia. Anchor bolts under compression loads are thereby ignored. Validation of anchor bolt carrying capability is then carried out for the anchor bolt with the highest load.

Distribution of transverse load on the individual anchor bolts in a group depends upon the type of failure:
For steel fracture and concrete fracture failures on the non-loaded side, one can assume that all anchor bolts in the group transfer the transverse load equally if the clearance hole diameter in the anchor plate has not exceeded the values given in Table 4.1 of ETAG 001, Appendix C.

Tab. 5.1: Excerpt from Appendix C of ETAG 001

Outside diameter $d^{(1)}$ or $d_{nom}^{(2)}$ (mm)	6	8	10	12	14	16	18	20	22	24	27	30
Diameter d_f of the clearance hole in the attached part (mm)	7	9	12	14	16	18	20	22	24	26	30	33

(1) if the bolt is applied to the attached part
(2) if the anchor bolt sleeve is applied to the attached part

If the clearance hole diameters are larger, only the least favourable anchor bolts (i.e. the anchor bolt series with the smallest distance to the edge in the load direction) must be considered for load exposure. In the case of concrete edge failure, only the least favourable anchor bolts are taken for the transverse load, independent of the diameter of the clearance holes in the anchor plate (i.e. the anchor bolts with the shortest distance to the edge in the load direction). This type of failure occurs only with a distance from the edge of $c \leq 10 \cdot h_{ef}$.

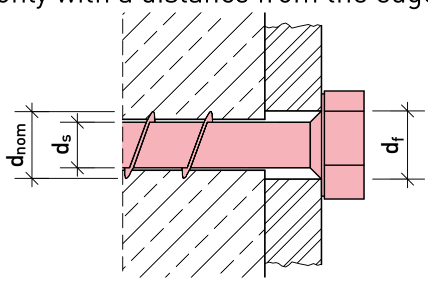


Fig. 5.5: Clearance hole in the component

5.2 Carrying behaviour and proof of attachment in concrete

Outside forces are distributed into the concrete through anchor bolts or head bolts. Depending upon the type of anchor bolt and the stress situation (pull, cross- or oblique loads), there can be a fracture or a extraction of the fastener, or the anchor foundation could fail.
Despite different types of working principles, undercut, metal spreading anchor bolts and head bolts have much in common in their carrying behaviour. Rating and proof are carried out in similar ways.

In order to rate anchor bolts in ULS as per Appendix C in ETAG 001, three rating procedures (A, B and C) are available, which differ according to the calculation effort required and the precision of the results. Each approval shows which of the rating procedures must be used with which specific types of anchor bolts.

Rating procedure A is the most precise rating procedure, but it requires the highest calculation effort. This is common practice to rate safety-relevant anchor bolts. The characteristic resistances for all possible types of failures in anchor bolts or groups of anchor bolts are calculated with consideration of concrete solidity, group effects, the axis and edge distances of the anchor bolts as well as the influence of the load direction and any eccentricity which may exist under the prevalent load, or are given in the respective anchor bolts' ETAs. The lowest resistance is used, and may not be less than the rated value of the exposure.
Rating procedures B and C are simplified in comparison to A, but their results are distinctly conservative, and therefore less commercially viable than when using rating procedure A. In the CEN/TS 1992-4, only rating procedure A is used.

Rating of head bolts is done in adherence to Appendix C of ETAG 001. However, this rating is not the same in all points, and is described as examples in the respective approvals for head bolts. The rating of head bolts is described in a separate section of CEN/TS 1992-4 (CEN/TS, 1992-4-2, head bolts).

5.2.1 Carrying behaviour and types of failure under tensile loads

Anchor bolts in concrete can fail due to steel fractures, they can pull out, concrete can fail, or gaps in concrete can fail under tensile loads. The evidence can be found in Table 5.2.

Tab. 5.2.: Validation for tensile stress

	Individual anchor bolts	Anchor bolt groups	
Steel fracture	$N_{Sd} \leq N_{Rk,s}/\gamma_{Ms}$	$N^{h}_{Sd} \leq N_{Rk,s}/\gamma_{Ms}$	
Extraction	$N_{Sd} \leq N_{Rk,p}/\gamma_{Mp}$	$N^{h}_{Sd} \leq N_{Rk,p}/\gamma_{Mp}$	
Concrete fracture	$N_{Sd} \leq N_{Rk,c}/\gamma_{Mc}$		$N^{g}_{Sd} \leq N_{Rk,c}/\gamma_{Mc}$

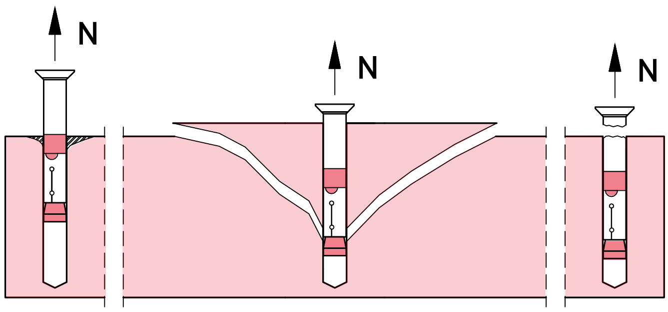


Fig. 5.6: Failure types under tensile stress: Extraction (left); concrete fracture (middle); steel fracture (right)

5.2.1.1 Steel fracture

The anchor bolt fails in this type of failure at the shaft or thread area, or the bolt sleeve fails (see Fig. 5.6, right). Steel fractures present the upper limits of carrying capability of an anchor bolt, and generally occur only with high anchoring stiffnesses or when anchoring in high-strength concrete. The characteristic resistance of an anchor bolt with a steel fracture $N_{RK,s}$ (Index 's' for steel) is given in the anchor bolt approval, or can be derived from the following formula:

$$N_{Rk,s} = A_s \cdot f_{uk} \tag{5.6}$$

5.2.1.2 Extraction

Extraction occurs when the friction forces between the spread shell and the drill hole wall are less than the external tensile forces. The anchor bolt is then pulled out of the drill hole (see Fig. 5.6, left). Then the concrete near the surface can be damaged. This has no influence, however, on resistance against extraction. With properly anchored, force-controlled spreading anchor bolts, pull-through failures can occur. In this case, the friction between the cone and the spreading sleeve is less than that between the spreading sleeve and the anchor foundation. The cone is pulled through the spreading sleeve. For simplification, both types of failure types, extraction and pulling through are treated under the joint term of "pulling through." The characteristic resistance $N_{Rk,p}$ (Index 'p' for pull-out) of an anchor bolt against extraction is given in the approval for the respective anchor bolt. This depends upon the type of anchor bolt, and cannot be determined through calculations; rather, it can only be determined through testing. The respective ETA generally contains characteristic resistance against extraction for a C20/25 concrete anchor foundation. The ETA amplification factors are given for higher concrete strengths.

5.2.1.3 Concrete fracture

In the failure type concrete fracture, the concrete in the anchor foundation is used until the concrete's tensile strength is exhausted. This then forms a symmetrical, cone-shaped concrete fracture body (see Fig. 5.6, middle and 5.7). The concrete fracture failure type is relatively brittle. The tilt angle of the fracture body is, on average, 35°. In addition, if the anchor bolt foundation is vertical to the force direction for compression or pull, the fracture cone will be steeper or flatter. Its height is 0.8 to 1 times the height of the spread anchor bolt, and for undercut anchor bolts, 1-times the anchoring depth h_{ef}, i.e. the distance between the concrete surface and the end of the force introduction in the concrete.

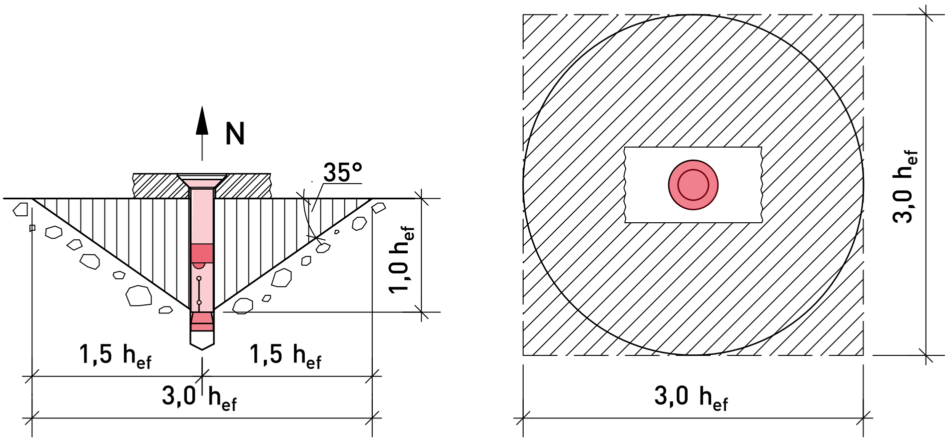


Fig. 5.7: Idealised concrete fracture body and surface of an anchor bolt distant from the edge

Group concrete fracture will occur if several anchor bolts are loaded at the same time over one anchor plate, as with, for example, a SHERPA connector, and the distance of the anchor bolts to one another is too small. This lowers the fracture load compared to the maximum possible value. If an anchor bolt is near a component edge, i.e. the distance of the anchor bolt to the edge is less than 1.5 h_{ef}, then an overload will cause an edge fracture. In this case as well, no complete fracture cone will be formed (see Fig. 5.8)

Also, the fracture load in this case sinks compared to the maximum possible value.

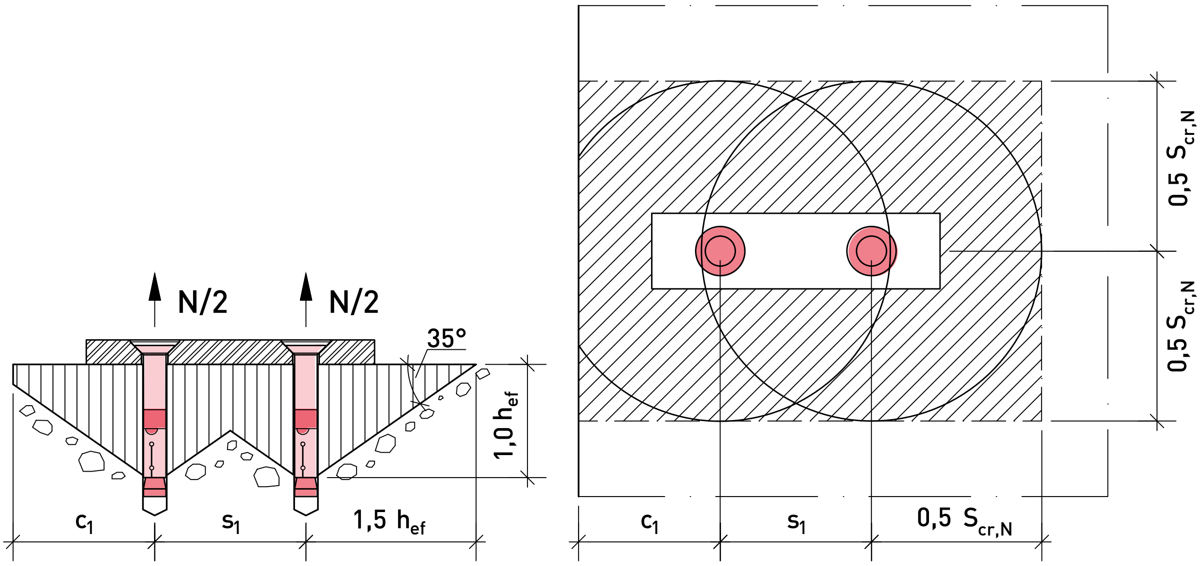


Fig. 5.8: Concrete fracture cone of a double fastener, whereby the cone is limited by the edge and axis spacings.

The characteristic resistance $N_{Rk,c}$ (index 'c' for concrete) of an anchor bolt or a group of anchor bolts can be derived from the following formula:

$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \qquad (5.7)$$

$N^0_{Rk,c}$ is thus the starting value for characteristic resistance of an individual anchor bolt in cracked concrete. It is produced by a function of a factor used to calculate concrete fracture load k_1 (7.2 for cracked and 10.1 for uncracked concrete), the anchoring depth as well as the cube compressive strength of the concrete serving as an anchor foundation

$$N^0_{Rk,c} = k_1 \cdot h_{ef}^{1,5} \cdot \sqrt{f_{ck,cube}} \qquad (5.8)$$

The reason for a low factor k_1 in cracked concrete can be found in disruption of the stress state through the crack formation around the anchor bolt. If the anchor bolt is anchored in uncracked concrete, the stresses induced by the anchor bolt load are distributed in a rotationally symmetric manner to the attachment edge. Balance is ensured by ring tensile forces. However, if the anchor bolt is located in a crack, no tensile forces can be transferred vertical to the crack. The crack causes a change in the stress distribution in the concrete, and the area available to transfer tensile forces is reduced. The crack creates two independent concrete fracture bodies which meet in the area of the crack.

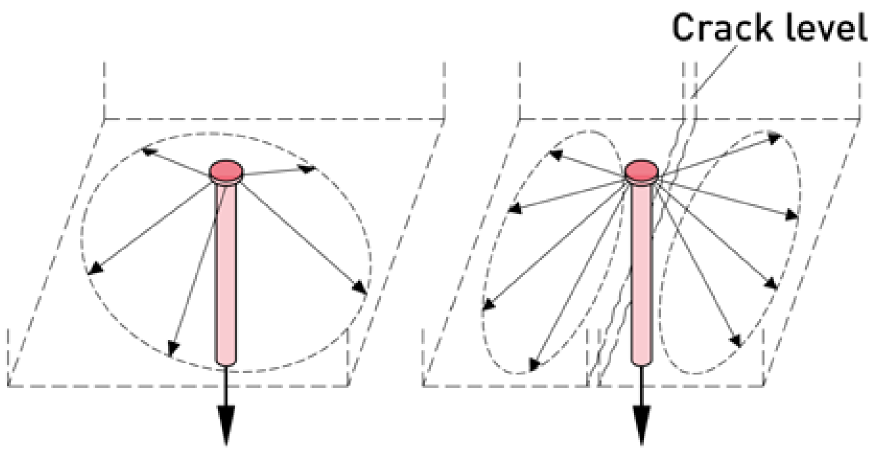


Fig. 5.9: Influence of a crack on the crack course of head bolts exposed to tensile stress.

left: uncracked concrete

right: cracked concrete

The diameter of the fracture cone footprint corresponds to three times the depth of the anchor. Since the footprint of the cone can be determined depending upon the diameter squared, the concrete fracture load will then increase proportional to h_{ef}^2, i.e. increasing the anchoring depth by a factor of three leads to a ninefold increase in the fracture load. It is known from test series, however, that this is not the case, and a threefold increase in the anchoring depth only leads to an approximate 5.7-fold increase in the fracture load – the fracture load therefore only climbs in proportion to $h_{ef}^{1,6}$. This can be traced back to the so-called size effect of the concrete cone failure load: the nominal carrying capability (the failure load related to the area) increases with decreasing component size.

The geometry of the rating situation (anchor bolt group, edge i.e. corner) is considered using the projected $A_{c,N}$ / $A^0_{c,N}$ ratio. The fracture body is idealised as a pyramid with a height of h_{ef} and a length of the footprint as $3 \times h_{ef} = s_{cr,N}$.

The projected area $A^0_{c,N}$ therefore corresponds to the area of the idealised pyramid.

$$A^0_{c,N} = s_{cr,N} \cdot s_{cr,N} = 9 \cdot h_{ef}^2 \qquad (5.9)$$

Hence a single attachment will therefore only reach its characteristic carrying capability if an undisturbed square area is available on the concrete surface. A group of anchor bolts only reaches the sum of its characteristic carrying capabilities in its anchor bolts if, for each individual anchor bolt, the complete area is available, and there are no overlaps.
Area $A_{c,N}$ corresponds to the actual existing concrete surface available to one anchor bolt or a group of anchor bolts in the respective rating situation. The area can either be limited by the component edges or overlapping of the fracture body of the anchor bolt in a group.

Therefore, if the available area $A_{c,N}$ is limited in this way, the factor will be smaller than the number N of the anchor bolts, and there is a reduction of the characteristic resistance $N_{Rk,c}$ of an anchor bolt or an anchor bolt group.

Factor $\psi_{s,N}$ to consider the influence of edges on the symmetrically rotated stress state around the fastener.
This factor will consider a disruption in the symmetrically rotated stress state in concrete caused by the component edges. A component edge is similar to a crack which is so wide that no tensile stresses can be transferred across the crack. In addition to the reduced concrete fracture surface considered in $A_{c,N}$ / $A^0_{c,N}$, the disruption of a symmetrically rotated stress state causes further reduction in carrying capability compared to an anchor bolt which is far from the edge.

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{c}{c_{cr,N}} \leq 1,00 \qquad 5.10)$$

Whereby:

c	is the minimum existing edge distance [mm]
$c_{cr,N}$	characteristic edge distance [mm], $c_{cr,N} = 1.5 \cdot h_{ef}$

Factor $\psi_{ec,N}$ to consider eccentricity
This factor considers the influence of the differing tensile loads prevailing and caused by bending torques on the respective anchor bolts in an anchor bolt group.

$$\psi_{ec,N} = \frac{1}{1 + 2 \cdot \frac{e_N}{s_{cr,N}}} \leq 1,00 \qquad (5.11)$$

Thus:
e_N the centre of the resulting tensile force on the anchor bolt group [mm]
$s_{cr,N}$ characteristic axis spacing [mm]

Factor $\psi_{re,N}$ to consider dense reinforcement in the anchor foundation
This factor is also called the shell spalling factor. A crosswise surface reinforcement which is nor mally in flat components generally has no influence on the carrying capability of the connection in the presence of the concrete fracture type of failure, because it is arranged vertically to the force direction. If there is a small distance to the reinforcement, the fracture cone could rest on the reinforcement network, which may cause a more ductile fracture behaviour.
However, if the anchor bolt is anchored in the concrete cover or near the reinforcement, the stresses overlap due to the compound effect of the reinforcement bars with the tensile forces from the anchor bolt connection.
Furthermore, the reinforcement can reduce the concrete surface available to transfer tensile forces. The concrete strength can be less than in a component interior due to the dense reinforcement in this area.
These effects reduce the carrying capability and are considered with the shell spalling factor.

$$\psi_{re,N} = 0{,}5 + \frac{h_{ef}}{200\ \text{mm}} \leq 1{,}00 \tag{5.12}$$

If the axis spacing of the reinforcement bars is less than 150 mm, or the reinforcement has a diameter smaller than or equal to 10 mm, and an axis spacing greater than 100 mm, factor $\psi_{re,N}$ can be defined as 1.00.

5.2.1.4 Splitting

Splitting in the concrete can occur during assembly, as well as under load, if the component dimensions are too small, or the anchor bolts are near the edge, or are arranged in a distance which is too close to one another. The fracture load is generally smaller than the concrete fracture failure case.
Resistance in the concrete of the anchoring foundation to splitting grows proportionally with greater concrete strength, greater edge or corner distance and greater axis spacing in an anchor bolt group.

The minimum centre and edge spacing needed to prevent splitting the concrete differs according to the type of anchor bolt, design and manufacturer. This must be determined by experiment, and can be found in the respective anchor bolt approvals.
Splitting during installation of the anchor bolt can be prevented by adherence to the respective ETA's minimum values for the distance from the edge c_{min}, the axis spacing s_{min}, the component thickness $h_{min}$and the reinforcement.

One can assume under load that there will not be a splitting of the concrete if the edge distance in all directions is $c \geq 1.5 \cdot c_{cr,sp}$ and the component thickness is $h \geq 2 \cdot h_{ef}$.
If these conditions are not fulfilled, verification must be carried out for the splitting failure type. Calculating the characteristic resistance for this type of failure is similar to the concrete fracture failure type, as the resistance of an anchor bolt is influenced by the same parameters (concrete strength, anchoring depth, axis and edge distance and load eccentricity).

There are differences only in the size of the characteristic axis spacing and edge distances (index 'sp' for splitting) for the splitting failure type in comparison to the characteristic axis spacing and edge distances for the concrete fracture failure type. These two values, taken from respective approvals, must then be used in the rating formulae for the concrete fracture failure type instead of the axis spacing and edge distances.

$$N_{Rk,sp} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \cdot \psi_{h,sp} \tag{5.13}$$

In the concrete fracture failure type, the resistance is independent of the component thickness. For splitting, however, the force needed increases with the thickness of the component. Therefore, the thickness of the component is included in the calculation with the factor $\psi_{h,sp}$.

Factor $\psi_{h,sp}$ to consider the thickness of the component

$$\psi_{h,sp} = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} < 1{,}50 \tag{5.14}$$

Whereby:

h	available component thickness [mm]
h_{min}	minimum component thickness taken from the respective approval [mm]

5.2.1.5. Carrying behaviours and failure types under transverse loads

A transverse load is first transferred from the friction between the anchor plate and the concrete. After the friction is overcome and the hole clearance is bridged, the transverse load is transferred to the non-load side of the concrete. With increasing transverse loads, the jamb compression in the area of the drill hole opening grow, leading to a mussel-shaped spalling in front of the anchor bolt. As the loads increase further, the anchor bolt is sheared at the drill hole opening. For head bolts, metal spreading anchor bolts and concrete screws, validation of the following failure types is necessary: steel fractures with lever arm, steel fractures without lever arm, concrete edge fractures as well as concrete fracture of the non-loaded side.

Tab. 5.3: Validation for failure behaviour under tensile stress

	Individual anchor bolt	Anchor bolt group	
Steel fracture without a lever arm	$V_{Sd} \leq V_{Rk,s}/\gamma_{Ms}$	$V^h_{Sd} \leq V_{Rk,s}/\gamma_{Ms}$	
Extraction with a lever arm	$V_{Sd} \leq V_{Rk,p}/\gamma_{Mp}$	$V^h_{Sd} \leq V_{Rk,p}/\gamma_{Mp}$	
Concrete fracture on the non-loaded side	$V_{Sd} \leq V_{Rk,cp}/\gamma_{Mc}$		$V^g_{Sd} \leq V_{Rk,cp}/\gamma_{Mc}$
Concrete edge fracture	$V_{Sd} \leq N_{Rk,c}/\gamma_{Mc}$		$V^g_{Sd} \leq N_{Rk,c}/\gamma_{Mc}$

5.2.1.6 Steel fracture without a lever arm

An anchor bolt is subject to a combination of normal, shearing and bending tension under transverse loads. The last-named influence can be ignored, however, if the anchor plate is stressed without an interlayer against the concrete surface. If a mortar layer is placed to balance the unevenness between the concrete surface and the anchor plate, this may not exceed a thickness of 3 mm, as per ETAG 001, otherwise one could assume a steel fracture without a lever arm. The thickness of the mortar layer is limited to half the anchor bolt's rated diameter in CEN/TS, 1992-4.

If the thickness of the mortar layer is greater, there is a risk that the mortar could spall, and the transverse load is no longer distributed through shearing force in the mortar, but rather through bending the anchor bolt in the anchor foundation. The anchor bolt either shears at the sleeve, shaft or thread area in the case of steel fracture under transverse loads without a lever arm. This type of failure leads to the highest possible resistance of a fastener under transverse loads. The surface concrete can spall in a mussel-shape shortly before the highest load is reached. Hence this is what causes anchor bolt deformation, not the acceptable highest load.

The characteristic resistance $V_{Rk,s}$ (Index ‘s‘ for steel) of an anchor bolt or head bolt is given in the respective anchor bolt's approval, or can be calculated.

$$V_{Rk,s} = 0{,}5 \cdot A_s \cdot f_{uk} \tag{5.15}$$

The 0.5 reduction factor in comparison to resistance against steel fracture under tensile stress is derived from the fact that there is an overlap of shearing, bending and normal stresses under transverse loads in the fracture state, which leads to an according reduction in carrying capability.
Because the cross-carrying capability of an anchor bolt is influenced by the ductility of the steel used, the characteristic resistance in some anchor bolts can be less than shown in the formula to calculate $V_{RK,s}$ resistance. In this case, the value $V_{Rk,s}$ is taken directly from the approval.

5.2.1.7 Steel fracture with a lever arm

The anchor bolt will also be subject to bending if a distance between the anchor plate and concrete (distance installation) is created by standard practice, or if the thickness is above and the solidity of the mortar balancing level below the limit values. The characteristic resistance of the anchor bolt is therefore derived from a function of the characteristic resistance torque $M_{Rk,s}$, the lever arm l between load and clamping (see Fig. 5.10) as well as the torque coefficient α_M:

$$V_{Rk,s} = \alpha_M \cdot \frac{M_{Rk,s}}{l} \tag{5.16}$$

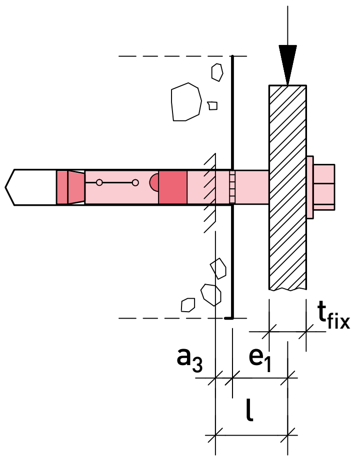


Fig. 5.10: Lever arm for transverse stress with offset mounting

Characteristic resistance torque $M_{Rk,s}$ is given in the respective anchor bolt approval, or can be calculated with the following formula:

$$M_{Rk,s} = 1{,}2 \cdot W_{el} \cdot f_{uk} \tag{5.17}$$

The torque coefficient α_M is dependent on the clamping situation. It is 1.0 with a free rotatable component, and 2.0 with a completely clamped component.
The lever arm l of a transverse load is determined as the sum of the distance of the transverse load from the concrete surface e_1 and a section a_3. One can assume half the nominal diameter of the anchor bolt for the section a_3.

5.2.1.8 Concrete edge fracture

If an anchor bolt or an anchor bolt group is found too close to a component edge, the anchor bolt can fracture with the concrete edge. The angle of the fracture body is similar to the angle of the fracture body for the concrete fracture failure type under tensile stress, about 35°. But in contrast, tensile stress does not produce a complete cone, but rather a half fracture cone since the concrete only fractures on the underside (see Fig. 11).

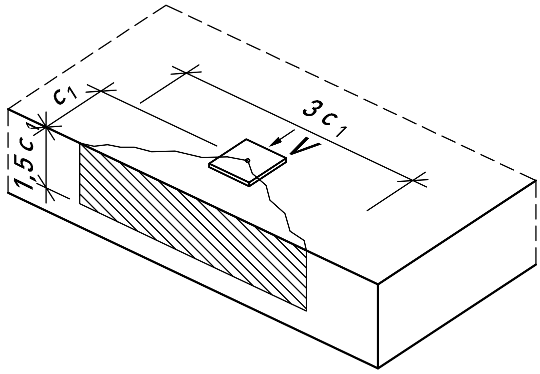


Fig. 5.11: Idealised concrete fracture body with single attachment at the component edge

The characteristic resistance $V_{Rk,c}$ of an anchor bolt or an anchor bolt group with a concrete edge fracture can be calculated with the following formula:

$$V_{Rk,c} = V^0_{Rk,c} \cdot \frac{A_{c,V}}{V^0_{c,V}} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V} \qquad (5.18)$$

$V^0_{Rk,c}$ is thus the output value of an individual anchor bolt in cracked concrete, and is calculated with the following formula.

$$V_{Rk,c} = k_1 \cdot d_{nom}{}^{\alpha} \cdot h_{ef}{}^{\beta} \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1,5} \qquad (5.19)$$

Whereby:

$$\alpha = 0,1 \cdot \left(\frac{l_f}{c_1}\right)^{0,5} \qquad (5.20)$$

$$\beta = 0,1 \cdot \left(\frac{d_{nom}}{c_1}\right)^{0,2} \qquad (5.21)$$

c_1	Edge distance in the direction of the transverse load [mm]
d_{nom}	Outside diameter of the anchor bolt as per ETA [mm]
l_f	effective load introduction length as per ETA [mm]
$f_{ck,cube}$	characteristic cube strength of the concrete
$k_1 = 1.70$	applied in the case of cracked concrete
$k_2 = 2.40$	applied in the case of uncracked concrete

The geometry of the rating situation is considered analgously to that of the failure type concrete fracture using the ratio of the projected surfaces $A_{c,V}$ / $A^0_{c,V}$. In this case, however, the fracture body is idealised as a half pyramid with a height of c_1 and a base area of 4.5 $c_{1,2}$. This area must be available to every anchor bolt in order to mobilise the maximum support capacity. $A_{c,V}$ is again the surface area available in real terms in the rating situation. This may be restricted by the component thickness, the anchor bolts adjacent to the fracture body as well as the component edges. (see Fig. 5.12).

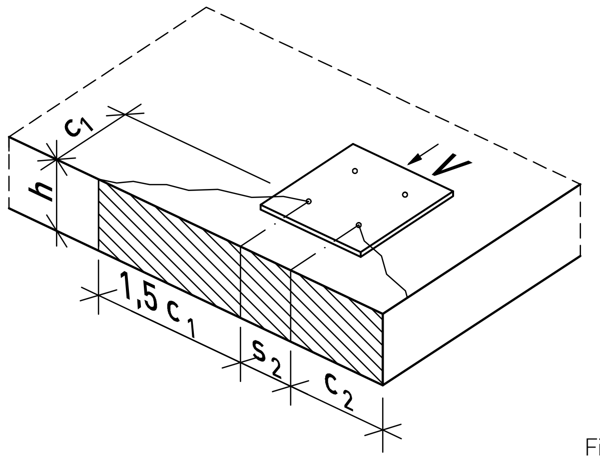


Fig. 5.12: Anchor bolt group at the component edge in a thin component

Factor $\psi_{s,V}$ to consider further edges

This factor is used to consider the disruption to the symmetrical rotational tension status caused by additional edges.

$$\psi_{s,V} = 0{,}7 + 0{,}3 \cdot \frac{c_2}{1{,}5 \cdot c_1} \leq 1{,}00 \tag{5.22}$$

Whereby

c_1 Edge distance in the load direction [mm]

c_2 Edge distance orthogonally to the load direction [mm]

Factor $\psi_{h,V}$ to consider the component thickness.

The factor to consider the component thickness is an amplification factor. The results are overly conservative if it is not applied. The fracture load is not reduced proportionally (linearly) for the concrete edge fracture failure case for thin components, as assumed in the $A_{c,V}$ / $A^0_{c,V}$ ratio, but rather to a lower degree. The $\psi_{h,V}$ factor compensates for this.

$$\psi_{h,V} = \left(\frac{1{,}5 \cdot c_1}{h}\right)^{\frac{1}{2}} \geq 1{,}00 \tag{5.23}$$

Whereby

h component thickness available [mm]

c_1 Edge distance in the load direction [mm]

Factor to consider the load direction.

The factor to consider load direction is also an amplification factor. If the load does not impact vertically, but rather at an angle $\alpha$to the free component edge, this leads to an increase in the characteristic resistance against the concrete edge fracture failure type. In this, the possible angle of incidence for the load is distributed in three different areas, each possessing its own distinct value for $\psi_{\alpha,V}$

The factor $\psi_{\alpha,V}$ for area 1 ($0° \leq \alpha_V \leq 55°$) is:

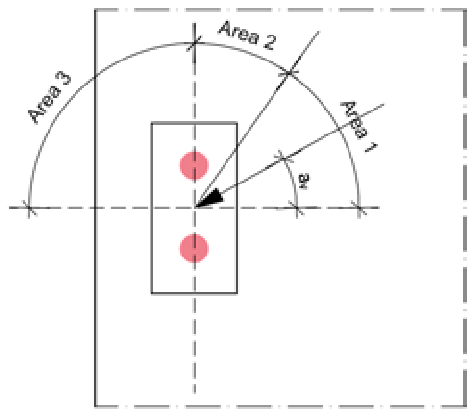
$$\psi_{\alpha,V} = 1{,}00 \tag{5.24}$$

For area 2 ($55° \leq \alpha_V \leq 90°$):

$$\psi_{\alpha,V} = \frac{1}{(\cos\alpha_V + 0{,}5 \cdot \sin\alpha_V)} \tag{5.25}$$

For area 3 ($90° \leq \alpha_V \leq 180°$):

$$\psi_{\ ,V} = 2{,}00 \tag{5.26}$$



Factor $\psi_{ec,V}$ to consider eccentricity

The influence of an eccentric load on the anchor bolt in an anchor bolt group is considered through the use of this factor. It results in:

$$\psi_{ec,V} = \frac{1}{1+2\cdot\frac{e_v}{3\cdot c_1}} \leq 1{,}00 \tag{5.27}$$

Whereby

c_1	Edge distance in the load direction [mm]
e_V	Eccentricity of the resulting transverse load on the anchor bolt [mm]

Factor $\psi_{re,V}$ to consider the position of the fastener

$\psi_{re,V}$ = 1.0	Fixed in uncracked concrete and fixed in cracked concrete without edge and frame reinforcement
$\psi_{re,V}$ = 1.	Fixed in cracked concrete with straight edge reinforcement (≥ Ø 100 mm)
$\psi_{re,V}$ = 1.4	Fixed in cracked concrete with edge reinforcement and narrow frame reinforcement (a ≤ 100 mm)

5.2.1.9 Concrete fracture on the non-load side

When fastening with a low anchoring depth and a large cross-section, it is possible that the concrete will fracture on the non-load side due to the transverse load (see Fig. 5.13).

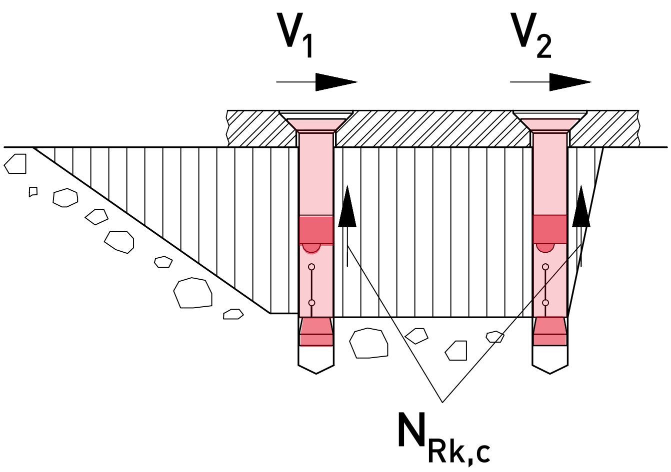


Abb. 5.13: Concrete fracture on the non-load side exposed to transverse stress

The transverse load can create compression on the non-load side between the concrete in the anchor foundation and the anchor bolt. This compression leads to damage to the concrete near the surface on the underside of the load as the load increases. Thus the resulting end of resistance moves deeper into the anchor foundation. At the same time, the anchor plate loses its retention on the underside of the load, and loosens on the load-carrying side of the concrete.

Both these effects are increased by the eccentricity between the transverse load impact and the resulting end of resistance. The torque created by this eccentricity creates a compressive, compensating force on the non-load side between the anchor plate and the anchor foundation as well as a tensile force in the anchor bolt (see Fig. 5.14).

The characteristic resistance (index 'cp' for concrete pryout) for the concrete fracture failure type on the non-load side can be determined by multiplying the resistance to concrete fracture under tensile loads $N_{RK,c}$ by the coefficient k for the concrete fracture failure type on the non-load side.
Fracture bodies in this failure type are smaller than the concrete fracture failure type, but the highest load is determined using the same influencing factors. That is why the characteristic resistance can be calculated using the value for concrete fracture under tensile loads.

The coefficient k depends upon the anchoring depth, and can be found in the approval for the respective anchor bolt. In general, for anchoring depths ≤ 60 mm it is 1.0, and for anchoring depths > 60 mm 2.0.

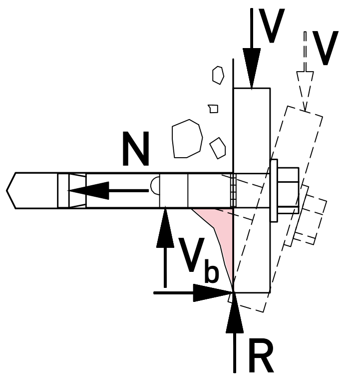


Abb. 5.14: Carrying mechanism of an anchor beam connection under transverse stress

$$V_{Rk,cp} = k \cdot N_{Rk,c} \tag{5.28}$$

5.2.2 Combined tensile and transverse stress

The carrying capability of an anchor bolt or an anchor bolt group under combined tensile and transverse stress depends upon the angle of incidence of the load, and lies somewhere between the carrying capability of pure tensile or pure transverse stress.

Essentially, the failure types that occur under pure tensile or transverse stress are the same. The more dominant stress exerts proportionately greater influence on the form of failure. The following failure combinations are possible under a combination of stresses:

» steel fracture under tensile and transverse stress

» concrete fracture under tensile and steel fracture under transverse stress

» concrete fracture under tensile and transverse stress

All validations must be performed for normal and transverse stress as well as additional interaction validation for an anchor bolt or an anchor bolt group exposed to a combination of normal and transverse forces.

When validating interaction, the ratio of rated value of exposure and rated value of resistance for tensile and transverse stress respectively must not exceed 1.0, and the sum of both ratios cannot exceed 1.2.

$$\beta_N = \frac{N_{Sd}}{N_{Rd}} \le 1{,}00 \tag{5.29}$$

$$\beta_N = \frac{V_{Sd}}{V_{Rd}} \le 1{,}00 \tag{5.30}$$

$$\beta_N + \beta_V \le 1{,}20 \tag{5.31}$$

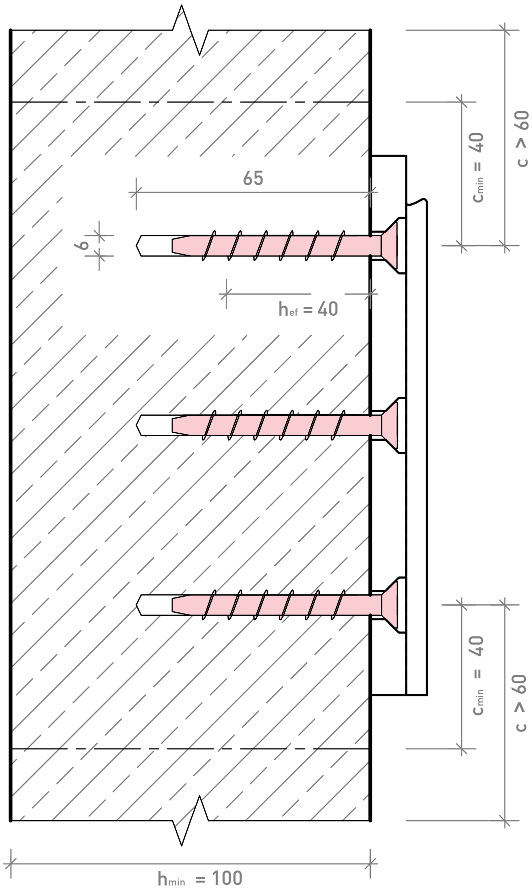
However, the three formulae above produce conservative results. The following formula delivers more realistic results:

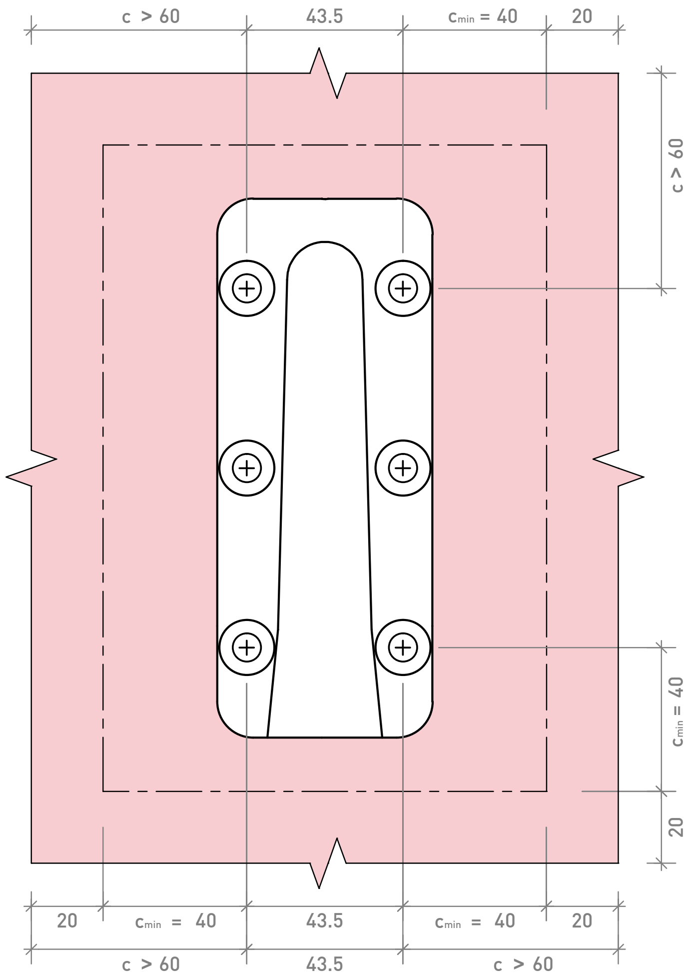
$$(\beta_N)^\alpha + (\beta_V)^\alpha \le 1{,}00 \tag{5.32}$$

Whereby
$\alpha = 2.0$ for relevant failure type for steel fracture in both load directions
$\alpha = 1.5$ for all other failure types

5.3 Minimum distances for SHERPA CS Series M to XXL

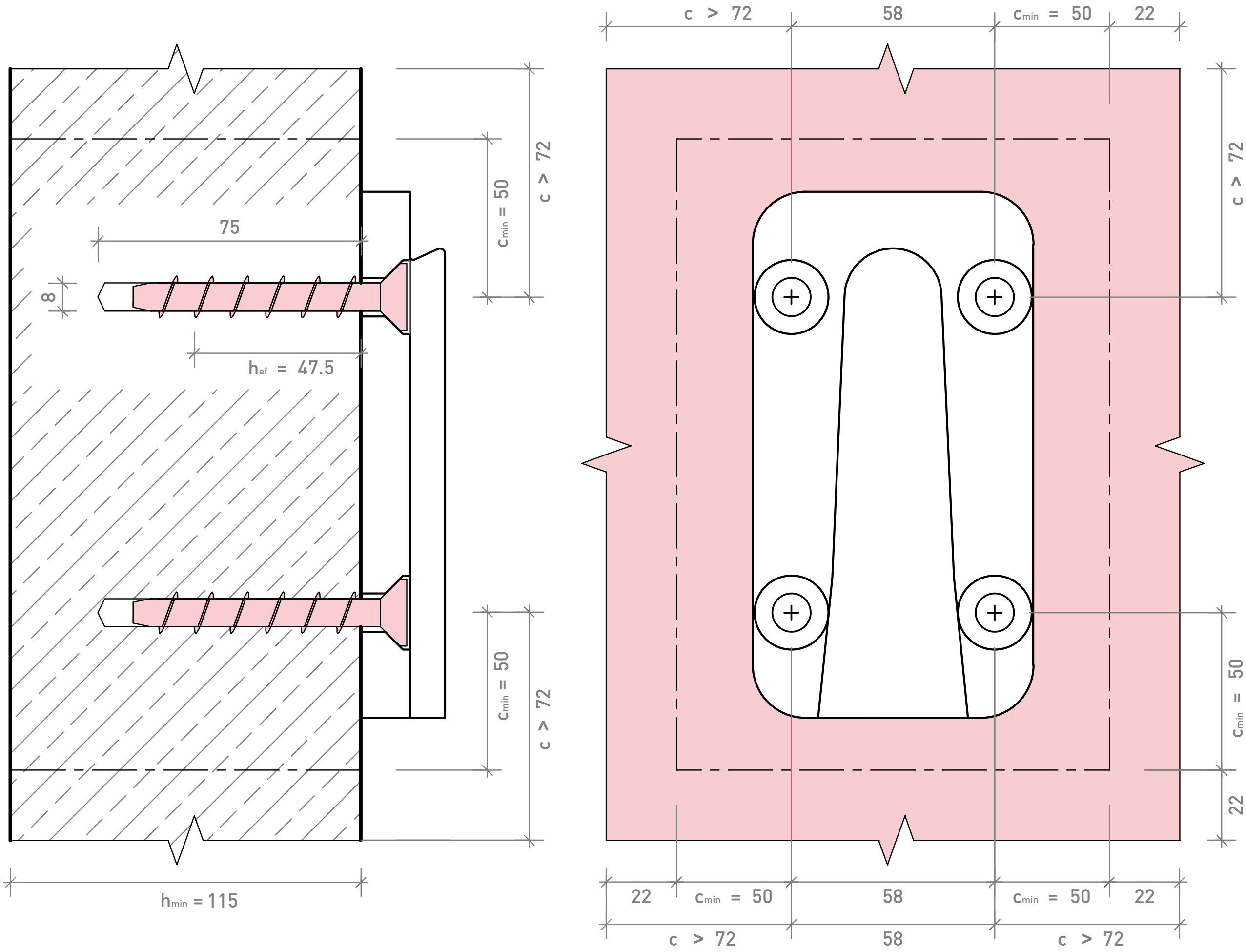
5.3.1 Minimum distances for CS Series M with HECO MMS F 7.5 x 60 mm





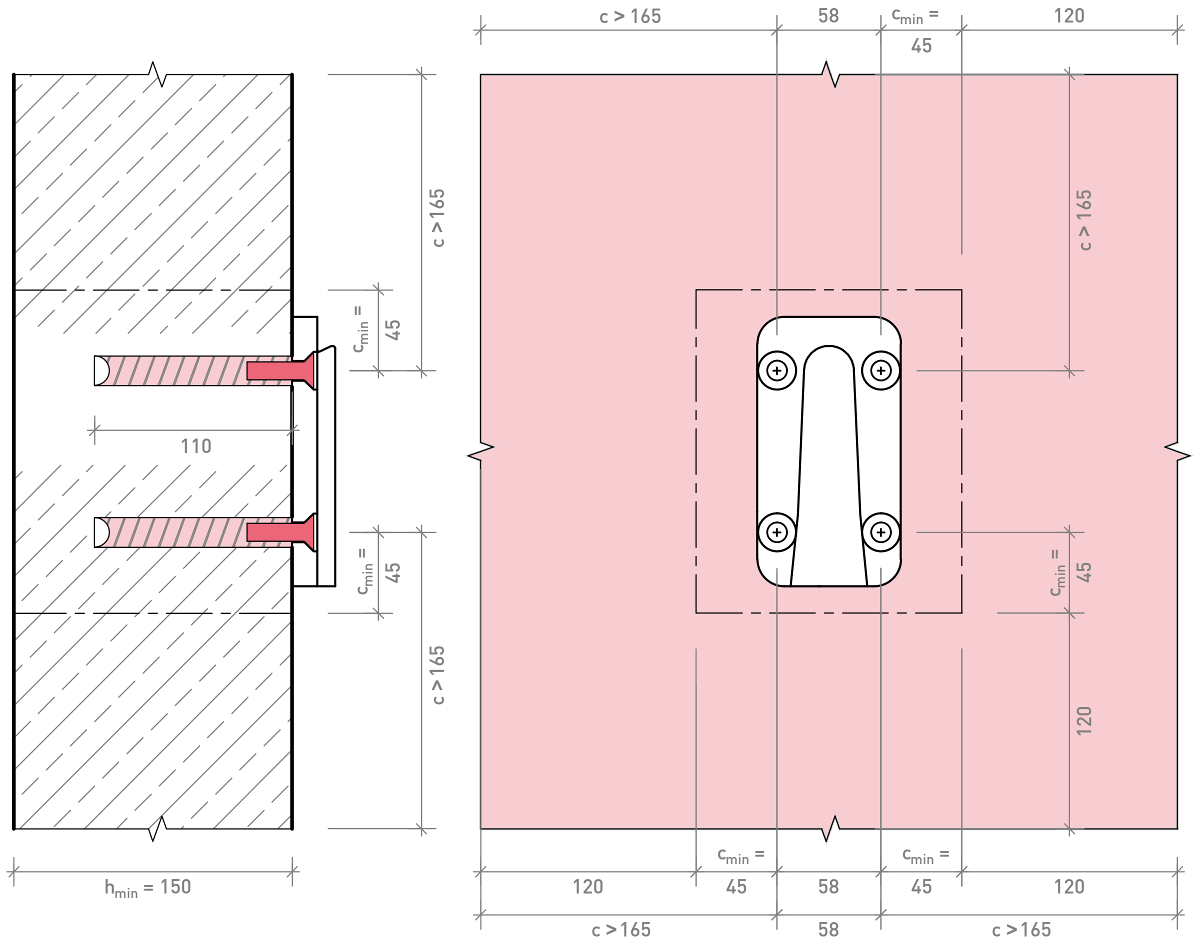
HECO MMS F 7.5 x 60 mm		
minimum component thickness h_{min}	(mm)	100
minimum axis spacing s_{min}	(mm)	40
minimum edge distance c_{min}	(mm)	40
effective anchoring depth h_{ef}	(mm)	40
characteristic axis spacing $s_{cr,N}$	(mm)	120
characteristic edge distance $c_{cr,N}$	(mm)	60
characteristic axis spacing (cracks) $s_{cr,cp}$	(mm)	120
characteristic edge distance (cracks) $c_{cr,sp}$	(mm)	60

5.3.2 Minimum distances, CS Series L with HECO MMS F 10 x 80 mm



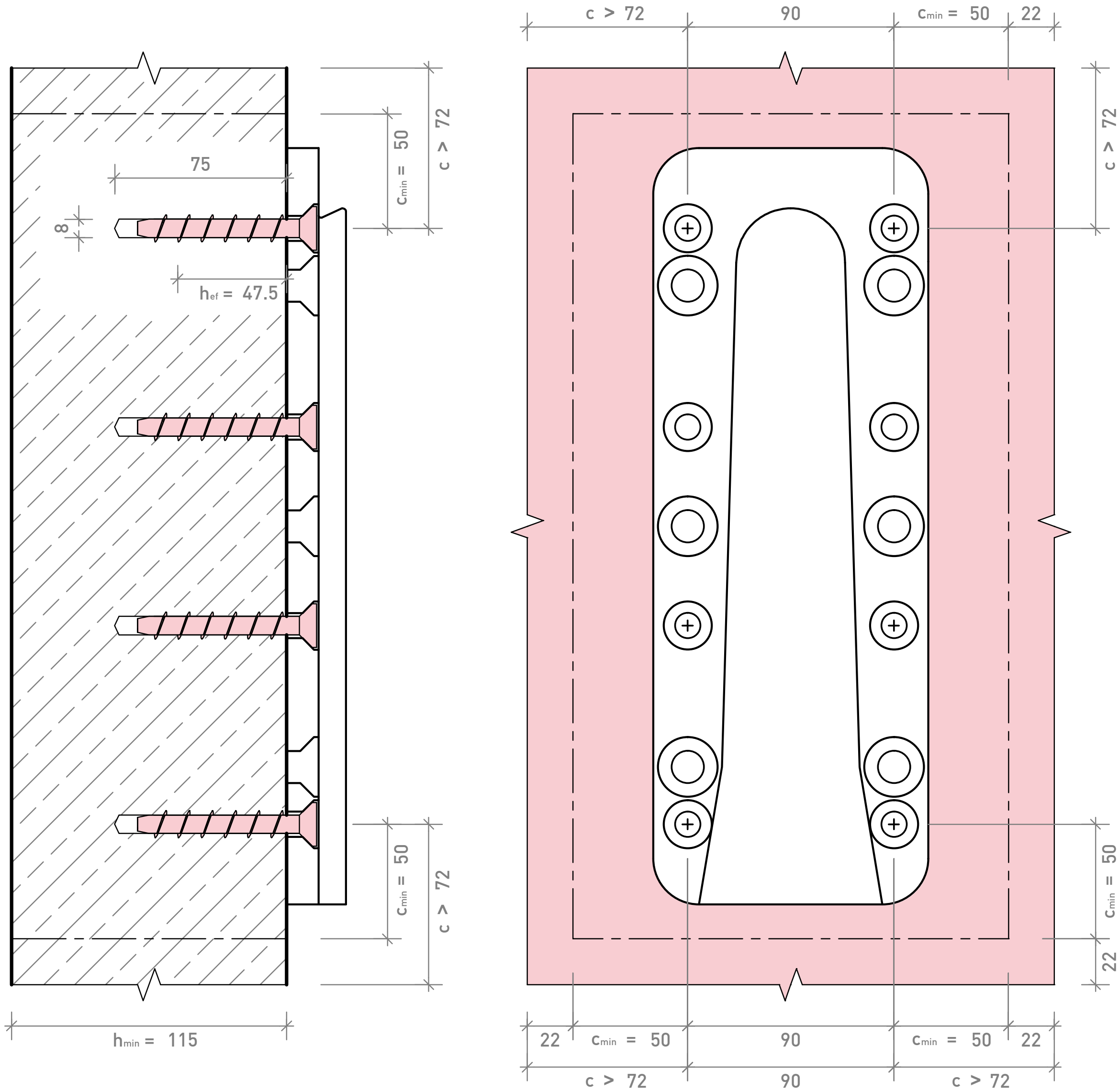
HECO MMS-F 10 x 80 mm		
minimum component thickness h_{min}	(mm)	115
minimum axis spacing s_{min}	(mm)	50
minimum edge distance c_{min}	(mm)	50
effective anchoring depth h_{ef}	(mm)	47.5
characteristic axis spacing $s_{cr,N}$	(mm)	142.5
characteristic edge distance $c_{cr,N}$	(mm)	72
characteristic axis spacing (cracks) $s_{cr,cp}$	(mm)	142.5
characteristic edge distance (cracks) $c_{cr,sp}$	(mm)	72

5.3.3 Minimum distance, CS Series L with inner thread sleeves, M10 from HILTI



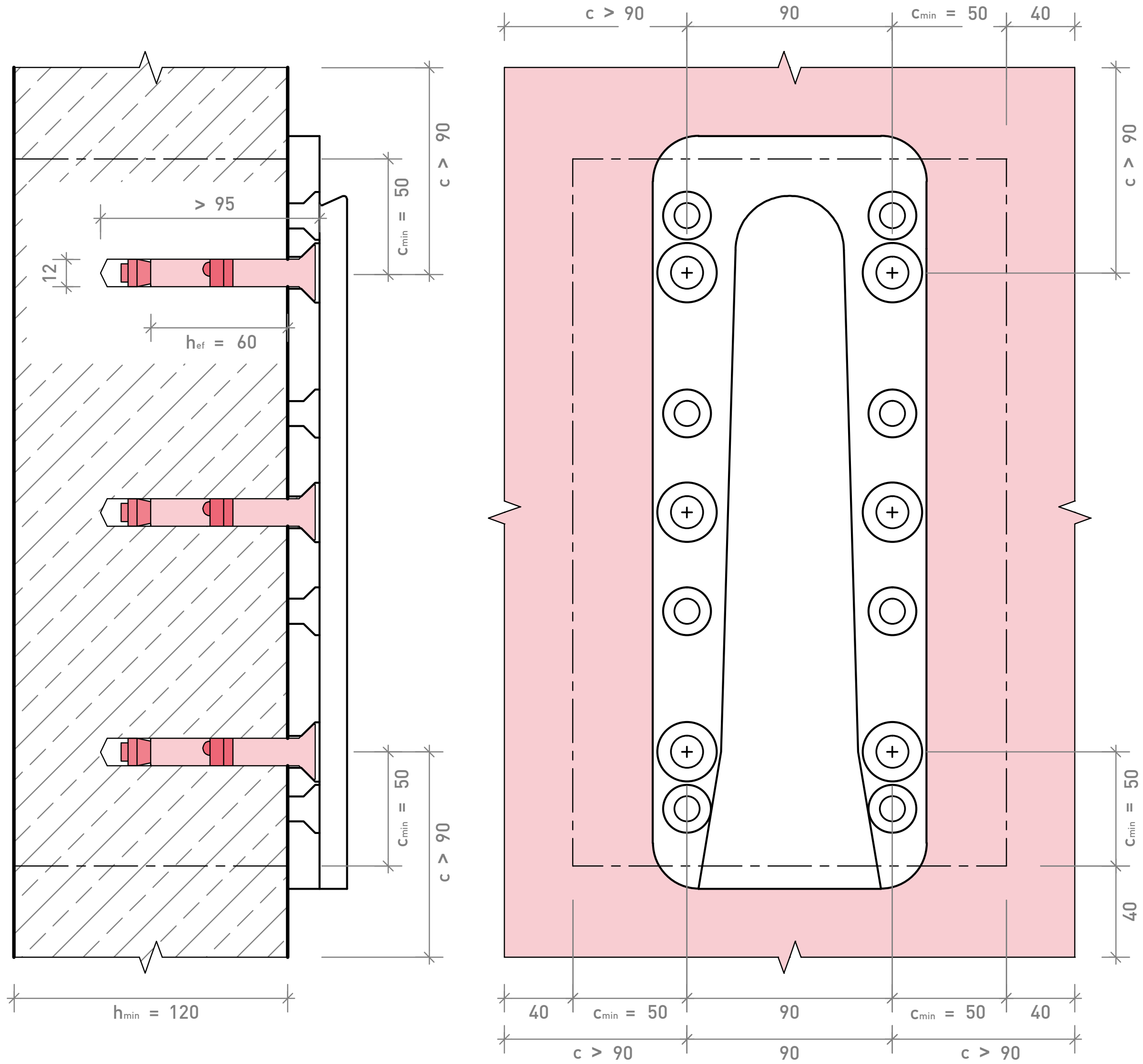
HILTI inner thread sleeves, HIS-N/RN M10 x 110 mm with injection mortar, HIT-RE 500-SD		
minimum component thickness h_{min}	(mm)	150
minimum axis spacing s_{min}	(mm)	45
minimum edge distance c_{min}	(mm)	45
effective anchoring depth h_{ef}	(mm)	110
characteristic axis spacing $s_{cr,N}$	(mm)	330
characteristic edge distance $c_{cr,N}$	(mm)	165

5.3.4 Minimum distance, CS Series XL with HECO MMS-F 10 x 80 mm



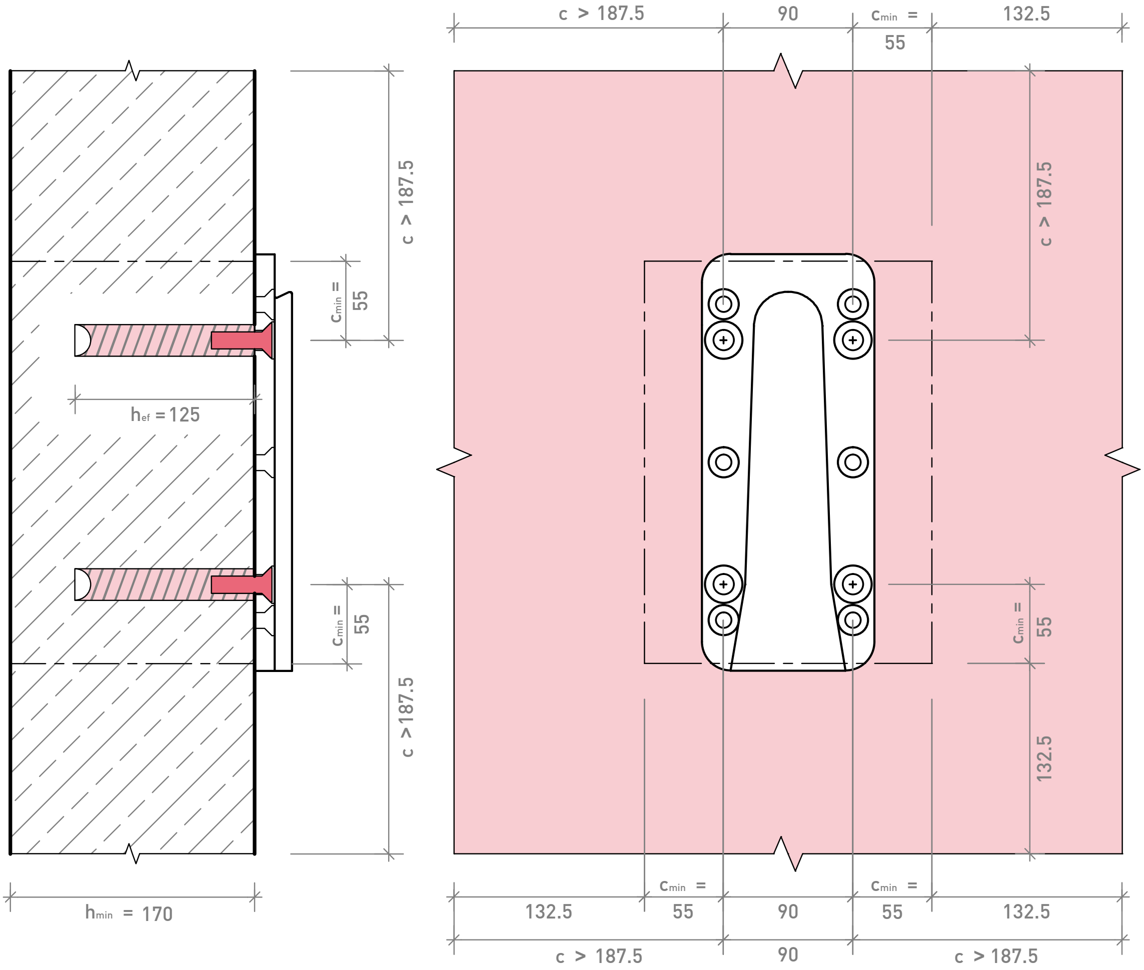
HECO MMS-F 10 x 80 mm		
minimum component thickness h_{min}	(mm)	115
minimum axis spacing s_{min}	(mm)	50
minimum edge distance c_{min}	(mm)	50
effective anchoring depth h_{ef}	(mm)	47.5
characteristic axis spacing $s_{cr,N}$	(mm)	142.5
characteristic edge distance $c_{cr,N}$	(mm)	72
characteristic axis spacing (cracks) $s_{cr,cp}$	(mm)	142.5
characteristic edge distance (cracks) $c_{cr,sp}$	(mm)	72

5.3.5 Minimum distance, CS Series XL with HL anchor FH II SK 12/15



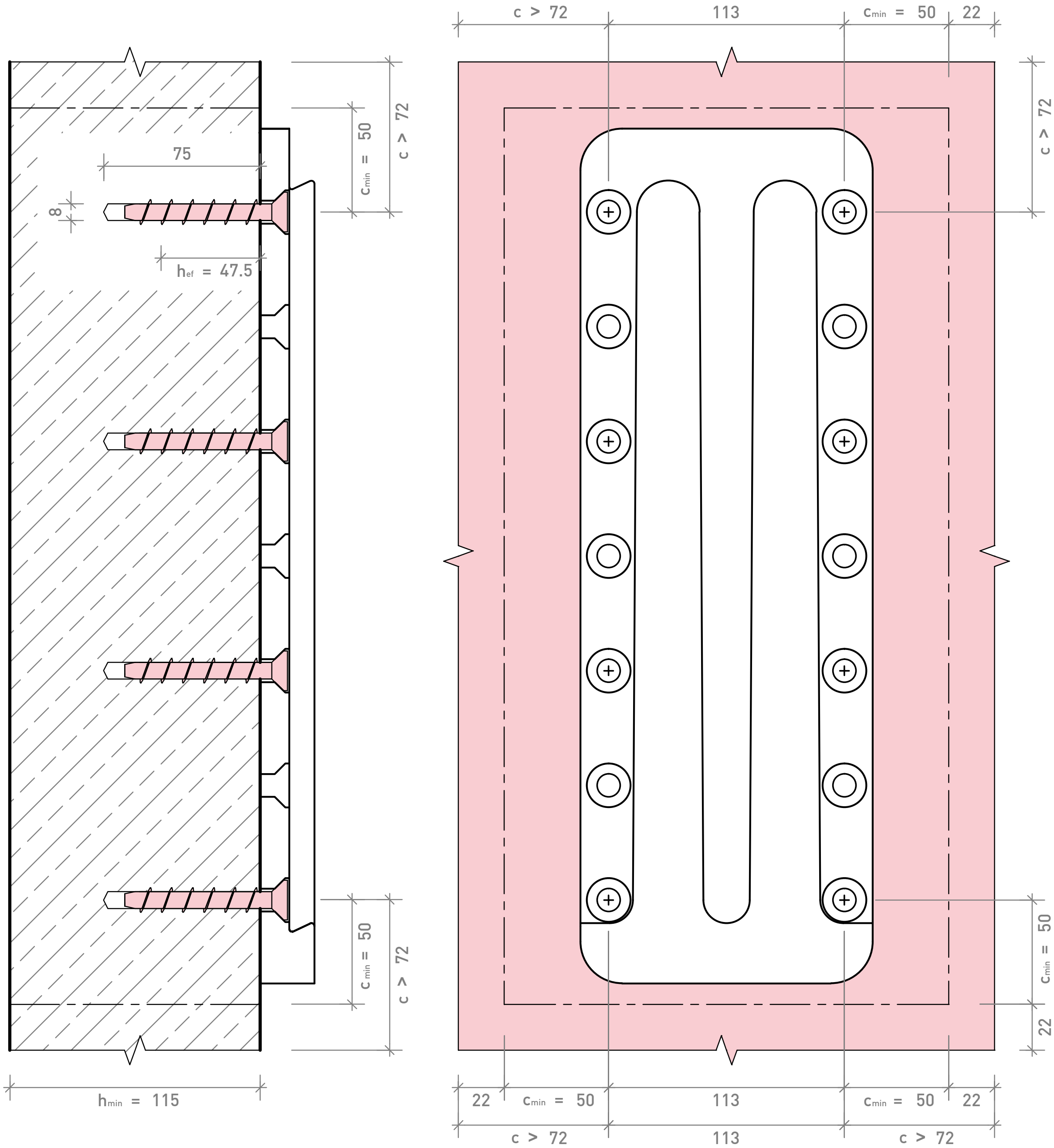
FISCHER High-performance anchor, FH II SK 12/15		
minimum component thickness h_{min}	(mm)	120
minimum axis spacing s_{min}	(mm)	50
minimum edge distance c_{min}	(mm)	50
effective anchoring depth h_{ef}	(mm)	60
characteristic axis spacing $s_{cr,N}$	(mm)	180
characteristic edge distance $c_{cr,N}$	(mm)	90
characteristic axis spacing (cracks) $s_{cr,cp}$	(mm)	300
characteristic edge distance (cracks) $c_{cr,sp}$	(mm)	150

5.3.6 Minimum distance, CS Series XL with inner thread sleeves, M12, from HILTI



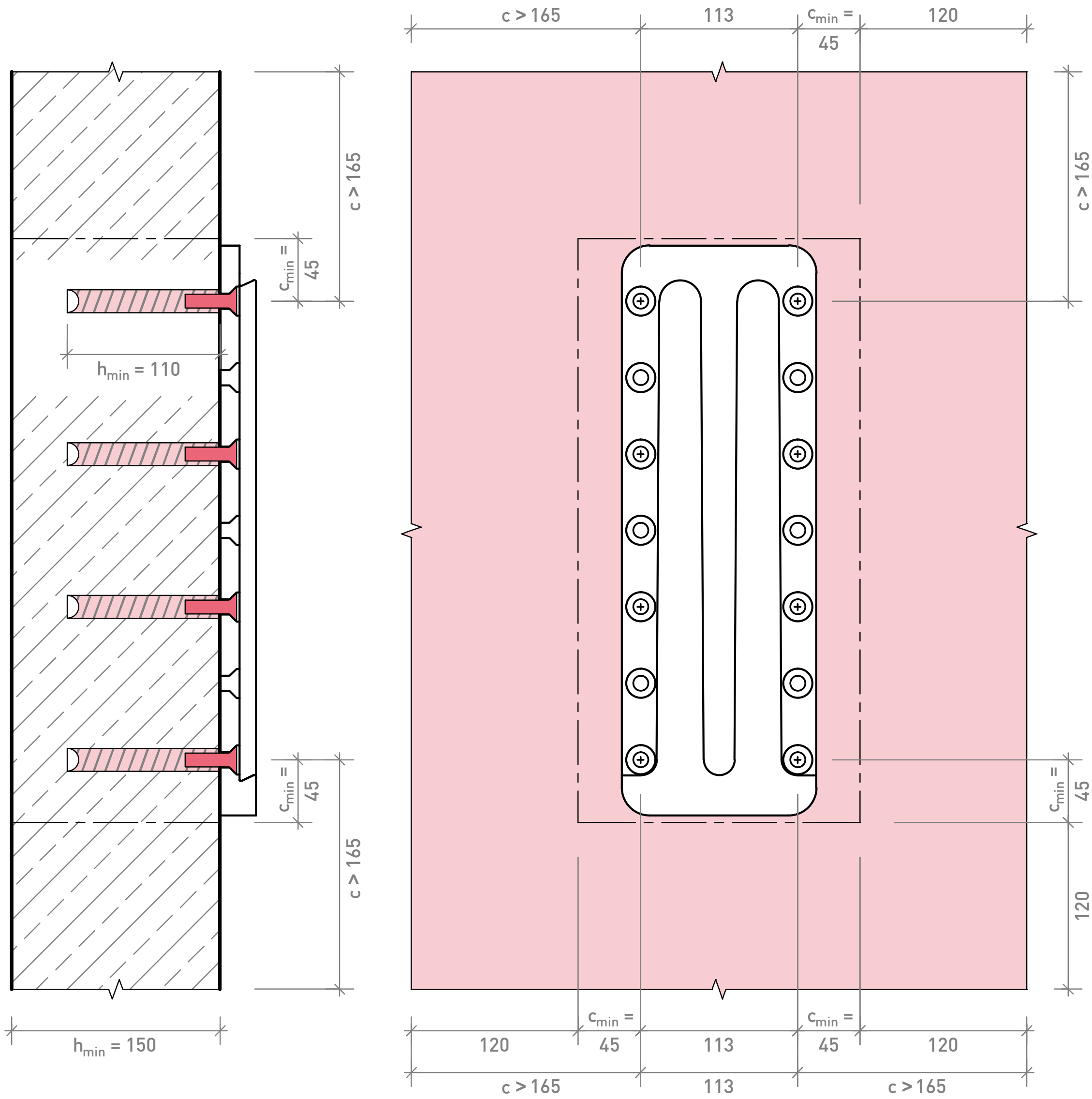
HILTI inner thread sleeves HIS-N/RN M12 x 125 mm with injection mortar HIT-RE 500-SD		
minimum component thickness h_{min}	(mm)	170
minimum axis spacing s_{min}	(mm)	55
minimum edge distance c_{min}	(mm)	55
effective anchoring depth h_{ef}	(mm)	125
characteristic axis spacing $s_{cr,N}$	(mm)	375
characteristic edge distance $c_{cr,N}$	(mm)	187.5

5.3.7 Minimum distance, CS Series XXL with HECO MMS-F 10 x 80 mm



HECO MMS-F 10 x 80 mm		
minimum component thickness h_{min}	(mm)	115
minimum axis spacing s_{min}	(mm)	50
minimum edge distance c_{min}	(mm)	50
effective anchoring depth h_{ef}	(mm)	47.5
characteristic axis spacing $s_{cr,N}$	(mm)	142.5
characteristic edge distance $c_{cr,N}$	(mm)	72
characteristic axis spacing (cracks) $s_{cr,cp}$	(mm)	142.5
characteristic edge distance (cracks) $c_{cr,sp}$	(mm)	72

5.3.8 Minimum distance, CS Series XXL with inner thread sleeves M10 from HILTI



HILTI inner thread sleeves HIS-N/RN M10 x 110 mm with injection mortar HIT-RE 500-SD		
minimum component thickness h_{min}	(mm)	150
minimum axis spacing s_{min}	(mm)	45
minimum edge distance c_{min}	(mm)	45
effective anchoring depth h_{ef}	(mm)	110
characteristic axis spacing $s_{cr,N}$	(mm)	330
characteristic edge distance $c_{cr,N}$	(mm)	165

5.4 Features for the SHERPA CS Series M to XXL

5.4.1 Features for the SHERPA CS Series M

Connector type		M 15 CS	M 20 CS	M 25 CS	M 30 CS	M 40 CS
Geometric data QR code for PDF						
Width	[mm]	60				
Height	[mm]	90	110	130	150	170
Thickness	[mm]	20				
Minimum wood cross-section						
Secondary beam	[mm]	80/120	80/140	80/160	80/180	80/200
Wood connector, SHERPA special screws, 6.5 x 65 mm						
Helical screws						
Secondary beam		4	6	8	10	12
Torque screws						
Secondary beam		5				
Total		9	11	13	15	17
Steel-reinforced concrete connector with HECO MMS-F 7.5 x 60 mm						
Main beam		4	4	4	6	6
Steel connector with steel construction screw M6 4.6 or 8.8 with countersunk screw as per DIN 7991						
Main beam		4	4	4	6	6

This information applies to:

- » Concrete as the anchor foundation, strength class C20/25 to C50/60.
- » Solid wood consisting of softwood with a minimum strength class of C24 as per EN 338 or EN 14081-1
- » All glulam strength classes as per EN 1194 or EN 14080
- » All laminated veneer lumber (LVL) as per EN 14374
- » Components with glulam similar to solid wood (dual and triple beams) as per prEN 14080.
- » Plywood board as per European Technical Approvals or national provisions.
- » Strand lumber (e.g. clamped strip wood - intralam, clamped strip wood - paralam) as per European Technical Approvals or national provisions

Solid wood may have a wood moisture content of at most 18% when manufactured, and must be separated from the core at least at the grain ends.
SHERPA may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1, and withstand the following corrosion stress on the screw coating:

- » Yellow zinc plated, moderate stress – corrosive categories C1, C2 and C3 as per EN ISO 12944-2.
- » Zinc-nickel plated, very severe stress – corrosive categories C1 to C5 M long as per EN ISO 12944-2.

Moisture penetration due to regular condensate water formation must be prevented.
A separation layer or a coating must be provided against possible contact corrosion between the connector back and the steel or concrete surface.
The ratings apply under the assumption that the characteristic edge distances as well as the minimum component thickness for the respective connector materials are not undercut. Furthermore, reinforcement limiting the crack widths to w_k = 0.3 mm must be fitted.

Any mortar layer, if present, to compensate for unevenness between the concrete and the SHERPA connector may be greater than the standard in ETAG 001" of 3 mm (as per CEN/TS 1992-4 half anchor bolt diameter). The compression strength of the mortar layer must therefore be at least 30 N/mm².

If these conditions are not fulfilled, the carrying capabilities must be determined as per ETAG 001, Appendix C.

$R_{2,d}$ Rated values for carrying capability $R_{2,d}$ with central stress in the insertion direction in kN

For HECO MMS-F 7.5 x 60 mm as per ETA-05/0010 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	M 15 CS		M 20 CS		M 25 CS		M 30 CS		M 40 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	11.0		12.4		13.8		15.2		16.6	
C 25/30	12.1		13.6		15.1		16.6		18.1	
C 30/37	13.4		15.1		16.8		18.5		20.1	
C 35/45	14.8	9.5	16.7	15.1	18.4	17.8	20.4	20.5	22.2	25.7
C 40/50	15.6		17.6		18.4		21.5		23.4	
C 45/55	16.4		18.4		18.4		22.5		24.5	
C 50/60	17.1		18.4		18.4		23.5		25.6	

For steel construction screws M6 4.6 or 8.8 with countersunk screws as per DIN 7991 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	M 15 CS		M 20 CS		M 25 CS		M 30 CS		M 40 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
4.6	15.4	9.5	15.4	15.1	15.4	17.8	23.15	20.5	23.15	25.7
8.8	30.8		30.8		30.8		46.3		46.3	

$R_{1,d}$ Rated values for carrying capability $R_{1,d}$ with central stress in the direction of the secondary beam longitudinal axis in kN

For HECO MMS-F 7.5 x 60 mm as per ETA-05/0010 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	M 15 CS		M 20 CS		M 25 CS		M 30 CS		M 40 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	9.2		10.3		11.1		12.6		13.8	
C 25/30	10.1		11.1		11.1		13.8		15.1	
C 30/37	11.2		12.6		13.6		15.4		16.8	
C 35/45	12.3	6.7	13.6	10.6	13.6	12.5	17.0	14.3	18.5	18.0
C 40/50	13.0		14.6		15.7		17.9		19.5	
C 45/55	13.6		15.3		15.7		18.7		20.5	
C 50/60	14.2		16.0		17.2		19.6		21.4	

For steel construction screws M6 4.6 or 8.8 with countersunk screws as per DIN 7991 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	M 15 CS		M 20 CS		M 25 CS		M 30 CS		M 40 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
4.6	16	6.7	16	10.6	16	12.5	24	14.3	24	18.0
8.8	32		32		32		48		48	

5.4.2 Features for the SHERPA CS Series L

Connector type		L 30 CS	L 40 CS	L 50 CS	L 60 CS	L 80 CS
Geometric data QR code for PDF						
Width	[mm]			80		
Height	[mm]	150	170	210	250	290
Thickness	[mm]			29		
Minimum wood cross-section						
Secondary beam	[mm]	100/180	100/200	100/240	100/280	100/320
Wood connector, SHERPA special screws, 8.0 x 100 mm						
Helical screws						
Secondary beam		4	6	8	10	12
Torque screws						
Secondary beam				5		
Total		9	11	13	15	17
Steel-reinforced concrete connector with HECO MMS-F 10 x 80 mm						
Main beam		4	4	6	6	6
Steel-reinforced concrete connector with HILTI inner thread sleeves M10 and HIT-RE 500-SD injection mortar						
Main beam		4	4	6	6	6
Steel connector with steel construction screw M6 4.6 or 8.8 with countersunk screw as per DIN 7991						
Main beam		4	4	6	6	6

This information applies to:

- » Concrete as the anchor foundation, strength class C20/25 to C50/60.
- » Solid wood as softwood with a minimum strength class of C24 as per EN 338 or EN 14081-1
- » All glulam strength classes as per EN 1194 or EN 14080
- » All laminated veneer lumber (LVL) as per EN 14374
- » Components with glulam similar to solid wood (dual and triple beams) as per prEN 14080.
- » Plywood board as per European technical approvals or national provisions.
- » Strand lumber (e.g. clamped strip wood - intralam, clamped strip wood - paralam) as per European technical approvals or national provisions

Solid wood may have a wood moisture content of at most 18% when manufactured, and must be separated from the core at least at the grain ends.
SHERPA may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1, and withstand the following corrosion stress on the screw layers:

- » Yellow zinc plated, moderate stress - corrosive categories C1, C2 and C3 as per EN ISO 12944-2.
- » Zinc-nickel plated, very severe stress – corrosive categories C1 to C5 M long as per EN ISO 12944-2.

Moisture penetration due to regular condensate water formation must be prevented.
A separation layer or a coating must be provide against possible contact corrosion between the connector back and the steel or concrete surface.

The ratings apply under the assumption that the characteristic edge distances as well as the minimum component thickness for the respective connector materials are not undercut.

Furthermore, reinforcement must be fitted to limit the crack widths to w_k = 0.3 mm.
Any mortar layer, if present, to even out unevenness between the concrete and the SHERPA connector must be greater than the standard in ETAG 001" 3 mm (as per CEN/TS 1992-4 half anchor bolt diameter). The compression strength of the mortar layer must therefore be at least 30 N/mm².

If these conditions are not fulfilled, the support capabilities are to be determined as per ETAG 001, Appendix C.

$R_{2,d}$ **Rated values for carrying capability $R_{2,d}$ with a wood-steel-reinforced concrete connection with central stress in the insertion direction in kN**

For HECO MMS-F 10 x 80 mm as per ETA-05/0010 and
glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	L 30 CS		L 40 CS		L 50 CS		L 60 CS		L 80 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	36.1		39.2		45.4		51.6		57.8	
C 25/30	39.5		42.7		49.7		56.5		63.3	
C 30/37	42.7		42.7		55.2		62.8		64.0	
C 35/45	42.7	23.1	42.7	28.3	60.9	33.3	64.0	43.1	64.0	52.7
C 40/50	42.7		42.7		64.0		64.0		64.0	
C 45/55	42.7		42.7		64.0		64.0		64.0	
C 50/60	42.7		42.7		64.0		64.0		64.0	

For inner thread sleeves (HILTI HIS-N/RN M10x110) with injection mortar (HILTI HIT-RE 500-SD) and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN

Connector type	L 30 CS		L 40 CS		L 50 CS		L 60 CS		L 80 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	73.6		73.6		110.4		110.4		110.4	
C 25/30	73.6		73.6		110.4		110.4		110.4	
C 30/37	73.6		73.6		110.4		110.4		110.4	
C 35/45	73.6	23.1	73.6	28.3	110.4	33.3	110.4	43.1	110.4	52.7
C 40/50	73.6		73.6		110.4		110.4		110.4	
C 45/55	73.6		73.6		110.4		110.4		110.4	
C 50/60	73.6		73.6		110.4		110.4		110.4	

$R_{2,d}$ **Rated values for carrying capability $R_{2,d}$ with a wood-steel connection with central stress in the insertion direction in kN**

For steel construction screws M10 4.6 or 8.8 with countersunk screws as per DIN 7991 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	L 30 CS		L 40 CS		L 50 CS		L 60 CS		L 80 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
4.6	44.5	23.1	44.5	28.3	66.8	33.3	66.8	43.1	66.8	52.7
8.8	89		89		133.6		133.6		133.6	

$R_{1,d}$ **Rated values for carrying capability $R_{1,d}$ of a wood-steel-reinforced concrete connection in the direction of the secondary beam longitudinal axis in kN**

For HECO MMS-F 10 x 80 mm as per ETA-05/0010 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	L 30 CS		L 40 CS		L 50 CS		L 60 CS		L 80 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	15.0		16.3		18.9		21.5		24.1	
C 25/30	16.5		17.9		20.7		23.5		26.4	
C 30/37	18.3		19.9		23.0		26.2		29.3	
C 35/45	20.2	16.3	21.9	19.8	25.4	23.4	28.8	30.3	32.3	37.1
C 40/50	21.3		23.1		26.7		30.4		34.1	
C 45/55	22.3		24.2		28.0		31.9		35.7	
C 50/60	23.3		25.3		29.3		33.3		37.3	

For inner thread sleeves (HILTI HIS-N/RN M10x110) with injection mortar (HILTI HIT-RE 500-SD) and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN

Connector type	L 30 CS		L 40 CS		L 50 CS		L 60 CS		L 80 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	29.5		30.9		33.8		36.6		39.9	
C 25/30	31.3		32.6		37.0		40.3		43.1	
C 30/37	33.1		34.4		40.5		43.4		46.2	
C 35/45	34.4	16.3	35.8	19.8	43.0	23.4	45.9	30.3	48.8	37.1
C 40/50	35.2		36.5		44.2		47.1		50.0	
C 45/55	35.8		37.0		45.2		48.1		51.0	
C 50/60	36.3		37.5		46.0		49.0		51.9	

$R_{1,d}$ **Rated values for carrying capability $R_{1,d}$ of a wood-steel connection in the direction of the secondary beam longitudinal axis in kN**

For steel construction screws M10 4.6 or 8.8 with countersunk screws as per DIN 7991 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	L 30 CS		L 40 CS		L 50 CS		L 60 CS		L 80 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
4.6	46.8	16.3	46.8	19.8	70.2	23.4	70.2	30.3	70.2	37.1
8.8	93.6		93.6		140.4		140.4		140.4	

5.4.3 Features for the SHERPA CS Series XL

Connector type		XL 55 CS	XL 70 CS	XL 80 CS	XL 100 CS	XL 120 CS
Geometric data QR code for PDF						
Width	[mm]	120				
Height	[mm]	250	290	330	370	410
Thickness	[mm]	29				
Minimum wood cross-section						
Secondary beam	[mm]	140/280	140/320	140/360	140/400	140/440
SHERPA wood connection, special screws, 8 x 160 mm or optional 8 x 120/140/180 mm						
Helical screws						
Secondary beam		4	6	8	8	10
Torque screws						
Secondary beam		6				
Total		10	12	14	14	16
Steel-reinforced concrete connector with HECO MMS-F 10 x 80 mm						
Main beam		6	6	8	8	8
Steel-reinforced concrete connection with FISCHER high-performance anchors, FH-II SK 12/15						
Main beam		4	4	6	6	6
Steel-reinforced concrete connector with HILTI inner thread sleeves M12 and HIT-RE 500-SD injection mortar						
Main beam		4	4	6	6	6
Steel connector with steel construction screw M6 4.6 or 8.8 with countersunk screw as per DIN 7991						
Main beam		6	6	8	8	8

Connector type		XL 140 CS	XL 170 CS	XL 190 CS	XL 250 CS
Geometric data QR code for PDF					
Width	[mm]	120			
Height	[mm]	450	490	530	610
Thickness	[mm]	29			
Minimum wood cross-section					
Secondary beam	[mm]	140/480	140/520	140/560	140/640
SHERPA wood connection, special screws, 8 x 160 mm or optional 8 x 120/140/180 mm					
Helical screws					
Secondary beam		12	14	16	20
Torque screws					
Secondary beam		6			
Total		18	20	22	26
Steel-reinforced concrete connector with HECO MMS-F 10 x 80 mm					
Main beam		8	8	10	10
Steel-reinforced concrete connection with FISCHER high-performance anchors, FH-II SK 12/15					
Main beam		6	6	8	8
Steel-reinforced concrete connector with HILTI inner thread sleeves M12 and injection mortar					
Main beam		6	6	8	8
Steel connector with steel construction screw M6 4.6 or 8.8 with countersunk screw as per DIN 7991					
Main beam		8	8	10	10

This information applies to:

» Concrete as the anchor foundation, strength class C20/25 to C50/60.

» Solid wood consisting of softwood with a minimum strength class of C24 as per EN 338 or EN 14081-1

» All glulam strength classes as per EN 1194 or EN 14080

» All laminated veneer lumber (LVL) as per EN 14374

» Components with glulam similar to solid wood (dual and triple beams) as per prEN 14080.

» Plywood board as per European Technical Approvals or national provisions.

» Strand lumber (e.g. clamped strip wood – intralam, clamped strip wood - paralam) as per European Technical Approvals or national provisions

Solid wood may have a wood moisture content of at most 18% when manufactured, and must be separated from the core at least at the grain ends.
SHERPA may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1, and withstand the following corrosion stress on the screw coating:

» Yellow zinc plated, moderate stress – corrosive categories C1, C2 and C3 as per EN ISO 12944-2.

» Zinc-nickel plated, very severe stress – corrosive categories C1 to C5 M long as per EN ISO 12944-2.

Moisture penetration due to regular condensate water formation must be prevented.
A separation layer or a coating must be provide against possible contact corrosion between the connector back and the steel or concrete surface.

The ratings apply under the assumption that the characteristic edge distances as well as the minimum component thickness for the respective connector materials are not undercut.
Furthermore, reinforcement must be fitted to limit the crack widths to w_k = 0.3 mm.
Any mortar layer, if present, to compensate unevenness between the concrete and the SHERPA connector may be greater than the standard in ETAG 001" of 3 mm (as per CEN/TS 1992-4 half anchor bolt diameter). The compression strength of the mortar layer must therefore be at least 30 N/mm².

If these conditions are not fulfilled, the carrying capabilities are to be determined as per ETAG 001, Appendix C.

$R_{2,d}$ Rated values for carrying capability $R_{2,d}$ with a wood-steel-reinforced concrete connection with central stress in the insertion direction in kN

For HECO MMS-F 10 x 80 mm as per ETA-05/0010 and
glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XL 55 CS		XL 70 CS		XL 80 CS		XL 100 CS		XL 120 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	58.0		64.0		72.4		79.6		85.3	
C 25/30	63.6		64.0		79.3		85.3		85.3	
C 30/37	64.0		64.0		85.3		85.3		85.3	
C 35/45	64.0	41.92	64.0	51.2	85.3	60.4	85.3	69.4	85.3	87.0
C 40/50	64.0		64.0		85.3		85.3		85.3	
C 45/55	64.0		64.0		85.3		85.3		85.3	
C 50/60	64.0		64.0		85.3		85.3		85.3	

For HECO MMS-F 10 x 80 mm as per ETA-05/0010 and
glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XL 140 CS		XL 170 CS		XL 190 CS		XL 250 CS	
		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	85.3		85.3		106.7		106.7	
C 25/30	85.3		85.3		106.7		106.7	
C 30/37	85.3		85.3		106.7		106.7	
C 35/45	85.3	95.6	85.3	112.6	106.7	129.4	106.7	162.2
C 40/50	85.3		85.3		106.7		106.7	
C 45/55	85.3		85.3		106.7		106.7	
C 50/60	85.3		85.3		106.7		106.7	

For FISCHER high performance anchors, FH II-SK 12/15 mm as per ETA-07/0025 and
glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} /γ_M = 0.80 /1.25) and in kN

Connector type	XL 55 CS		XL 70 CS		XL 80 CS		XL 100 CS		XL 120 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	51.9		58.6		65.3		71.9		78.6	
C 25/30	56.8		64.2		71.5		78.8		86.1	
C 30/37	63.1		71.2		79.4		87.5		95.7	
C 35/45	69.6	41.92	78.6	51.2	87.5	60.4	96.5	69.4	105.5	87.0
C 40/50	73.4		82.8		92.3		101.7		111.2	
C 45/55	76.9		86.9		96.8		106.7		116.6	
C 50/60	80.4		90.7		101.1		111.5		121.8	

Connector type	XL 140 CS		XL 170 CS		XL 190 CS		XL 250 CS	
		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	85.3		90.4		98.7		111.7	
C 25/30	93.5		99.0		108.1		122.3	
C 30/37	103.8		109.9		120.1		135.8	
C 35/45	114.5	95.6	121.2	112.6	132.4	129.4	149.8	162.2
C 40/50	120.7		127.8		139.6		157.9	
C 45/55	126.6		134.0		146.4		165.6	
C 50/60	132.2		140.0		152.9		173.0	

$R_{2,d}$ Rated values for carrying capability $R_{2,d}$ of a wood-steel-reinforced concrete connection with central stress in the insertion direction in kN

For inner thread sleeves (HILTI HIS-N/RN M12x125) with injection mortar (HILTI) and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XL 55 CS		XL 70 CS		XL 80 CS		XL 100 CS		XL 120 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	104.0		104.0		129.8		138.6		147.6	
C 25/30	104.0		104.0		142.2		151.9		156.0	
C 30/37	104.0		104.0		156.0		156.0		156.0	
C 35/45	104.0	41.92	104.0	51.2	156.0	60.4	156.0	69.4	156.0	87.0
C 40/50	104.0		104.0		156.0		156.0		156.0	
C 45/55	104.0		104.0		156.0		156.0		156.0	
C 50/60	104.0		104.0		156.0		156.0		156.0	

For inner thread sleeves (HILTI HIS-N/RN M12x125) with injection mortar (HILTI) and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XL 140 CS		XL 170 CS		XL 190 CS		XL 250 CS	
		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	156.0		156.0		174.1		190.9	
C 25/30	156.0		156.0		190.8		208.0	
C 30/37	156.0		156.0		208.0		208.0	
C 35/45	156.0	95.6	156.0	112.6	208.0	129.4	208.0	162.2
C 40/50	156.0		156.0		208.0		208.0	
C 45/55	156.0		156.0		208.0		208.0	
C 50/60	156.0		156.0		208.0		208.0	

$R_{2,d}$ Rated values for carrying capability $R_{2,d}$ of a wood-steel connection with central stress in the insertion direction in kN

For steel construction screws M10 4.6 or 8.8 with countersunk screws as per DIN 7991 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XL 55 CS		XL 70 CS		XL 80 CS		XL 100 CS		XL 120 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
4.6	66.8	41.92	66.8	51.2	89.0	60.4	89.0	69.4	89.0	87.0
8.8	133.6		133.6		178.2		178.2		178.2	

Connector type	XL 140 CS		XL 170 CS		XL 190 CS		XL 250 CS	
		GL 24h		GL 24h		GL 24h		GL 24h
4.6	89.0	95.6	89.0	112.6	111.4	129.4	111.4	162.2
8.8	178.2		178.2		222.7		222.7	

$R_{1,d}$ Rated values for carrying capability $R_{1,d}$ with stress in the direction of the secondary beam longitudinal axis in kN

For HECO MMS-F 10 x 80 mm as per ETA-05/0010 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XL 55 CS		XL 70 CS		XL 80 CS		XL 100 CS		XL 120 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	24.2		27.2		30.2		33.2		36.2	
C 25/30	26.5		29.8		33.1		36.3		39.6	
C 30/37	29.4		33.1		36.7		40.4		44.0	
C 35/45	32.4	39.9	36.5	39.9	40.5	39.9	44.5	39.9	48.5	39.9
C 40/50	34.2		38.4		42.7		46.9		51.2	
C 45/55	35.9		40.3		44.8		49.2		53.7	
C 50/60	37.5		42.1		46.7		51.4		56.0	

Connector type	XL 140 CS		XL 170 CS		XL 190 CS		XL 250 CS	
		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	39.2		40.0		45.2		50.0	
C 25/30	40.0		40.0		49.5		59.0	
C 30/37	47.7		48.8		54.9		61.0	
C 35/45	48.8	39.9	48.8	39.9	60.6	39.9	61.0	39.9
C 40/50	55.4		56.4		63.9		70.5	
C 45/55	56.4		56.4		67.0		70.5	
C 50/60	60.7		62.0		69.6		77.5	

For FISCHER high performance anchors, FH II-SK 12/15 mm as per ETA-07/0025 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} /γ_M = 0.80 /1.25) and in kN

Connector type	XL 55 CS		XL 70 CS		XL 80 CS		XL 100 CS		XL 120 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	26.7		26.7		36.3		40.0		40.0	
C 25/30	26.7		26.7		39.7		40.0		40.0	
C 30/37	32.5		32.5		44.0		48.6		48.8	
C 35/45	32.5	39.9	32.5	39.9	48.6	39.9	48.8	39.9	48.8	39.9
C 40/50	37.6		37.6		51.3		56.4		56.4	
C 45/55	37.6		37.6		53.8		56.4		56.4	
C 50/60	41.3		41.3		56.2		61.9		61.9	

Connector type	XL 140 CS		XL 170 CS		XL 190 CS		XL 250 CS	
		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	40.0		40.0		53.3		53.3	
C 25/30	40.0		40.0		53.3		53.3	
C 30/37	48.8		48.8		65.1		65.1	
C 35/45	48.8	39.9	48.8	39.9	65.1	39.9	65.1	39.9
C 40/50	56.4		56.4		75.2		75.2	
C 45/55	56.4		56.4		75.2		75.2	
C 50/60	62.0		62.0		82.1		82.1	

$R_{1,d}$ Rated values for carrying capability $R_{1,d}$ with stress in the direction of the secondary beam longitudinal axis in kN

For inner thread sleeves (HILTI HIS-N/RN M12x125) with injection mortar (HILTI) and Glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN

Connector type	XL 55 CS		XL 70 CS		XL 80 CS		XL 100 CS		XL 120 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	40.0		43.2		46.3		49.5		52.7	
C 25/30	43.8		47.3		50.8		54.2		57.8	
C 30/37	48.5		52.2		56.4		60.2		64.1	
C 35/45	51.4	39.9	55.0	39.9	61.8	39.9	65.7	39.9	69.5	39.9
C 40/50	52.7		56.4		64.3		68.2		72.1	
C 45/55	53.9		57.5		66.4		70.3		74.2	
C 50/60	54.9		58.4		68.2		72.1		76.0	

Connector type	XL 140 CS		XL 170 CS		XL 190 CS		XL 250 CS	
		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	55.9		59.0		62.2		68.2	
C 25/30	61.2		64.7		68.1		74.7	
C 30/37	67.9		71.8		75.2		82.9	
C 35/45	73.3	39.9	77.1	39.9	83.4	39.9	91.5	39.9
C 40/50	75.9		79.6		87.9		95.8	
C 45/55	78.0		81.8		91.5		99.1	
C 50/60	79.8		83.8		94.2		101.9	

$R_{1,d}$ Rated values for carrying capability $R_{1,d}$ with stress in the direction of the secondary beam longitudinal axis in kN

For steel construction screws M10 4.6 or 8.8 with countersunk screws as per DIN 7991 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XL 55 CS		XL 70 CS		XL 80 CS		XL 100 CS		XL 120 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
4.6	70.2	39.9	70.2	39.9	93.6	39.9	93.6	39.9	93.6	39.9
8.8	140.4		140.4		187.2		187.2		187.2	

Connector type	XL 140 CS		XL 170 CS		XL 190 CS		XL 250 CS	
		GL 24h		GL 24h		GL 24h		GL 24h
4.6	93.6	39.9	93.6	39.9	117.0	39.9	117.0	39.9
8.8	187.2		187.2		234.0		234.0	

5.4.4 Features for the SHERPA CS Series XXL

Connector type		**XXL 170 CS**	**XXL 190 CS**	**XXL 220 CS**	**XXL 250 CS**	**XXL 280 CS**	**XXL 300 CS**
Geometric data QR code for PDF							
Width	[mm]	140					
Height	[mm]	410	450	490	530	570	610
Thickness	[mm]	29					
Minimum wood cross-section							
Secondary beam	[mm]	160/440	160/480	160/520	160/560	160/600	160/640
SHERPA wood connection, special screws, 8 x 160 mm or optional 8 x 120/140/180 mm							
Helical screws							
Secondary beam		15	18	21	24	24	27
Torque screws							
Secondary beam		6					
Total		21	24	27	30	30	33
Steel-reinforced concrete connector with HECO MMS-F 10 x 80 mm							
Main beam		8	8	10	10	10	10
Steel-reinforced concrete connector with HILTI inner thread sleeves M10 and HIT-RE 500-SD injection mortar							
Main beam		8	8	10	10	10	10
Steel connector with steel construction screw M6 4.6 or 8.8 with countersunk screw as per DIN 7991							
Main beam		14	14	18	18	18	18

This information applies to:

» Concrete as the anchor foundation, strength class C20/25 to C50/60.

» Solid wood consisting of softwood with a minimum strength class of C24 as per EN 338 or EN 14081-1

» All glulam strength classes as per EN 1194 or EN 14080

» All laminated veneer lumber (LVL) as per EN 14374

» Components with glulam similar to solid wood (dual and triple beams) as per prEN 14080.

» Plywood board as per European Technical Approvals or national provisions.

» Strand lumber (e.g. clamped strip wood - intralam, clamped strip wood - paralam) as per European Technical Approvals or national provisions

Solid wood may have a wood moisture content of at most 18% when manufactured, and must be separated from the core at least at the grain ends.
SHERPA may only be used in climactic conditions in use classes 1 and 2 as per EN 1995-1-1, and must withstand the following corrosion stress on the screw layers:

» Yellow zinc plated, moderate stress – corrosive categories C1, C2 and C3 as per EN ISO 12944-2.

» Zinc-nickel plated, very severe stress – corrosive categories C1 to C5 M long as per EN ISO 12944-2.

Moisture penetration due to regular condensate water formation must be prevented.
A separation layer or a coating must be provided against possible contact corrosion between the connector back and the steel or concrete surface.

The ratings apply under the assumption that the characteristic edge distances as well as the minimum component thickness for the respective connector materials are not undercut.

Furthermore, reinforcement must be installed to limit the crack widths to w_k = 0.3 mm.

Any mortar layer, if present, to compensate unevenness between the concrete and the SHERPA connector must be greater than the standard in ETAG 001" of 3 mm (as per CEN/TS 1992-4 half anchor bolt diameter). The compression strength of the mortar layer must therefore be at least 30 N/mm².

If these conditions are not fulfilled, the support capabilities are to be determined as per ETAG 001, Appendix C.

$R_{2,d}$ Rated values for carrying capability $R_{2,d}$ with a wood-steel-reinforced concrete connection with central stress in the insertion direction in kN

For HECO MMS-F 10 x 80 mm as per ETA-05/0010 and
glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XXL 170 CS		XXL 190 CS		XXL 220 CS		XXL 250 CS		XXL 280 CS		XXL 300 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	85.3		85.3		106.7		106.7		106.7		106.7	
C 25/30	85.3		85.3		106.7		106.7		106.7		106.7	
C 30/37	85.3		85.3		106.7		106.7		106.7		106.7	
C 35/45	85.3	112.6	85.3	129.4	106.7	145.9	106.7	162.2	106.7	178.4	106.7	194.4
C 40/50	85.3		85.3		106.7		106.7		106.7		106.7	
C 45/55	85.3		85.3		106.7		106.7		106.7		106.7	
C 50/60	85.3		85.3		106.7		106.7		106.7		106.7	

For inner thread sleeves (HILTI HIS-N/RN M10x110) with injection mortar (HILTI HIT-RE 500-SD) and
glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XXL 170 CS		XXL 190 CS		XXL 220 CS		XXL 250 CS		XXL 280 CS		XXL 300 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	147.2		147.2		164.4		173.7		182.8		184.0	
C 25/30	147.2		147.2		180.1		184.0		184.0		184.0	
C 30/37	147.2		147.2		184.0		184.0		184.0		184.0	
C 35/45	147.2	112.6	147.2	129.4	184.0	145.9	184.0	162.2	184.0	178.4	184.0	194.4
C 40/50	147.2		147.2		184.0		184.0		184.0		184.0	
C 45/55	147.2		147.2		184.0		184.0		184.0		184.0	
C 50/60	147.2		147.2		184.0		184.0		184.0		184.0	

$R_{2,d}$ Rated values for carrying capability $R_{2,d}$ with a wood-steel connection with central stress in the insertion direction in kN

For steel construction screws M10 4.6 or 8.8 with countersunk screws as per
DIN 7991 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XXL 170 CS		XXL 190 CS		XXL 220 CS		XXL 250 CS		XXL 280 CS		XXL 300 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
4.6	155.9	112.6	155.9	129.4	200.4	145.9	200.4	162.2	200.4	178.4	200.4	194.4
8.8	311.8		311.8		400.9		400.9		400.9		400.9	

$R_{1,d}$ Rated values for carrying capability $R_{1,d}$ with stress in the direction of the secondary beam longitudinal axis in kN

For HECO MMS-F 10 x 80 mm as per ETA-05/0010 and
glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XXL 170 CS		XXL 190 CS		XXL 220 CS		XXL 250 CS		XXL 280 CS		XXL 300 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	38.9		40.0		44.7		48.0		50.0		50.0	
C 25/30	40.0		40.0		49.0		50.0		50.0		50.0	
C 30/37	47.3		48.8		54.4		58.4		61.0		61.0	
C 35/45	48.8	39.9	48.8	39.9	60.0	39.9	61.0	39.9	61.0	39.9	61.0	39.9
C 40/50	55.0		56.4		63.2		67.9		70.5		70.5	
C 45/55	56.4		56.4		66.3		70.5		77.5		77.5	
C 50/60	60.3		62.0		69.2		74.3		77.5		77.5	

For inner thread sleeves (HILTI HIS-N/RN M10x110) with injection mortar (HILTI HIT-RE 500-SD) and
glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XXL 170 CS		XXL 190 CS		XXL 220 CS		XXL 250 CS		XXL 280 CS		XXL 300 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
C 20/25	53.2		55.6		58.7		62.0		65.3		65.3	
C 25/30	58.2		60.7		64.3		67.9		71.5		71.5	
C 30/37	64.7		65.4		71.4		75.4		79.4		79.4	
C 35/45	69.5	39.9	69.2	39.9	77.5	39.9	81.1	39.9	84.7	39.9	84.7	39.9
C 40/50	71.7		71.1		79.9		83.6		87.2		87.2	
C 45/55	73.5		72.6		81.9		85.7		89.4		89.4	
C 50/60	75.0		73.9		83.7		87.5		91.2		91.2	

$R_{1,d}$ Rated values for carrying capability $R_{1,d}$ with stress in the direction of the secondary beam longitudinal axis in kN

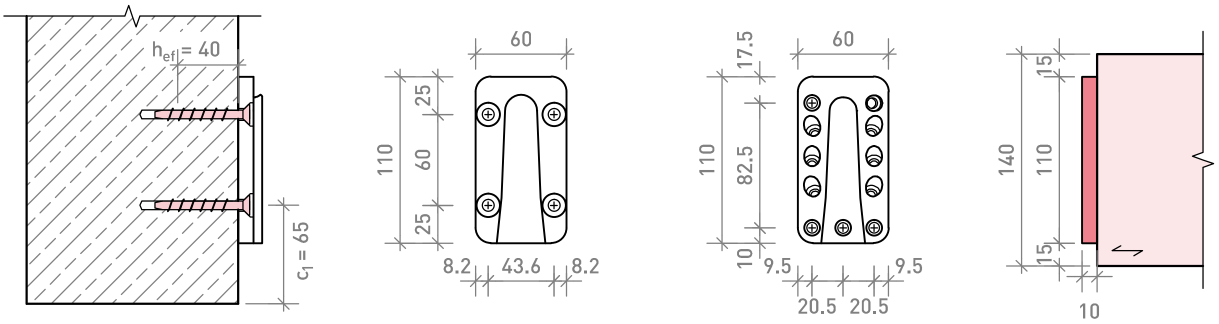
For steel construction screws M10 4.6 or 8.8 with countersunk screws as per
DIN 7991 and glulam GL 24h as per EN 1194 or EN 14080 (k_{mod} / γ_M = 0.80 /1.25) in kN.

Connector type	XXL 170 CS		XXL 190 CS		XXL 220 CS		XXL 250 CS		XXL 280 CS		XXL 300 CS	
		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h		GL 24h
4.6	163.8	39.9	163.8	39.9	210.6	39.9	210.6	39.9	210.6	39.9	210.6	39.9
8.8	327.6		327.6		421.2		421.2		421.2		421.2	

5.5 Features for the SHERPA CS Series M to XXL

5.5.1 Connection to an M 20 CS with HECO MMS-F 7.5 x 60 mm

Overview



Information and boundary conditions

Material	
SHERPA	M 20 CS
Substrate	cracked C 20/25 concrete
Connecting material concrete	4 units, HECO MMS-F 7.5 x 60 mm
Glulam	80/140 mm; Gl 24h
Connecting material wood	11 units, 6.5 x 65 mm

Distances		
Distance to edge c_1	[mm]	65
Distance to edge c_2	[mm]	-
Axis spacing s_1	[mm]	43.5
Axis spacing s_2	[mm]	60
$c_{cr,N} = c_{cr,s\,p}$	[mm]	60
$s_{cr,N} = s_{cr,s\,p}$	[mm]	120
Component thickness h	[mm]	180
Anchoring depth h_{ef}	[mm]	40

Stresses		
Tensile stress $N_{S,d}$	[kN]	2
Transverse stress $V_{S,d}$	[kN]	6.29

Tension resistance

Steel fracture

» Characteristic value for resistance against steel fracture per anchor bolt

$$N_{Rk,s} = 19{,}4\,kN$$

» Partial safety coefficient for steel fracture

$$\gamma_{Ms} = 1{,}4$$

» Rated value for resistance against steel fracture per anchor bolt

$$N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}} = \frac{19,4}{1,4} = 13,9kN$$

» Rated value for carrying capability in the group of anchor bolts, steel fracture failure type

$$N^{g}_{Rd,s} = 4 \cdot 13,9 = 55,6kN$$

Extraction

» Characteristic value for resistance against extraction per anchor bolt

$$N_{Rk,p} = 5kN$$

» Partial safety coefficient for extraction

$$\gamma_{Mp} = 1,8$$

» Rated value for resistance against extraction per anchor bolt

$$N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}} = \frac{5}{1,8} = 2,78kN$$

» Rated value for carrying capability in the group of anchor bolts, pull-out failure type

$$N^{g}_{Rd,p} = 4 \cdot 2,78 = 11,1kN$$

Concrete fracture

» Starting value of characteristic resistance of an individual anchor bolt in cracked concrete

$$N^{0}_{Rk,c} = k \cdot h_{ef}^{1,5} \cdot \sqrt{f_{ck,cube}} = 7,2 \cdot 40^{1,5} \cdot \sqrt{25} = 9,12kN$$

» Ratio of the projected surfaces

Area of the idealised pyramid of an individual anchor bolt

$$A^{0}_{c,N} = s_{cr,N} \cdot s_{cr,N}$$

$$s_{cr,N} = 120mm$$

$$A^{0}_{c,N} = 120 \cdot 120 = 14400mm^2$$

Surface available in the rating situation

$$A_{c,N} = (0,5 \cdot s_{cr,N} + s_1 + 0,5 \cdot s_{cr,N}) \cdot (0,5 \cdot s_{cr,N} + s_1 + 0,5 \cdot s_{cr,N})$$

$$A_{c,N} = (163,5) \cdot (180) = 29430mm^2$$

$$\frac{A_{c,N}}{A^{0}_{c,N}} = \frac{29430}{14400} = 2,04$$

» Factor to consider edges

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{c}{c_{cr,N}} \leq 1,0$$

$$c = \min\{c_1; c_2\} = 65mm \qquad c_{cr,N} = \frac{s_{cr,N}}{2} = 60mm$$

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{65}{60} = 1,025 > 1$$

$$\psi_{s,N} \Rightarrow 1$$

» Factor to consider eccentricity

$$\psi_{ec,N} = \frac{1}{1 + 2 \cdot \frac{e_N}{s_{cr,N}}} \leq 1,0$$

$$e_N = 0 \Rightarrow \psi_{ec,N} = 1,0$$

» Factor to consider dense reinforcement

$$\psi_{re,N} = 0,5 + \frac{h_{ef}}{200} \leq 1,0 \qquad \psi_{re,N} = 0,5 + \frac{40}{200} = 0,7$$

However: Axis spacing of the reinforcement bars < 150 mm

$$\Rightarrow \psi_{re,N} = 1,0$$

» Characteristic resistance of the anchor bolt group with concrete fracture

$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{ec,N} \cdot \psi_{re,N} = 9,12 \cdot 2,04 \cdot 1 \cdot 1 \cdot 1 = 18,6kN$$

» Partial safety coefficient, concrete fracture

$$\gamma_{Mc} = 1,8$$

» Rated value for carrying capability in the group of anchor bolts, concrete fracture failure type

$$N^g_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}} = \frac{18,6}{1,8} = 10,3kN$$

Cracks

Concrete splitting is prevented during installation by adherence to the minimum values specified in the in approval for edge distance, axis spacing and component thickness.

$$h = 180 > h_{min} = 100mm$$

$$s = 58mm > s_{min} = 40mm$$

$$c = 43,5mm > c_{min} = 40mm$$

Splitting under stress

$$c = 43,5mm < c_{cr,sp} = 1,5 \cdot 40 = 60mm$$

$$h = 200mm \geq 2 \cdot h_{ef} = 95mm$$

$$w_k \sim 0,3mm$$

Insufficient distance to edge→ Validate for absence of splitting.

$$N_{Rk,sp} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \cdot \psi_{h,sp}$$

$$s_{cr,sp} = s_{cr,N} = 3 \cdot h_{ef} = 3 \cdot 40 = 120mm$$

$$c_{cr,sp} = c_{cr,sp} = 1{,}5 \cdot h_{ef} = 1{,}5 \cdot 40 = 60mm$$

→ Characteristic edge and axis spacings for the failure type of splitting correspond to the characteristic edge and axis spacings for the concrete fracture failure type.

» Characteristic value for resistance against extraction per anchor bolt

$$N^0_{Rk,c} = 9{,}12kN$$

» Ratio of the projected surfaces

$$\frac{A_{c,N}}{A^0_{c,N}} = 2{,}04$$

» Factor to consider edges

$$\psi_{s,N} = 1{,}0$$

» Factor to consider eccentricities

$$\psi_{ec,N} = 1{,}0$$

» Factor to consider dense reinforcement

$$\psi_{re,N} = 1{,}0$$

» Factor to consider component thickness

$$\psi_{h,sp} = \left(\frac{h}{h_{min}}\right)^{2/3} = \left(\frac{180}{100}\right)^{2/3} = 1{,}48$$

» Characteristic resistance of the anchor bolt group with splitting

$$N_{Rk,sp} = 9{,}12 \cdot 2{,}04 \cdot 1 \cdot 1 \cdot 1 \cdot 1{,}48 = 27{,}5kN$$

» Rated value for resistance in the group of anchor bolts for splitting failure type

$$N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{Mc}} = \frac{27{,}5}{1{,}8} = 15{,}3kN$$

Tension resistance of attachment on the concrete side

The relevant form of failure is concrete fracture This produces a maximum tension resistance of the connection on the concrete side of 10.3 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the direction of the secondary beam lengthwise axis

$$R_{1,k} = 16{,}6kN$$

» Rated values for carrying capability $R_{1,d}$ with stress in the direction of the secondary beam longitudinal axis in kN

$$R_{1,d} = \frac{k_{mod} \cdot R_{1,k}}{\gamma_M} = \frac{0,9 \cdot 16,6}{1,25} = 12,0\,kN$$

Transverse carrying capability

Steel fracture without a lever arm

» Characteristic value of resistance of one anchor bolt against steel fracture without a lever arm

$$V_{Rk,s} = 6,9\,kN$$

» Partial safety coefficient of resistance against steel fracture without a lever arm

$$\gamma_{Ms} = 1,5$$

» Rated value of resistance against steel fracture without a lever arm

$$V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}} = \frac{6,9}{1,5} = 4,6\,kN$$

» Carrying capability of an anchor bolt group, steel fracture failure type without a lever arm

$$V^{g}_{Rd,s} = 4 \cdot 4,6 = 18,4\,kN$$

Concrete fracture on the non-load side

» Characteristic value of resistance of one anchor bolt against concrete edge fracture on the non-load side

$$V_{Rk,cp} = k \cdot N_{Rk,c} = 1 \cdot 10,3 = 10,3\,kN$$

» Factor k from approval

$$k = 1$$

» Partial safety coefficient for concrete fracture on the non-load side

$$\gamma_{Mc} = 1,5$$

» Carrying capability of the anchor bolt group, concrete fracture failure type, on the non-load side

$$V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mcp}} = \frac{10,3}{1,5} = 6,87\,kN$$

Concrete edge fracture

» Characteristic resistance $V_{Rk,c}$ of the anchor bolt group:

$$V_{Rk,c} = V^{0}_{Rk,c} \cdot \frac{A_{c,V}}{A^{0}_{c,V}} \cdot \psi_{s,V} \cdot \psi_{h,V} \cdot \psi_{\alpha,V} \cdot \psi_{ec,V} \cdot \psi_{re,V}$$

» Starting value of the characteristic resistance of one anchor bolt at the edge with stress vertical to the edge in cracked concrete

$$V^{0}_{Rk,c} = k_1 \cdot d_{nom}{}^{\alpha} \cdot h^{\beta}_{ef} \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1,5} = 1,7 \cdot 6^{0,078} \cdot 40^{0,062} \cdot \sqrt{25} \cdot 65^{1,5} = 6,44\,kN$$

Whereby:

$k_1 = 1{,}7$ for cracked concrete

$$\alpha = 0{,}1 \cdot \left(\frac{l_f}{c_1}\right)^{0{,}5} = 0{,}1 \cdot \left(\frac{40}{65}\right)^{0{,}5} = 0{,}078$$

$$\beta = 0{,}1 \cdot \left(\frac{d_{nom}}{c_1}\right)^{0{,}2} = 0{,}1 \cdot \left(\frac{6}{65}\right)^{0{,}2} = 0{,}062$$

c_1 Edge distance in the direction of the transverse stress

d_{nom} Outside diameter of the anchor bolt as per ETA

l_f Effective load introduction length as per ETA

$\frac{A_{c,V}}{A^0_{c,V}}$ Ratio of the projected surfaces

$$A^0_{c,V} = 1{,}5 \cdot c_1 \cdot 3 \cdot c_1 = 4{,}5 \cdot c_1^2 = 4{,}5 \cdot 65^2 = 19012{,}5\text{mm}^2$$

$$A_{c,V} = 1{,}5 \cdot c_1 \cdot \left(1{,}5 \cdot c_1 + s_2 + 1{,}5 \cdot c_1\right) = 1{,}5 \cdot 65 \cdot \left(1{,}5 \cdot 65 + 43{,}5 + 1{,}5 \cdot 65\right) = 23253{,}75\text{mm}^2$$

$$\frac{A_{c,V}}{A^0_{c,V}} = \frac{23253{,}75}{19012{,}5} = 1{,}22$$

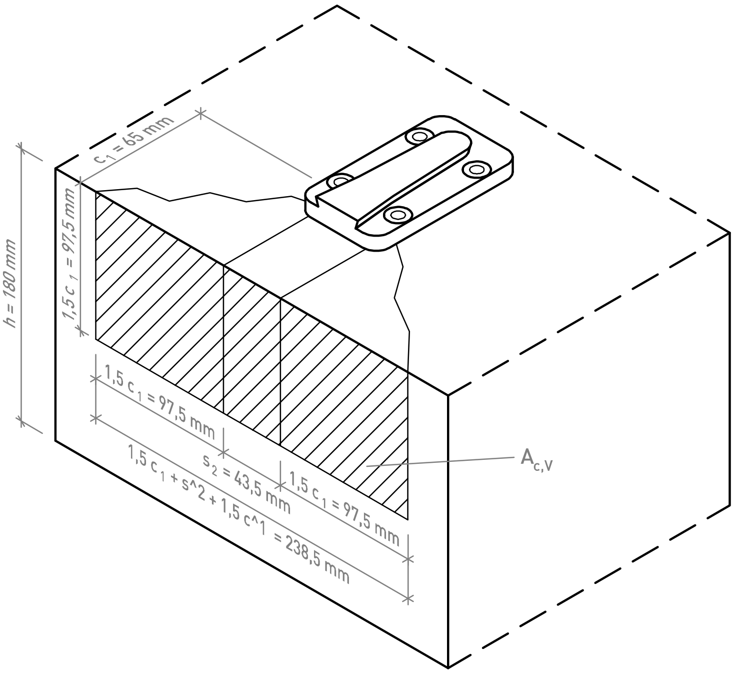


Fig. 5.15: Fractured section in concrete edge failure

» Factor to consider further edges

$$\psi_{s,V} = 0{,}7 + 0{,}3 \cdot \frac{c_2}{1{,}5 \cdot c_1} \leq 1$$

$$c_2 \Rightarrow c_1 \Rightarrow \psi_{s,V} = 1$$

» Factor to consider component thickness

$$\psi_{h,V} = \left(\frac{1{,}5 \cdot c_1}{h}\right)^{1/2} \geq 1$$

$$\psi_{h,V} = \left(\frac{1{,}5 \cdot 65}{200}\right)^{1/2} = 0{,}69 \Rightarrow \psi_{h,V} = 1$$

» Factor to consider load direction

$$\psi_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V) + \left(\frac{\sin\alpha_V}{2{,}5}\right)^2}} \geq 1{,}0$$

$$\alpha_V = 0° \Rightarrow \psi_{\alpha,V} = 1$$

» Factor to consider eccentricity

$$\psi_{ec,V} = \frac{1}{1 + 2 \cdot e_V / (3 \cdot c_1)} \leq 1$$

$$e_V = 0 \Rightarrow \psi_{ec,V} = 1$$

» Factor to consider the position of the attachment

$\psi_{re,V} = 1{,}2$ Attachment in cracked concrete with straight edge reinforcement $\geq \varnothing 12mm$

» Characteristic resistance $V_{Rk,c}$ of the anchor bolt group:

$$V_{Rk,c} = 6{,}44 \cdot 1{,}22 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1{,}2 = 9{,}43kN$$

» Rated value for resistance in the group of anchor bolts

$$V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{Mc}} = \frac{9{,}43}{1{,}5} = 6{,}29kN$$

Tension resistance of attachment on the concrete side

The relevant form of failure is concrete edge fracture This produces maximum tension resistance of the connection on the concrete side of 6.29 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the insertion direction

$$R_{2,k} = 23{,}6kN$$

» Rated value of the carrying capability with stress in the insertion direction(k_{mod}= 0.9)

$$R_{2,d} = \frac{k_{mod} \cdot R_{2,k}}{\gamma_M} = \frac{0{,}9 \cdot 23{,}6}{1{,}25} = 17{,}0kN$$

Combined tensile and transverse stress

The following formulae must be fulfilled on the concrete side:

$$\beta_N = \frac{N_{Sd}}{N_{Rd}} = \frac{2}{10,3} = 0,194 \leq 1,0$$

$$\beta_V = \frac{V_{Sd}}{V_{Rd}} = \frac{4}{6,29} = 0,636 \leq 1,0$$

$$\beta_N + \beta_V = 0,194 + 0,636 = 0,83 \leq 1,2$$

Precise validation of interaction:

$$(\beta_N)^{\alpha} + (\beta_V)^{\alpha} = (0,194)^{1,5} + (0,636)^{1,5} = 0,592 \leq 1,0$$

α = 1.5 relevant failure type in both load directions is not steel fracture (otherwise: α = 2.0)

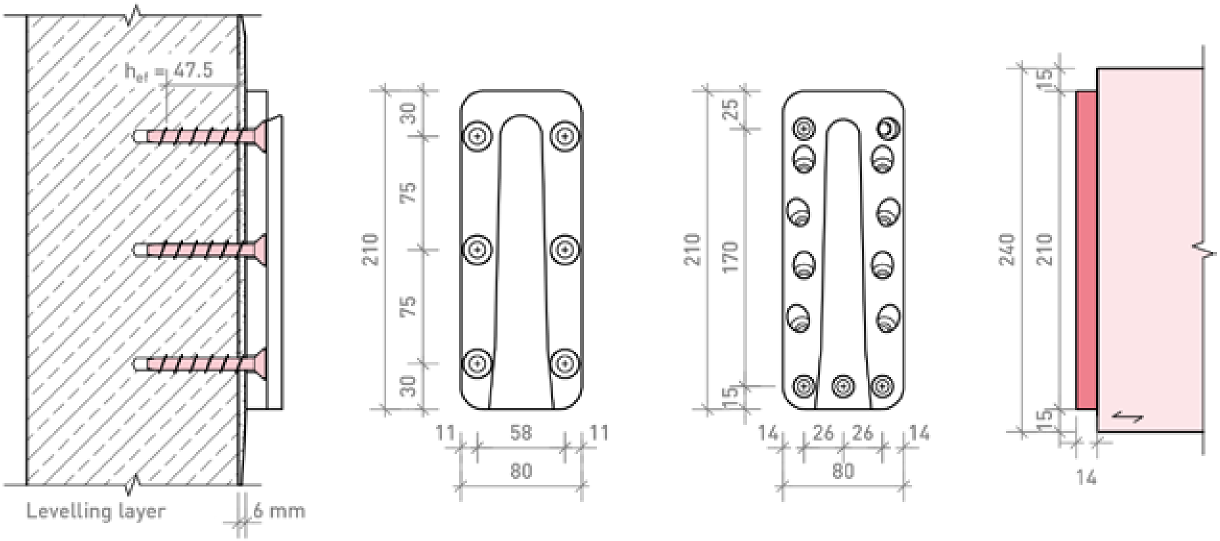
The following formula must be fulfilled on the wood side:

$$\left(\frac{N_{S,d}}{R_{1,d}}\right)^2 + \left(\frac{V_{S,d}}{R_{2,d}}\right)^2 \leq 1,0 \Rightarrow \left(\frac{2}{12}\right)^2 + \left(\frac{4}{17}\right)^2 = 0,08 < 1,0$$

The connection to the concrete side is decisive!

5.5.2 Connection of an L 50 CS with HECO MMS-F 10 x 80 mm

Overview



Information and boundary conditions

Material	
SHERPA	L 50 CS
Substrate	cracked C 25/30 concrete
Connecting material: concrete	6 units, HECO MMS-F 10 x 80 mm
Glulam	100/240 mm; Gl 24h
Connecting material: wood	13 units, 8.0 x 100 mm

Distances		
Distance to edge c_1	[mm]	-
Distance to edge c_2	[mm]	41
Axis spacing s_1	[mm]	58
Axis spacing s_2	[mm]	75
$c_{cr,N} = c_{cr,s\,p}$	[mm]	72
$s_{cr,N} = s_{cr,s\,p}$	[mm]	142.5
Component thickness h	[mm]	200
Anchoring depth h_{ef}	[mm]	47.5
Mortar evenness layer	[mm]	6

Stresses		
Tensile stress $N_{S,d}$	[kN]	3.2
Transverse stress $V_{S,d}$	[kN]	4.15

Tension resistance

Steel fracture

» Characteristic value for resistance against steel fracture per anchor bolt

$$N_{Rk,s} = 16\,kN$$

» Partial safety coefficient for steel fracture

$$\gamma_{Ms} = 1{,}4$$

» Rated value for resistance against steel fracture per anchor bolt

$$N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}} = \frac{16}{1{,}4} = 11{,}4\,kN$$

» Rated value for carrying capability in the group of anchor bolts, steel fracture failure type

$$N^{g}_{Rd,s} = 6 \cdot 11{,}4 = 68{,}4\,kN$$

Extraction

» Characteristic value for resistance against extraction per anchor bolt

$$N_{Rk,p} = 9\,kN$$

» Partial safety coefficient for extraction

$$\gamma_{Mp} = 1{,}8$$

» Rated value for resistance against extraction per anchor bolt

$$N_{Rd,p} = \frac{9}{1{,}8} = 5\,kN$$

» Rated value for carrying capability in the group of anchor bolts, extraction failure type

$$N^{g}_{Rk,p} = 6 \cdot 5 = 30\,kN$$

Concrete fracture

» Starting value of characteristic resistance of an individual anchor bolt in cracked concrete

$$N^{0}_{Rk,c} = k \cdot h_{ef}^{1,5} \cdot \sqrt{f_{ck,cube}} = 7{,}2 \cdot 47{,}5^{1,5} \cdot \sqrt{30} = 12{,}9\,kN$$

» Ratio of the projected surfaces

Area of the idealised pyramid of an individual anchor bolt

$$A^{0}_{c,N} = s_{cr,N} \cdot s_{cr,N}$$

$$s_{cr,N} = 142{,}5\,mm$$

$$A^{0}_{c,N} = 142{,}5 \cdot 142{,}5 = 20306{,}25\,mm^2$$

Surface available in the rating situation

$$A_{c,N} = (0{,}5 \cdot s_{cr,N} + s_2 + s_2 + 0{,}5 \cdot s_{cr,N}) + (0{,}5 \cdot s_{cr,N} + s_1 + c_2)$$

$$A_{c,N} = (170{,}25) \cdot (292{,}5) = 49798{,}13\,mm^2$$

$$\frac{A_{c,N}}{A^{0}_{c,N}} = \frac{49798{,}13}{20306{,}25} = 2{,}45$$

» Factor to consider edges

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{c}{c_{cr,N}} \leq 1,0$$

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{41}{72} = 0,87$$

» Factor to consider eccentricity

$$\psi_{ec,N} = \frac{1}{1 + 2 \cdot \frac{e_N}{s_{cr,N}}} \leq 1,0$$

$$e_N = 0 \Rightarrow \psi_{ec,N} = 1,0$$

» Factor to consider dense reinforcement

$$\psi_{re,N} = 0,5 + \frac{h_{ef}}{200} \leq 1,0$$

$$\psi_{re,N} = 0,5 + \frac{47,5}{200} = 0,74$$

However: Axis spacing of the reinforcement bars < 150 mm

$$\Rightarrow \psi_{re,N} = 1,0$$

» Characteristic resistance of the anchor bolt group with concrete fracture

$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{ec,N} \cdot \psi_{re,N} = 12,9 \cdot 2,45 \cdot 0,87 \cdot 1 \cdot 1 = 27,5\text{kN}$$

» Partial safety coefficient, concrete fracture

$$\gamma_{Mc} = 1,8$$

» Rated value for carrying capability in the group of anchor bolts, concrete fracture failure type

$$N^g_{Rk,d} = \frac{N_{Rk,c}}{\gamma_{Mc}} = \frac{27,5}{1,8} = 15,3\text{kN}$$

Cracks

Concrete splitting is prevented during installation by adherence to the minimum values specified in the in approval for edge distance, axis spacing and component thickness.

$$h = 200\text{mm} > h_{min} = 115\text{mm}$$

$$s = 58\text{mm} > s_{min} = 50\text{mm}$$

$$c = 41\text{mm} > c_{min} = 50\text{mm}$$

Splitting under stress

$$c = 41\text{mm} < c_{cr,sp} = 1,5 \cdot 47,5 = 71,25\text{mm}$$

$$h = 200\text{mm} \geq 2 \cdot h_{ef} = 95\text{mm}$$

$$w_k \sim 0,3\text{mm}$$

Distance to edge too little → Validate for absence of splitting.

$$N_{Rk,sp} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \cdot \psi_{h,sp}$$

$$s_{cr,sp} = s_{cr,N} = 3 \cdot h_{ef} = 3 \cdot 47{,}5 = 142{,}5mm$$

$$c_{cr,sp} = c_{cr,sp} = 1{,}5 \cdot h_{ef} = 1{,}5 \cdot 47{,}5 = 72mm$$

→ Characteristic edge and axis spacings for the failure type of splitting correspond to the characteristic edge and axis spacings for the concrete fracture failure type.

» Characteristic value for resistance against extraction per anchor bolt

$$N^0_{Rk,c} = 12{,}9kN$$

» Ratio of the projected surfaces

$$\frac{A_{c,N}}{A^0_{c,N}} = 2{,}45$$

» Factor to consider edges

$$\psi_{s,N} = 0{,}87$$

» Factor to consider eccentricities

$$\psi_{ec,N} = 1{,}0$$

» Factor to consider dense reinforcement

$$\psi_{re,N} = 1{,}0$$

» Factor to consider component thickness

$$\psi_{h,sp} = \left(\frac{h}{h_{min}}\right)^{2/3} = \left(\frac{200}{115}\right)^{2/3} = 1{,}45$$

» Characteristic resistance of the anchor bolt group with cracks

$$N_{Rk,sp} = 12{,}9 \cdot 2{,}45 \cdot 0{,}87 \cdot 1 \cdot 1 \cdot 1{,}45 = 39{,}9kN$$

» Rated value for resistance in the group of anchor bolts, cracks failure type

$$N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{Mc}} = \frac{39{,}9}{1{,}8} = 22{,}2kN$$

Tension resistance of attachment on the concrete side

The relevant form of failure is concrete fracture This produces maximum tension resistance of the connection on the concrete side of15.3 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the direction of the secondary beam lengthwise axis

$$R_{1,k} = 36{,}5kN$$

» Rated values for carrying capability with stress in the direction of the secondary beam longitudinal axis (k_{mod}= 0.9):

$$R_{1,d} = \frac{k_{mod} \cdot R_{1,k}}{\gamma_M} = \frac{0,9 \cdot 36,5}{1,25} = 26,3\,kN$$

Transverse carrying capability

Steel fracture with a lever arm

» Characteristic value of resistance of one anchor bolt against steel fracture with a lever arm

$$V_{Rk,s} = \alpha_M \cdot \frac{M_{Rk,s}}{l}$$

» Characteristic resistance of one anchor bolt with bending stress [Nm]

$$M^0_{Rk,s} = 38\,Nm$$

$$M_{Rk,s} = M^0_{Rk,s} \cdot (1 - N_{Sd}/N_{Rd,s})$$

$$M_{Rk,s} = 38 \cdot (1 - 3,2/15,3) = 38 \cdot 0,791 = 30,05\,Nm$$

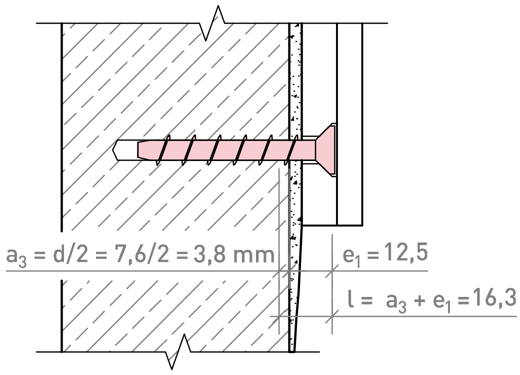


Fig. 5.16: Lever arm of transverse stress

» Torque coefficient

$$\alpha_M = 1$$

» Lever arm l of transverse stress

$$l = a_3 + e_1 = 3,8 + 12,5 = 16,3\,mm$$

» Characteristic value of resistance of one anchor bolt against steel fracture with a lever arm

$$V_{Rk,s} = 1 \cdot \frac{30,05}{0,0163} = 1,84\,kN$$

» Partial safety coefficient

$$\gamma_{Ms} = 1,5$$

» Rated value of the resistance of one anchor bolt

$$V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}} = \frac{1,84}{1,5} = 1,23\,kN$$

» Rated value for resistance in the group of anchor bolts

$$V^g_{Rd,s} = 6 \cdot 1,23 = 7,38\,kN$$

Concrete edge fracture

A concrete edge fracture will not occur in this rating situation due to the large edge distance in the stress direction

Concrete fracture on the non-load side

» Characteristic value of resistance of one anchor bolt against concrete edge fracture on the non-load side

$$V_{Rk,cp} = k \cdot N_{Rk,c} = 2 \cdot 27{,}5 = 55\,kN$$

» Factor k from approval

$$k = 2$$

» Partial safety coefficient for concrete fracture on the non-load side

$$\gamma_{Mc} = 1{,}5$$

» Carrying capability of the anchor bolt group, concrete fracture failure type, on the non-load side

$$V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mc}} = \frac{55}{1{,}5} = 36{,}7\,kN$$

Tension resistance of attachment on the concrete side

The relevant failure type is steel fracture with the lever arm. This produces maximum tension resistance of the connection on the concrete side of 7.38 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the insertion direction

$$R_{2,k} \quad 52{,}0\,kN$$

» Rated value of the carrying capability with stress in the insertion direction(k_{mod}= 0.9)

$$R_{2,d} = \frac{k_{mod} \cdot R_{2,k}}{\gamma_M} = \frac{0{,}9 \cdot 52{,}0}{1{,}25} = 37{,}4\,kN$$

Combined tensile and transverse stress

The following formulae must be fulfilled on the concrete side:

$$\beta_N = \frac{N_{Sd}}{N_{Rd}} = \frac{3{,}2}{15{,}3} = 0{,}21 \le 1{,}0$$

$$\beta_V = \frac{V_{Sd}}{V_{Rd}} = \frac{4{,}15}{7{,}38} = 0{,}56 \le 1{,}0$$

$$\beta_N + \beta_V = 0{,}21 + 0{,}56 = 0{,}77 \le 1{,}2$$

Precise validation of interaction:

$$(\beta_N)^\alpha + (\beta_V)^\alpha = (0{,}21)^{1{,}5} + (0{,}56)^{1{,}5} = 0{,}1 + 0{,}42 = 0{,}52 \le 1{,}0$$

The relevant failure type in both stress directions is not steel fracture α = 1.5

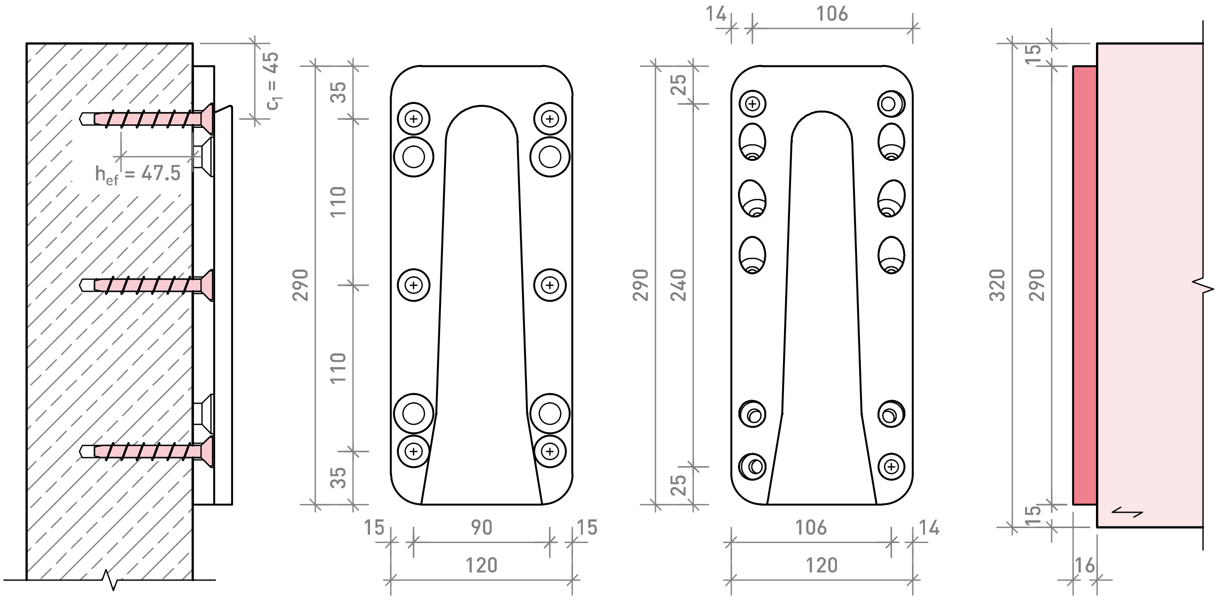
The following formula must be fulfilled on the wood side:

$$\left(\frac{N_{S,d}}{R_{1,d}}\right)^2 + \left(\frac{V_{S,d}}{R_{2,d}}\right)^2 \le 1{,}0 \;\Rightarrow\; \left(\frac{3{,}2}{26{,}3}\right)^2 + \left(\frac{4{,}15}{37{,}4}\right)^2 = 0{,}03 < \;1{,}0$$

The connection to the concrete side is decisive!!

5.5.3 Connection of an XL 70 CS with HECO MMS-F 10 x 80 mm

Overview



Information and boundary conditions

Material	
SHERPA	XL 70 CS
Substrate	cracked C 30/37 concrete
Connecting material: concrete	6 units, HECO MMS-F 10 x 80 mm
Glulam	140/320 mm; Gl 24h
Connecting material: wood	12 units, 8.0 x 160 mm

Distances		
Distance to edge c_1	[mm]	-
Distance to edge c_2	[mm]	45
Axis spacing s_1	[mm]	90
Axis spacing s_2	[mm]	115
$c_{cr,N} = c_{cr,sp}$	[mm]	72
$s_{cr,N} = s_{cr,sp}$	[mm]	142.5
Component thickness h	[mm]	200
Anchoring depth h_{ef}	[mm]	47.5

Stresses		
Tensile stress $N_{S,d}$	[kN]	6.8
Transverse stress $V_{S,d}$	[kN]	36

Tension resistance

Steel fracture

» Characteristic value for resistance against steel fracture per anchor bolt

$$N_{Rk,s} = 16kN$$

» Partial safety coefficient for steel fracture

$$\gamma_{Ms} = 1{,}4$$

» Rated value for resistance against steel fracture per anchor bolt

$$N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}} = \frac{16}{1{,}4} = 11{,}4kN$$

» Rated value for carrying capability in the group of anchor bolts, steel fracture failure type

$$N^g_{Rd,s} = 6 \cdot 11{,}4 = 68{,}4kN$$

Extraction

» Characteristic value for resistance against extraction per anchor bolt

$$N_{Rk,p} = 9kN$$

» Amplification factor for cracked C 30/37 concrete

$$\psi_c = 1{,}22 \qquad N_{Rk,p} = 1{,}22 \cdot 9 = 10{,}98kN$$

» Partial safety coefficient for extraction

$$\gamma_{Mp} = 1{,}8$$

» Rated value for resistance against extraction per anchor bolt

$$N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}} = \frac{10{,}98}{1{,}8} = 6{,}1kN$$

» Rated value for carrying capability in the group of anchor bolts, pull-out failure type

$$N^g_{Rd,p} = 6 \cdot 6{,}1 = 36{,}6kN$$

Concrete fracture

» Starting value of characteristic resistance of an individual anchor bolt in cracked concrete

$$N^0_{Rk,c} = k \cdot h_{ef}^{1{,}5} \cdot \sqrt{f_{ck,cube}} = 7{,}2 \cdot 47{,}5^{1{,}5} \cdot \sqrt{37} = 14{,}3kN$$

» Ratio of the projected surfaces

Area of the idealised pyramid of an individual anchor bolt

$$A^0_{c,N} = s_{cr,N} \cdot s_{cr,N}$$

$$s_{cr,N} = 142{,}5mm$$

$$A^0_{c,N} = 142{,}5 \cdot 142{,}5 = 20306{,}25mm^2$$

Surface available in the rating situation

$$A_{c,N} = (0,5 \cdot s_{cr,N} + s_2 + s_2 + 0,5 \cdot s_{cr,N}) + (0,5 \cdot s_{cr,N} + s_1 + c_2)$$

$$A_{c,N} = (72 + 90 + 72) \cdot (72 + 85 + 85 + 45) = 67158\,mm^2$$

$$\frac{A_{c,N}}{A^0_{c,N}} = \frac{67158,00}{20306,25} = 3,31$$

» Factor to consider edges

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{c}{c_{cr,N}} \leq 1,0$$

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{300}{72} = 1,95 \Rightarrow \psi_{s,N} = 1,0$$

» Factor to consider eccentricity

$$\psi_{ec,N} = \frac{1}{1 + 2 \cdot \frac{e_N}{s_{cr,N}}} \leq 1,0$$

$$e_N = 0 \Rightarrow \psi_{ec,N} = 1,0$$

» Factor to consider dense reinforcement

$$\psi_{re,N} = 0,5 + \frac{h_{ef}}{200} \leq 1,0$$

$$\psi_{re,N} = 0,5 + \frac{47,5}{200} = 0,74$$

However: Axis spacing of the reinforcement bars < 150 mm

$$\Rightarrow \psi_{re,N} = 1,0$$

» Characteristic resistance of the anchor bolt group with concrete fracture

$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} = 14,3 \cdot 3,31 \cdot 1 \cdot 1 \cdot 1 = 47,33\,kN$$

» Partial safety coefficient, concrete fracture

$$\gamma_{Mc} = 1,8$$

» Rated value for carrying capability in the group of anchor bolts, concrete fracture failure type

$$N^g_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}} = \frac{47,33}{1,8} = 26,3\,kN$$

Cracks

Concrete splitting during installation is prevented by adherence to the given minimum values in approval for edge distance, axis spacing and component thickness.
It is not necessary to conduct validation for splitting under load, as the edge distance in all directions is $c \geq 1.5 \cdot c_{cr,sp}$, component thickness h is $\geq 2 \cdot h_{ef}$, the crack widths through reinforcement remain limited to $w_k \sim 0,3$ mm and the characteristic resistances for the failure types of concrete fracture and extraction of cracked concrete were calculated.

Tension resistance of attachment on the concrete side

The relevant form of failure is concrete fracture This produces maximum tension resistance of the connection on the concrete side of 26.3 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the direction of the secondary beam lengthwise axis

$$R_{1,k} = 62{,}3\,kN$$

» Rated values for carrying capability with stress in the direction of the secondary beam longitudinal axis (k_{mod}= 0.9):

$$R_{1,d} = \frac{k_{mod} \cdot R_{1,k}}{\gamma_M} = \frac{0{,}9 \cdot 62{,}3}{1{,}25} = 44{,}9\,kN$$

Transverse carrying capability

Steel fracture without a lever arm

» Characteristic value of resistance of one anchor bolt against steel fracture without a lever arm

$$V_{Rk,s} = 16\,kN$$

» Partial safety coefficient of resistance of one anchor bolt against steel fracture without a lever arm

$$\gamma_{Ms} = 1{,}5$$

» Rated value of resistance of one anchor bolt against steel fracture without a lever arm

$$V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}} = \frac{16}{1{,}5} = 10{,}7\,kN$$

» Carrying capability of an anchor bolt group, steel fracture failure type without a lever arm

$$V_{Rd,s}^{g} = 6 \cdot 10{,}7 = 64\,kN$$

Concrete edge fracture

A concrete edge fracture will not occur in this rating situation due to the large edge distance in the stress direction

Concrete fracture on the non-load side

» Characteristic value of resistance of one anchor bolt against concrete edge fracture on the non-load side

$$V_{Rk,cp} = k \cdot N_{Rk,c} = 2 \cdot 47{,}33 = 94{,}66\,kN$$

» Factor k from approval

$$k = 2$$

» Partial safety coefficient for concrete fracture on the non-load side

$$\gamma_{Mc} = 1{,}5$$

» Carrying capability of the anchor bolt group, concrete fracture failure type, on the non-load side

$$V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mcp}} = \frac{94,66}{1,5} = 63,1kN$$

Tension resistance of attachment on the concrete side

The relevant failure type is steel fracture without lever arm. This produces maximum tension resistance of the connection on the concrete side of 63.1 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the insertion direction

$$R_{2,k} = 80,0kN$$

» Rated value of the carrying capability with stress in the insertion direction(k_{mod}= 0.9)

$$R_{2,d} = \frac{k_{mod} \cdot R_{2,k}}{\gamma_M} = \frac{0,9 \cdot 80,0}{1,25} = 57,6kN$$

Combined tensile and transverse stress

The following formulae must be fulfilled on the concrete side:

$$\beta_N = \frac{N_{Sd}}{N_{Rd}} = \frac{6,8}{26,3} = 0,26 \le 1,0$$

$$\beta_V = \frac{V_{Sd}}{V_{Rd}} = \frac{36}{63,1} = 0,57 \le 1,0$$

$$\beta_N + \beta_V = 0,26 + 0,57 = 0,83 \le 1,2$$

Precise validation of interaction:

$$(\beta_N)^\alpha + (\beta_V)^\alpha = (0,26)^{1,5} + (0,57)^{1,5} = 0,56 \le 1,0$$

The relevant failure type in both stress directions is not steel fracture α = 1.5

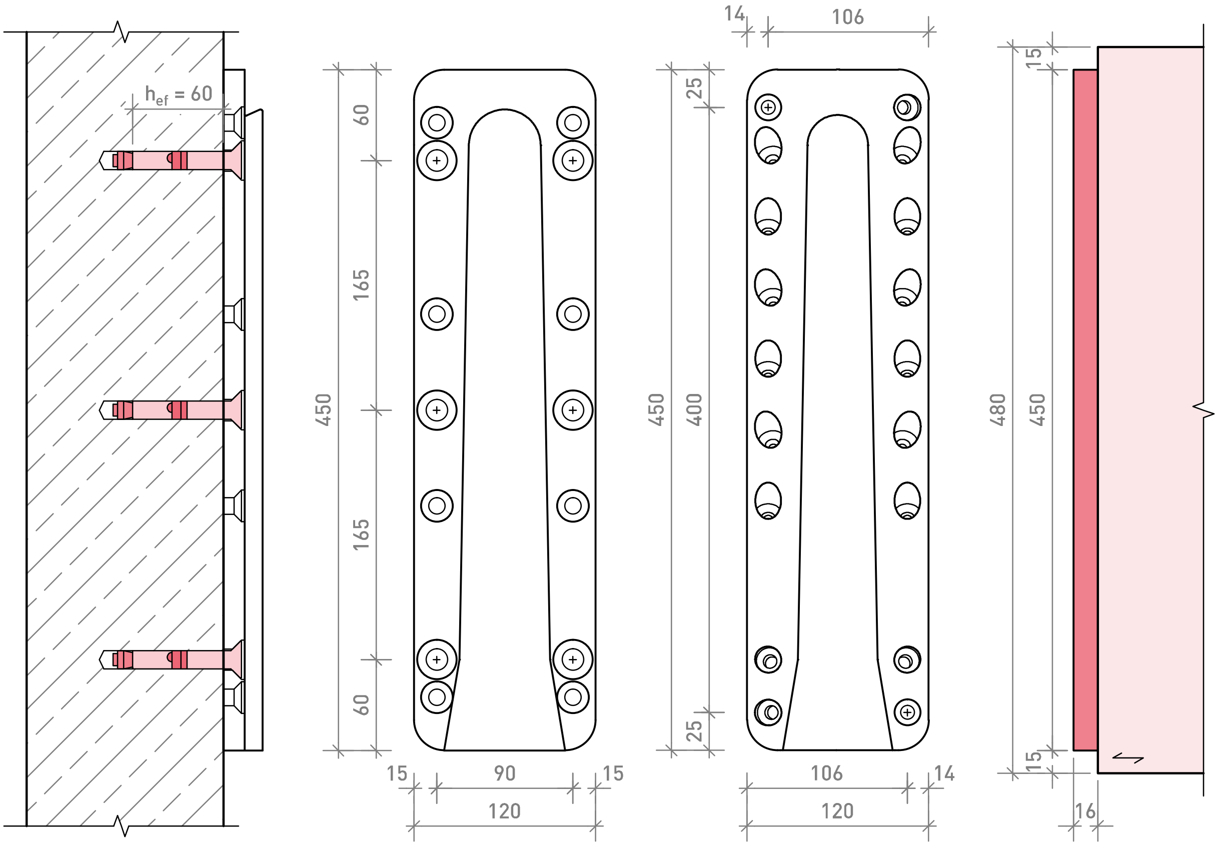
The following formula must be fulfilled on the wood side:

$$\left(\frac{N_{S,d}}{R_{1,d}}\right)^2 + \left(\frac{V_{S,d}}{R_{2,d}}\right)^2 \le 1,0 \Rightarrow \left(\frac{6,8}{44,9}\right)^2 + \left(\frac{36,0}{57,6}\right)^2 = 0,41 < 1,0$$

The connection to the concrete side is decisive!

5.5.4 Connection of an XL 140 CS with FISCHER high-performance anchor, FH II-SK 12/15

Overview



Information and boundary conditions

Material	
SHERPA	XL 140 CS
Substrate	cracked C 25/30 concrete
Connecting material: concrete	6 units FISHER FH II-SK 12/15 A4
Glulam	140/480 mm; Gl 24h
Connecting material: wood	18 units, 8.0 x 160 mm

Distances				
Distance to edge c_1		[mm]	-	
Distance to edge c_2		[mm]	-	
Axis spacing s_1		[mm]	90	
Axis spacing s_2		[mm]	165	
$c_{cr,N}$	$c_{cr,s\,p}$	[mm]	90	150
$s_{cr,N}$	$s_{cr,s\,p}$	[mm]	180	300
Component thickness h		[mm]	200	
Anchoring depth h_{ef}		[mm]	60	

Stresses		
Tensile stress $N_{S,d}$	[kN]	10
Transverse stress $V_{S,d}$	[kN]	60

Tension resistance

Steel fracture

» Characteristic value for resistance against steel fracture per anchor bolt

$$N_{Rk,s} = 25,6kN$$

» Partial safety coefficient for steel fracture

$$\gamma_{Ms} = 1,5$$

» Rated value for resistance against steel fracture per anchor bolt

$$N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}} = \frac{25,6}{1,5} = 17,1kN$$

» Carrying capability of an anchor bolt group, steel fracture failure type

$$N^{g}_{Rd,s} = 6 \cdot 17,1 = 102,6kN$$

Extraction

» Characteristic value for resistance against extraction per anchor bolt

$$N_{Rk,p} = 12kN$$

» Amplification factor for cracked C 25/30 concrete

$$\psi_c = 1,1 \qquad N_{Rk,p} = 12 \cdot 1,1 = 13,2kN$$

» Partial safety coefficient for extraction

$$\gamma_{Mp} = 1,5$$

» Rated value for resistance against extraction per anchor bolt

$$N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}} = \frac{13,2}{1,5} = 8,8kN$$

» Carrying capability of an anchor bolt group, extraction failure type

$$N^{g}_{Rd,p} = 6 \cdot 8,8 = 52,8kN$$

Concrete fracture

» Starting value of characteristic resistance of an individual anchor bolt in cracked concrete

$$N^{0}_{Rk,c} = k \cdot h_{ef}^{1,5} \cdot \sqrt{f_{ck,cube}} = 7,2 \cdot 60^{1,5} \cdot \sqrt{30} = 18,3kN$$

» Ratio of the projected surfaces

Area of the idealised pyramid of an individual anchor bolt

$$A^{0}_{c,N} = s_{cr,N} \cdot s_{cr,N}$$

$$s_{cr,N} = 3 \cdot h_{ef} = 3 \cdot 60 = 180mm$$

$$A^{0}_{c,N} = 180^2 = 32400mm^2$$

Surface available in the rating situation

$$A_{c,N} = (0,5 \cdot s_{cr,N} + s_1 + s_{cr,N}) \cdot (0,5 \cdot s_{cr,N} + s_2 + s_2 + 0,5 \cdot s_{cr,N})$$

$$A_{c,N} = (90+90+90)\cdot(90+165+165+90) = 137700\,mm^2$$

$$\frac{A_{c,N}}{A^0_{c,N}} = \frac{137700}{32400} = 4,25$$

» Factor to consider edges

$$\psi_{s,N} = 0,7 + 0,3\cdot\frac{c}{c_{cr,N}} \leq 1,0$$

$$\psi_{s,N} = 0,7 + 0,3\cdot\frac{300}{90} = 1,7 \rightarrow 1,0$$

» Factor to consider eccentricity

$$\psi_{ec,N} = \frac{1}{1+2\cdot\frac{e_N}{s_{cr,N}}} \leq 1,0$$

$$e_N = 0 \Rightarrow \psi_{ec,N} = 1,0$$

» Factor to consider dense reinforcement

$$\psi_{re,N} = 0,5 + \frac{h_{ef}}{200} \leq 1,0$$

$$\psi_{re,N} = 0,5 + \frac{60}{200} = 0,8$$

However: Axis spacing of the reinforcement bars < 150 mm

$$\Rightarrow \psi_{re,N} = 1,0$$

» Characteristic resistance of the anchor bolt group with concrete fracture

$$N_{Rk,c} = N^0_{Rk,c}\cdot\frac{A_{c,N}}{A^0_{c,N}}\cdot\psi_{s,N}\cdot\psi_{re,N}\cdot\psi_{ec,N} = 18,3\cdot 4,25\cdot 1\cdot 1\cdot 1 = 77,8\,kN$$

» Partial safety coefficient, concrete fracture

$$\gamma_{Mc} = 1,5$$

» Rated value for carrying capability in the group of anchor bolts, concrete fracture failure type

$$N^g_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}} = \frac{77,8}{1,5} = 51,9\,kN$$

Cracks

Concrete splitting during installation is prevented by adherence to the given minimum values in approval for edge distance, axis spacing and component thickness.
It is not necessary to conduct validation of splitting under load, as the edge distance in all directions is $c \geqslant 1.5\cdot c_{cr,sp}$, component thickness h is $\geqslant 2\cdot h_{ef}$, the crack widths through reinforcement remain limited to $w_k \sim 0,3$ mm and the characteristic resistances for the failure types of concrete fracture and extraction of cracked concrete were calculated.

Tension resistance of attachment on the concrete side

The relevant form of failure is concrete fracture This produces maximum tension resistance of the connection on the concrete side of 51.9 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the direction of the secondary beam lengthwise axis

$$R_{1,k} = 62,3\,kN$$

» Rated values for carrying capability with stress in the direction of the secondary beam longitudinal axis (k_{mod}= 0.9):

$$R_{1,d} = \frac{k_{mod} \cdot R_{1,k}}{\gamma_M} = \frac{0,9 \cdot 62,3}{1,25} = 44,9\,kN$$

Transverse carrying capability

Steel fracture without a lever arm

» Characteristic value of resistance of one anchor bolt against steel fracture without a lever arm

$$V_{Rk,s} = 28\,kN$$

» Partial safety coefficient of resistance against steel fracture without a lever arm

$$\gamma_{Ms} = 1,25$$

» Rated value of resistance of one anchor bolt against steel fracture without a lever arm

$$V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}} = \frac{28}{1,25} = 22,4\,kN$$

» Carrying capability of an anchor bolt group, steel fracture failure type without a lever arm

$$V_{Rd,s}^{g} = 6 \cdot 22,4 = 134,4\,kN$$

Concrete edge fracture

A concrete edge fracture will not occur in this rating situation due to the large edge distance in the stress direction

Concrete fracture on the non-load side

» Characteristic value of resistance of one anchor bolt against concrete edge fracture on the non-load side

$$V_{Rk,cp} = k \cdot N_{Rk,c} = 2 \cdot 77,8 = 155,6\,kN$$

» Factor k from approval

$$k = 2$$

» Partial safety coefficient for concrete fracture on the non-load side

$$\gamma_{Mc} = 1,5$$

» Carrying capability of the anchor bolt group, concrete fracture failure type, on the non-load side

$$V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mcp}} = \frac{155,6}{1,5} = 103,7\,kN$$

Tension resistance of attachment on the concrete side

Carrying capability of the anchor bolt group, concrete fracture failure type, on the side opposing the load This produces maximum tension resistance of the connection on the concrete side of 103.7 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the insertion direction

$$R_{2,k} = 149,4\,kN$$

» Rated value of the carrying capability with stress in the insertion direction(k_{mod}= 0.9)

$$R_{2,d} = \frac{k_{mod} \cdot R_{2,k}}{\gamma_M} = \frac{0,9 \cdot 149,4}{1,25} = 107,6\,kN$$

Combined tensile and transverse stress

The following formulae must be fulfilled on the concrete side:

$$\beta_N = \frac{N_{Sd}}{N_{Rd}} = \frac{10}{51,9} = 0,19 \le 1,0$$

$$\beta_V = \frac{V_{Sd}}{V_{Rd}} = \frac{60}{103,7} = 0,58 \le 1,0$$

$$\beta_N + \beta_V = 0,19 + 0,58 = 0,77 \le 1,2$$

Precise validation of interaction:

$$(\beta_N)^\alpha + (\beta_V)^\alpha = (0,19)^{1,5} + (0,58)^{1,5} = 0,08 + 0,44 = 0,52 \le 1,0$$

The relevant failure type in both stress directions is not steel fracture α = 1.5

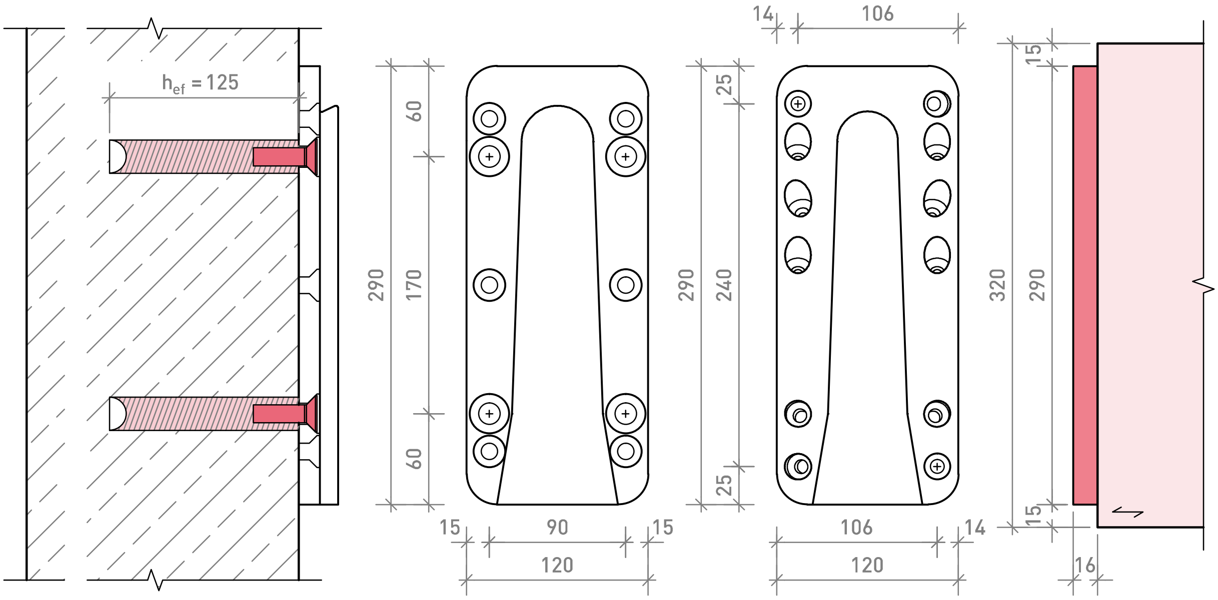
The following formula must be fulfilled on the wood side:

$$\left(\frac{N_{S,d}}{R_{1,d}}\right)^2 + \left(\frac{V_{S,d}}{R_{2,d}}\right)^2 \le 1,0 \Rightarrow \left(\frac{10}{44,9}\right)^2 + \left(\frac{60}{107,6}\right)^2 = 0,36 < \ 1,0$$

The connection to the concrete side is decisive!

5.5.5 Connection of an XL 70 CS with a HILTI inner thread sleeve, M10

Overview



Information and boundary conditions

Material	
SHERPA	XL 70 CS
Substrate	cracked C 20/25 concrete
Connecting material: concrete	4 units HILTI HIS-N/RN M12
Glulam	140/320 mm; Gl 24h
Connecting material: wood	18 units, 8.0 x 160 mm

Distances		
Distance to edge c_1	[mm]	-
Distance to edge c_2	[mm]	-
Axis spacing s_1	[mm]	90
Axis spacing s_2	[mm]	170
$c_{cr,N} = c_{cr,s\,p}$	[mm]	187.5
$s_{cr,N} = s_{cr,Np}$	[mm]	375
$c_{cr,sp}$	[mm]	215
$s_{cr,sp}$	[mm]	430
Component thickness h	[mm]	350
Anchoring depth h_{ef}	[mm]	125

Stresses		
Tensile stress $N_{S,d}$	[kN]	20
Transverse stress $V_{S,d}$	[kN]	45

Tension resistance

Steel fracture

» Characteristic value for resistance against steel fracture per anchor bolt

$$N_{Rk,s} = 67kN$$

» Partial safety coefficient for steel fracture

$$\gamma_{Ms,N} = 1,5$$

» Rated value for resistance against steel fracture per anchor bolt

$$N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms,N}} = \frac{67}{1,5} = 44,7kN$$

» Carrying capability of an anchor bolt group, steel fracture failure type

$$N^{g}_{Rd,s} = 4 \cdot 44,7 = 178,8kN$$

Extraction and concrete fracture

» Starting value of characteristic resistance of an individual anchor bolt in cracked concrete

$$N^{0}_{Rk,p} = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk}$$

or from approval (temperature range I: 40°C/24°C for cracked concrete):

$$N^{0}_{Rk,p} = N_{Rk,cr} = 60kN$$

» Ratio of the projected surfaces

Area of the idealised pyramid of an individual anchor bolt

$$A^{0}_{p,N} = s_{cr,Np} \cdot s_{cr,Np}$$

$$s_{cr,Np} = 20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7,5}\right)^{0,5} \leq 3 \cdot h_{ef}$$

$N_{Rk,ucr} = 95kN$ (for temperature range I: 40°C/24°C)

$$\tau_{Rk,ucr} = \frac{N_{Rk,ucr}}{\pi \cdot d \cdot h_{ef}} = \frac{95000}{\pi \cdot 20,5 \cdot 125} = 11,8N/mm^{2}$$

$$\tau_{Rk,cr} = \frac{{}_{Rk,cr}}{\pi \cdot d \cdot h_{ef}} = \frac{60000}{\pi \cdot 20,5 \cdot 125} = 7,45N/mm$$

$$s_{cr,Np} = 20 \cdot 20,5 \cdot \left(\frac{11,8}{7,5}\right)^{0,5} = 514,3mm$$

$$s_{cr,Np} = 3 \cdot h_{ef} = 3 \cdot 125 = 375mm$$

$$A^{0}_{p,N} = 375^{2} = 140625mm^{2}$$

Surface available in the rating situation

$$A_{p,N} = (0,5 \cdot s_{cr,Np} \cdot s_{1} \cdot 0,5 \cdot s_{cr,p}) \cdot \left(0,5 \cdot s_{cr,Np} + s_{2} + 0,5 \cdot s_{cr,Np}\right)$$

$$A_{p,N} = (0,5\cdot375\cdot90\cdot0,5\cdot375)\cdot\left(0,5\cdot375+170+0,5\cdot375\right) = 253425\,mm^2$$

$$\frac{A_{p,N}}{A^0_{p,N}} = \frac{253425}{140625} = 1,80$$

» Factor to consider edges

$$\psi_{s,N} = 0,7+0,3\cdot\frac{c}{c_{cr,N}} \le 1,0$$

$$c \Rightarrow c_{cr,Np} \Rightarrow \psi_{s,Np} = 1,0$$

» Factor to consider fastener groups

$$\psi_{g,Np} = \psi^0_{g,Np} - \left(\frac{s}{s_{cr,Np}}\right)^{0,5}\cdot\left(\psi^0_{g,Np}-1\right) \ge 1,0$$

$$\psi^0_{g,Np} = \sqrt{n}-\left(\sqrt{n}-1\right)\cdot\left(\frac{d\cdot\tau_{Rk}}{k\cdot\sqrt{h_{ef}\cdot f_{ck,cube}}}\right)^{1,5} \ge 1,0$$

$$\psi^0_{g,Np} = \sqrt{4}-\left(\sqrt{4}-1\right)\cdot\left(\frac{20,5\cdot7,45}{2,3\cdot\sqrt{125\cdot25}}\right)^{1,5} = 0,7 \Rightarrow \psi^0_{g,Np} = 1,0 \Rightarrow \psi_{g,Np} = 1,0$$

» Factor to consider eccentricity

$$\psi_{ec,N} = \frac{1}{1+2\cdot\frac{e_N}{s_{cr,N}}} \le 1,0$$

$$e_N = 0 \Rightarrow \psi_{ec,N} = 1,0$$

» Factor to consider dense surface reinforcement

$$\psi_{re,N} = 0,5+\frac{h_{ef}}{200} \le 1,0$$

$$\psi_{re,Np} = 0,5+\frac{125}{200} = 1,125 \Rightarrow \psi_{re,Np} = 1,0$$

» Characteristic resistance of the anchor bolt group with extraction and concrete fracture

$$N^0_{Rk,p}\cdot\frac{A_{p,N}}{A^0_{p,N}}\cdot\psi_{s,Np}\cdot\psi_{g,Np}\cdot\psi_{ec,Np}\cdot\psi_{re,Np} = 60\cdot1,8\cdot1,0\cdot1,0\cdot1,0\cdot1,0 = 108\,kN$$

» Rated value for carrying capability in the group of anchor bolts, failure type:

$$N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}} = \frac{108}{2,1} = 51,4\,kN$$

Concrete fracture

» Starting value of characteristic resistance of an individual anchor bolt in cracked concrete

$$N^0_{Rk,c} = k_1\cdot\sqrt{f_{ck,cube}}\cdot h_{ef}^{1,5} = 7,2\cdot\sqrt{25}\cdot125^{1,5} = 50,3\,kN$$

» Ratio of the projected surfaces

Area of the idealised pyramid of an individual anchor bolt

$$A^0_{c,N} = s_{cr,N} \cdot s_{cr,N}$$

$$s_{cr,N} = 3 \cdot h_{ef} = 3 \cdot 125 = 375 mm$$

$$A^0_{c,N} = 375^2 = 140625 mm^2$$

Surface available in the rating situation

$$A_{c,N} = (0,5 \cdot s_{cr,N} + s_1 + s_{cr,N}) \cdot (0,5 \cdot s_{cr,N} + s_2 + s_2 + 0,5 \cdot s_{cr,N})$$

$$A_{c,N} = (187,5 + 90 + 187,5) \cdot (187,5 + 170 + 187,5) = 253425 mm^2$$

$$\frac{A_{c,N}}{A^0_{c,N}} = \frac{253425}{140625} = 1,8$$

» Factor to consider edges

$$\psi_{s,N} = 0,7 + 0,3 \cdot \frac{c}{c_{cr,N}} \leq 1,0 \qquad c \Rightarrow c_{cr,N} \Rightarrow \psi_{s,N} = 1,0$$

» Factor to consider eccentricity

$$\psi_{ec,N} = \frac{1}{1 + 2 \cdot \frac{e_N}{s_{cr,N}}} \leq 1,0$$

$$e_N = 0 \Rightarrow \psi_{ec,N} = 1,0$$

» Factor to consider dense reinforcement

$$\psi_{re,N} = 0,5 + \frac{h_{ef}}{200} \leq 1,0$$

$$\psi_{re,N} = 0,5 + \frac{375}{200} = 2,38 \Rightarrow \psi_{re,N} = 1,0$$

» Characteristic resistance of the anchor bolt group with concrete fracture

$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} = 50,3 \cdot 1,8 \cdot 1 \cdot 1 \cdot 1 = 90,5 kN$$

» Partial safety coefficient, concrete fracture

$$\gamma_{Mc} = 2,1$$

» Rated value for carrying capability in the group of anchor bolts, concrete fracture failure type

$$N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}} = \frac{90,5}{2,1} = 43,1 kN$$

Cracks

Concrete splitting is prevented during installation by adherence to the given minimum values in approval for edge distance, axis spacing and component thickness.
It is not necessary to conduct validation of splitting under load, as the edge distance in all directions is $c \geqslant 1.2 \cdot c_{cr,sp}$, component thickness h is $\geqslant 2 \cdot h_{ef}$, the crack widths through reinforcement remain limited to $w_k \sim 0,3$ mm and the characteristic resistances for the failure types of concrete fracture and extraction of cracked concrete were calculated.

Tension resistance of attachment on the concrete side

The relevant form of failure is concrete fracture This produces maximum tension resistance of the connection on the concrete side of 43.1 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the direction of the secondary beam lengthwise axis

$$R_{1,k} = 62{,}3\,kN$$

» Rated values for carrying capability with stress in the direction of the secondary beam longitudinal axis (k_{mod}= 0.9):

$$R_{1,d} = \frac{k_{mod} \cdot R_{1,k}}{\gamma_M} = \frac{0{,}9 \cdot 62{,}3}{1{,}25} = 44{,}9\,kN$$

Transverse carrying capability

Steel fracture without a lever arm

» Characteristic value of resistance of one anchor bolt against steel fracture without a lever arm

$$V_{Rk,s} = 39\,kN$$

» Partial safety coefficient of resistance against steel fracture without a lever arm

$$\gamma_{Ms} = 1{,}5$$

» Rated value of resistance of one anchor bolt against steel fracture without a lever arm

$$V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}} = \frac{39}{1{,}5} = 26\,kN$$

» Carrying capability of an anchor bolt group, steel fracture failure type without a lever arm

$$V^{g}_{Rd,s} = 4 \cdot 26 = 104\,kN$$

Concrete edge fracture

A concrete edge fracture will not occur in this rating situation due to the large edge distance in the stress direction

Concrete fracture on the non-load side

» Characteristic value of resistance of one anchor bolt against concrete edge fracture on the non-load side

$$V_{Rk,cp} = k \cdot N_{Rk,p} = 2 \cdot 108 = 216\,kN$$

$$V_{Rk,cp} = k \cdot N_{Rk,c} = 2 \cdot 90{,}5 = 181\,kN$$

$$\rightarrow V_{Rk,cp} = 181\,kN$$

» Factor k from approval

$$k = 2$$

» Partial safety coefficient for concrete fracture on the non-load side

$$\gamma_{Mcp} = 1{,}5$$

» Carrying capability of the anchor bolt group, concrete fracture failure type, on the non-load side

$$V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mcp}} = \frac{181}{1{,}5} = 120{,}9\,kN$$

Tension resistance of attachment on the concrete side

The relevant concrete fracture failure type on the non-load side is steel fracture. This produces maximum tension resistance of the connection on the concrete side of 104 kN

Tension resistance on the wood side

» Characteristic value for carrying capability with stress in the insertion direction

$$R_{2,k} = 80\,kN$$

» Rated value of the carrying capability with stress in the insertion direction(k_{mod}= 0.9)

$$R_{2,d} = \frac{k_{mod} \cdot R_{2,k}}{\gamma_M} = \frac{0{,}9 \cdot 80}{1{,}25} = 57{,}6\,kN$$

Combined tensile and transverse stress

The following formulae must be fulfilled on the concrete side:

$$\beta_N = \frac{N_{Sd}}{N_{Rd}} = \frac{20}{43{,}1} = 0{,}46 \leq 1{,}0$$

$$\beta_V = \frac{V_{Sd}}{V_{Rd}} = \frac{45}{104} = 0{,}43 \leq 1{,}0$$

$$\beta_N + \beta_V = 0{,}46 + 0{,}43 = 0{,}89 \leq 1{,}2$$

The following formula must be fulfilled on the wood side:

$$\left(\frac{N_{S,d}}{R_{1,d}}\right)^2 + \left(\frac{V_{S,d}}{R_{2,d}}\right)^2 \leq 1{,}0 \Rightarrow \left(\frac{20}{44{,}9}\right)^2 + \left(\frac{45}{57{,}6}\right)^2 = 0{,}81 < 1{,}0$$

The connection to the concrete side is decisive!

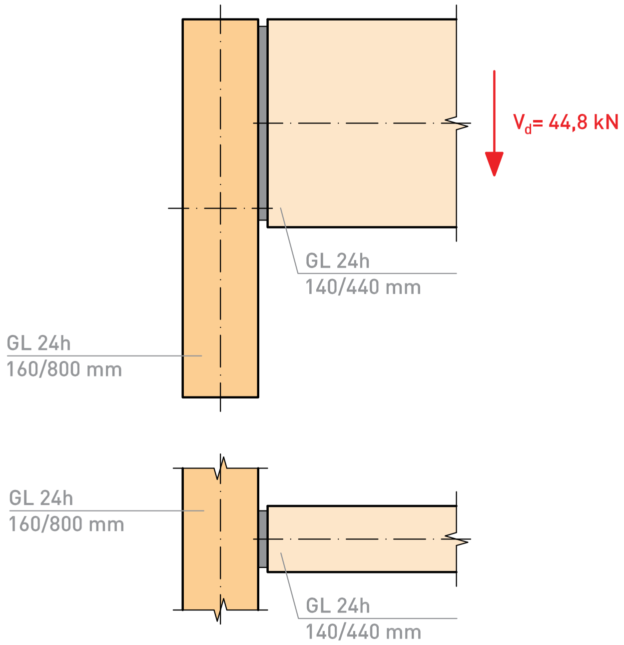
6 Calculation examples, XS to XXL Series

6 Calculation examples, XS to XXL Series

6.1 Central stress in the insertion direction

Overview

01



Information and boundary conditions

Connector:	XL 120	20/120/410 mm		
Installation situation:	A fire resistance check is not needed. The main beam is assumed to be sufficiently secured against distortion.			
Construction material:	Glulam	γ_M = 1.25		
Main beam:	GL 24h	w/h = 160/800 mm		
Secondary beam:	GL 24h	w/h = 140/440 mm	Span width l = 7.00 m	Influence width e = 2.50 m
Exposures:	Constant exposure		g_k = 0.50 kN/m²	
	Snow (height above sea level < 1000 m)		s_k = 3.00 kN/m²	ψ_0 = 0.5 ψ_2 = 0
	Wind (pressure)		w_k = 0.45 kN/m²	ψ_0 = 0.6 ψ_2 = 0
NKL: KLED:	$\left.\begin{matrix}2\\ \text{kurz}\end{matrix}\right\} k_{mod} = 0{,}9$			

Measured values for exposure as per EN 1990

» Equally distributed load

Combined exposure 1:
Snow as the leading effect and wind as a secondary effect

$$q_{d,1} = \left(\gamma_G \cdot g_k + \gamma_Q \cdot s_k + \gamma_Q \cdot \psi_{0,w} \cdot w_k\right) \cdot e$$

$$q_{d,1} = \left(1{,}35 \cdot 0{,}50 + 1{,}50 \cdot 3{,}00 + 1{,}50 \cdot 0{,}60 \cdot 0{,}45\right) \cdot 2{,}50 = 13{,}95 \text{ kN/m}$$

Combined exposure 2:
Wind as the leading effect and snow as a secondary effect

$$q_{d,2} = \left(\gamma_G \cdot g_k + \gamma_Q \cdot w_k + \gamma_Q \cdot \psi_{0,s} \cdot s_k\right) \cdot e$$

$$q_{d,2} = \left(1{,}35 \cdot 0{,}50 + 1{,}50 \cdot 0{,}45 + 1{,}50 \cdot 0{,}50 \cdot 3{,}00\right) \cdot 2{,}50 = 9{,}00 \text{ kN/m}$$

Measured values for internal forces

» Measured values for bending moment

$$M_d = \frac{q_d \cdot l^2}{8} = \frac{13{,}95 \cdot 7{,}00^2}{8} = 81{,}6 \text{ kNm}$$

» Measured values for transverse force or bearing force

$$V_d = \frac{q_d \cdot l}{2} = \frac{13{,}95 \cdot 7{,}00}{2} = 48{,}8 \text{ kN}$$

Measured values for building material properties in N/mm²

Characteristic values		Measured values	
Bending strength $f_{m,k}$	28.0	Bending strength $f_{m,d}$	20.16
Shear strength $f_{v,k}$	2.5	Shear strength $f_{v,d}$	1.8

The measured values for construction materials X_d are determined using a formula

$$X_d = \frac{k_{mod} \cdot X_k}{\gamma_M} =$$

with the modification coefficient k_{mod}= 0.9 and the partial safety coefficient γ_M= 1.25

Cross-sectional values

» Cross-sectional area

$$A_n = b \cdot h = 140 \cdot 440 = 6{,}16 \cdot 10^4 \text{ mm}^2$$

» Moment of resistance (around the y axis)

$$W_{n,y} = \frac{b \cdot h^2}{6} = \frac{140 \cdot 440^2}{6} = 4{,}52 \cdot 10^6 \text{ mm}^3$$

Validation of the suspended beam in the serviceability limit state

» Validation of bending

$$\frac{\sigma_{m,y,d}}{f_{m,d}} = \frac{\frac{M_{y,d}}{W_{n,y}}}{f_{m,d}} = \frac{\frac{81,6\cdot 10^6}{4,52\cdot 10^6}}{20,16} = \frac{18,05}{20,16} = 0,90 < 1,0$$

» Validation of shear

$$\frac{\tau_{z,d}}{f_{v,d}} = \frac{1,5\cdot\frac{V_{z,d}}{A_n}}{f_{v,d}} = \frac{1,5\cdot\frac{48,8\cdot 10^3}{6,16\cdot 10^4}}{1,8} = \frac{1,19}{1,80} = 0,66 < 1,0$$

Validation of the SHERPA connector

The characteristic value for carrying capacity in the insertion direction as per ETA-12/0067 for SHERPA XL 120 (20x120x410 mm) with GL 28h (410 kg/m³):

» $R_{2,k}$ = 144.4 kN

The main beam is assumed to be sufficiently secured against distortion.

» $R_{2,k} = R'_{2,k}$

» Rated value of carrying capacity in the insertion direction

$$R_{2,d} = \frac{k_{mod}\cdot R_{2,k}}{\gamma_M} = \frac{0,9\cdot 144,4}{1,25} = 104\ \text{kN}$$

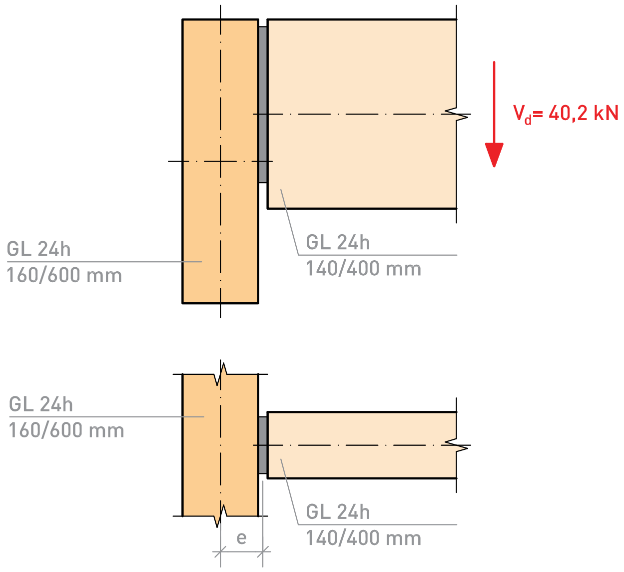
» Validation

$$\frac{V_{2,d}}{R_{2,d}} = \frac{48,8}{104} = 0,46 < 1,0$$

6.2 Eccentric stress in the insertion direction

Overview

02



Information and boundary conditions

Connector:	XL 80	20/120/330 mm		
Installation situation:	A fire resistance check is not needed. The main beam is NOT assumed to be sufficiently secured against distortion.			
Construction material:	Glulam	γ_M = 1.25		
Main beam:	GL 24h	w/h = 160/600 mm		
Secondary beam:	GL 24h	w/h = 140/400 mm	Span width l = 5.50 m	Influence width e = 1.00 m
Exposures:	Constant exposure		g_k = 2.50 kN/m²	
	Payload		p_k = 7.50 kN/m²	ψ_0 = 1.0 ψ_2 = 0.8
NKL: KLED:	$\left.\begin{matrix} 2 \\ \text{kurz} \end{matrix}\right\} k_{mod} = 0{,}8$			

Measured values for exposure as per EN 1990

» Equally distributed load

$$q_d = \left(\gamma_G \cdot g_k + \gamma_Q \cdot p_k\right) \cdot e$$

$$q_d = \left(1{,}35 \cdot 2{,}50 + 1{,}50 \cdot 7{,}50\right) \cdot 1{,}00 = 14{,}63 \text{ kN/m}$$

Measured values for internal forces

» Measured values for bending moment

$$M_d = \frac{q_d \cdot l^2}{8} = \frac{14{,}63 \cdot 5{,}50^2}{8} = 55{,}3 \text{ kNm}$$

» Measured values for transverse force or bearing force

$$V_d = \frac{q_d \cdot l}{2} = \frac{14{,}63 \cdot 5{,}50}{2} = 40{,}2 \text{ kN}$$

Measured values for building material properties in N/mm²

Characteristic values		Measured values	
Bending strength $f_{m,k}$	24.0	Bending strength $f_{m,d}$	15.36
Shear strength $f_{v,k}$	2.5	Shear strength $f_{v,d}$	1.6

The measured values for construction materials X_d is determined using a formula

$$X_d = \frac{k_{mod} \cdot X_k}{\gamma_M} =$$

with the modification coefficient k_{mod}= 0.8 and the partial safety coefficient γ_M= 1.25

Cross-sectional values

» Cross-sectional area

$$A_n = b \cdot h = 140 \cdot 400 = 5{,}60 \cdot 10^4 \text{ mm}^2$$

» Moment of resistance (around the y axis)

$$W_{n,y} = \frac{b \cdot h^2}{6} = \frac{140 \cdot 400^2}{6} = 3{,}73 \cdot 10^6 \text{ mm}^3$$

Validation of the suspended beam in the serviceability limit state

» Validation of bending

$$\frac{\sigma_{m,y,d}}{f_{m,d}} = \frac{\frac{M_{y,d}}{W_{n,y}}}{f_{m,d}} = \frac{\frac{55{,}3 \cdot 10^6}{3{,}73 \cdot 10^6}}{15{,}36} = \frac{14{,}83}{15{,}36} = 0{,}97 < 1{,}0$$

» Validation of shear

$$\frac{\tau_{z,d}}{f_{v,d}} = \frac{1{,}5 \cdot \frac{V_{z,d}}{A_n}}{f_{v,d}} = \frac{1{,}5 \cdot \frac{40{,}2 \cdot 10^3}{5{,}60 \cdot 10^4}}{1{,}6} = \frac{1{,}08}{1{,}60} = 0{,}68 < 1{,}0$$

Validation of the ceiling beam in the serviceability limit state

» Bending of the hanging support with a 1 degree load

$$J_y = \frac{b \cdot h^3}{12} = \frac{0{,}14 \cdot 0{,}40^3}{12} = 7{,}47 \cdot 10^{-4}\ \text{m}^4$$

$$w_{\text{"1"}} = \frac{5}{384} \cdot \frac{q \cdot l^4}{E_{0,mean} \cdot J_y} = \frac{5}{384} \cdot \frac{\text{"1"} \cdot 5{,}50^4}{1{,}16 \cdot 10^7 \cdot 7{,}47 \cdot 10^{-4}} = 1{,}38 \cdot 10^{-3}\ \text{mm}$$

» Validation of the rare measurement situation at time point t = 0

$$w_{Q,inst} = w_{Q,1;inst} + \sum_{i>1}^{n} \psi_{0,i} \cdot w_{Q,i;inst} = 1{,}38 \cdot 1{,}00 \cdot 7{,}50 = 10{,}4\ \text{mm} < \frac{l}{300} = \frac{5500}{300} = 18{,}3\ \text{mm}$$

» Validation of the rare measurement situation at time point t = ∝

$$w_{fin} - w_{G,inst} = w_{Q,inst} + \left(\sum_{j\geq 1}^{m} w_{G,k;j} + \sum_{i\geq 1}^{n} \psi_{2,i} \cdot w_{Q,i} \right) \cdot k_{def} =$$
$$= 10{,}4 + 1{,}38 \cdot 1{,}00 \cdot (2{,}50 + 0{,}8 \cdot 7{,}50) \cdot 0{,}60 =$$
$$= 17{,}4\ \text{mm} < \frac{l}{200} = \frac{5500}{200} = 27{,}5\ \text{mm}$$

» Validation of the quasi-permanent measurement situation at time point t = ∝

$$w_{fin} - w_0 = \left(\sum_{j\geq 1}^{m} w_{G,k;j} + \sum_{i\geq 1}^{n} \psi_{2,i} \cdot w_{Q,i} \right) \cdot (1 + k_{def}) - w_0 =$$
$$= 1{,}38 \cdot 1{,}00 \cdot (2{,}50 + 0{,}8 \cdot 7{,}50) \cdot (1 + 0{,}60) - 0 =$$
$$= 18{,}8\ \text{mm} < \frac{l}{200} = \frac{5500}{200} = 27{,}5\ \text{mm}$$

Validation of the SHERPA connector

The characteristic value for carrying capacity in the insertion direction as per ETA-12/0067 for SHERPA XL 80 (20x120x330 mm) with GL 24h (380 kg/m³):

» $R_{2,k}$ = 94.3 kN

The main beam is NOT sufficiently secured against distortion, i.e. the carrying capacity of the SHERPA connector must be reduced due to the cross-force-moment interaction.

» Load eccentricity

$$e = \frac{b_{MB}}{2} + 10 = \frac{160}{2} + 10 = 90\ \text{mm} > e_{limit} = 31{,}9\ \text{mm}$$

» Reduction using the ETA-12/0067 formula

$$R'_{2,k} = \frac{R_{2,k}}{\left[1+\left(\frac{e-e_{limit}}{e_2}\right)^3\right]^{\frac{1}{3}}} = \frac{94,3}{\left[1+\left(\frac{90-31,9}{62,5}\right)^3\right]^{\frac{1}{3}}} = 77,47\ \text{kN}$$

» For reduction using values in the table, see η_2 in Chapter 3

$$R'_{2,k} = \eta_2 \cdot R_{2,k} = 0,822 \cdot 94,3 = 77,5\ \text{kN}$$

» For reduction using the diagram, see QR code in Chapter 3

$$R'_{2,k} \approx 77\ \text{kN}$$

» Rated value of carrying capacity in the insertion direction

$$R'_{2,d} = \frac{k_{mod} \cdot R_{2,k}}{\gamma_M} = \frac{0,8 \cdot 77,47}{1,25} = 49,58\ \text{kN}$$

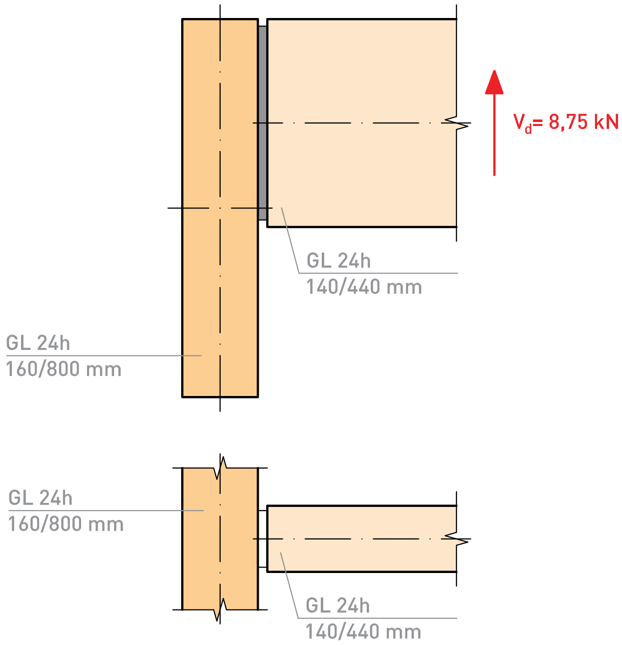
» Validation

$$\frac{V_d}{R'_{2,d}} = \frac{40,20}{49,58} = 0,81 < 1,0$$

6.3 Central stress against the insertion direction

Overview

03



Information and boundary conditions

Connector:	XL 120	20/120/410 mm

Installation situation:	A fire resistance check is not needed. The main beam is assumed to be sufficiently secured against distortion.

Construction material:	Glulam	γ_M = 1.25		
Main beam:	GL 24h	w/h = 160/800 mm		
Secondary beam:	GL 24h	w/h = 140/440 mm	Span width l = 7.00 m	Influence width e = 2.50 m

Exposures:	Constant exposure	g_k = 0.50 kN/m²	
	Snow (height above sea level < 1000 m)	s_k = 3.00 kN/m²	ψ_0 = 0.5 ψ_2 = 0
	Wind (suction)	w_k = 1.00 kN/m²	ψ_0 = 0.6 ψ_2 = 0

NKL: KLED:	$\left.\begin{matrix}2\\ \text{kurz}\end{matrix}\right\} k_{mod} = 0{,}9$

Measured values for exposure as per EN 1990

» Equally distributed load

$$q_d = \left(\gamma_G \cdot g_k + \gamma_Q \cdot w_k + \gamma_Q \cdot \psi_{0,s} \cdot s_k\right) \cdot e$$

$$q_d = \left(1{,}00 \cdot 0{,}50 - 1{,}50 \cdot 1{,}00 + 0 \cdot 0{,}50 \cdot 3{,}00\right) \cdot 2{,}50 = -2{,}50 \text{ kN/m}$$

Measured values for internal forces

» Measured values for transverse force or bearing force

$$V_d = \frac{q_d \cdot l}{2} = \frac{\left|-2{,}50\right| \cdot 7{,}00}{2} = -8{,}75 \text{ kN}$$

Validation of the SHERPA connector

The characteristic value for carrying capacity against the insertion direction as per ETA-12/0067 for SHERPA XL 120 (20x120x410 mm):

» $R_{3,k}$ = 40.6 kN

The main beam is assumed to be sufficiently secured against distortion.

» $R_{3,k} = R'_{3,k}$

» Rated value of carrying capacity in the insertion direction

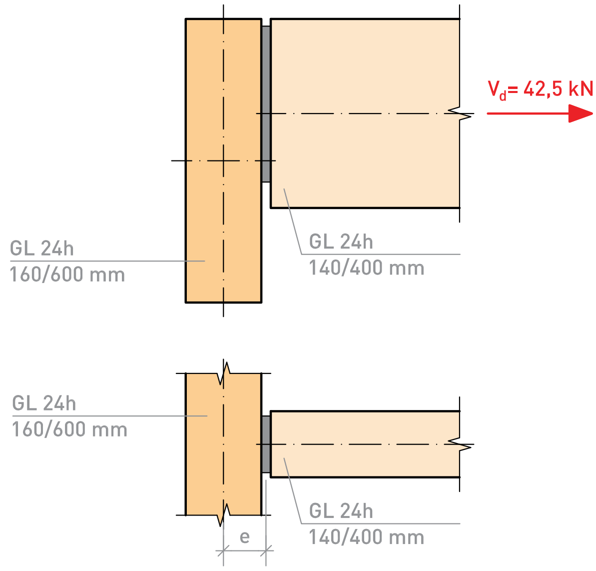
$$R_{3,d} = \frac{k_{mod} \cdot R_{3,k}}{\gamma_M} = \frac{0{,}9 \cdot 40{,}6}{1{,}25} = 29{,}2 \text{ kN}$$

» Validation

$$\frac{V_d}{R_{3,d}} = \frac{\left|-8{,}75\right|}{29{,}2} = 0{,}30 < 1{,}0$$

6.4 Tensile stress in the direction of the secondary beam lengthwise axis

Overview



Information and boundary conditions

Connector:	XL 100	20/120/370 mm

Installation situation:	A fire resistance check is not needed. The main beam is assumed to be sufficiently secured against distortion.

Construction material:	Glulam	γ_M = 1.25
Main beam:	GL 24h	w/h = 160/600 mm
Secondary beam:	GL 24h	w/h = 140/400 mm

NKL: KLED:	$\left.\begin{matrix} 2 \\ \text{kurz} \end{matrix}\right\} k_{mod} = 0{,}9$

Measured values for the effect

» Single tensile load

$$N_d = 42{,}5 \text{ kN}$$

Rated value of the construction material property

$$f_{t,0,k} = 16{,}5 \text{ N/mm}^2$$

$$f_{t,0,d} = \frac{k_{mod} \cdot f_{t,0,k}}{\gamma_M} = \frac{0{,}9 \cdot 16{,}5}{1{,}25} = 11{,}88 \text{ N/mm}^2$$

Cross-sectional area

$$A_n = b \cdot h = 140 \cdot 400 = 5{,}60 \cdot 10^4 \ \text{mm}^2$$

Validation of the suspended beam in the serviceability limit state

» Tensile validation

$$\frac{\sigma_{t,0,d}}{f_{t,0,d}} = \frac{\frac{N_d}{A_n}}{f_{t,0,d}} = \frac{\frac{42{,}5 \cdot 10^3}{5{,}60 \cdot 10^4}}{11{,}88} = \frac{0{,}76}{11{,}88} = 0{,}06 < 1{,}0$$

Validation of the SHERPA connector

The characteristic value for carrying capacity in the direction of the secondary beam lengthwise axis against tensile force as per ETA-12/0067 for SHERPA XL 100 (20x120x370 mm) with GL 24h (380 kg/m³):

» $R_{2,k}$ = 62.3 kN

» Measured tensile stress in the direction of the secondary beam lengthwise axis

$$R_{1,d} = \frac{k_{mod} \cdot R_{1,k}}{\gamma_M} = \frac{0{,}9 \cdot 62{,}3}{1{,}25} = 44{,}86 \ \text{kN}$$

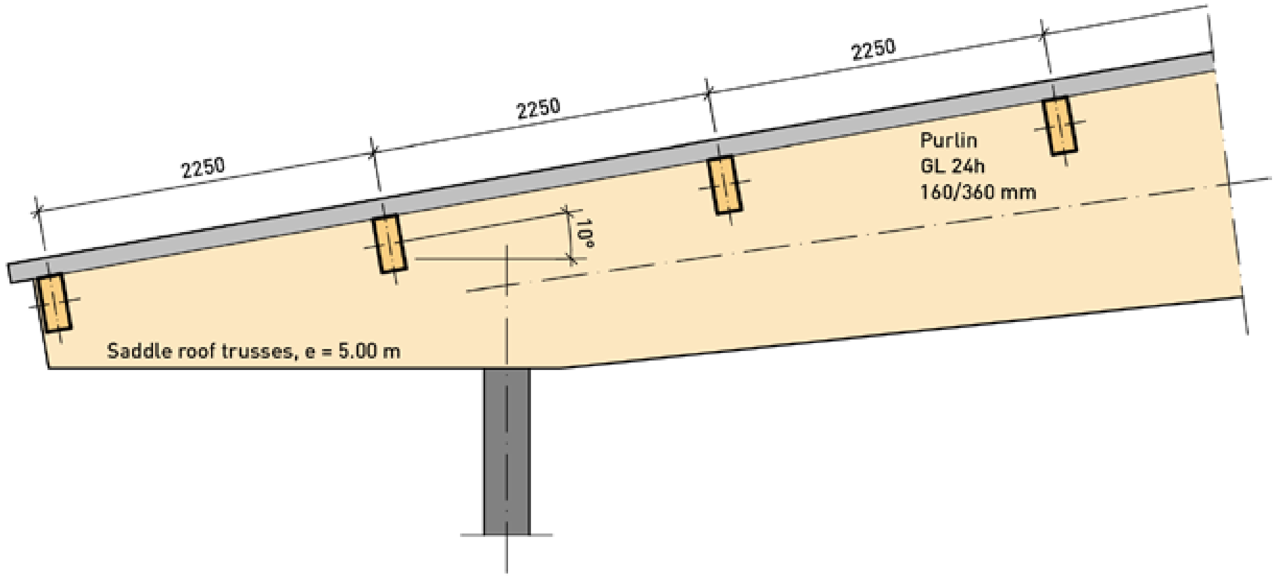
» Validation

$$\frac{N_d}{R_{1,d}} = \frac{42{,}5}{44{,}86} = 0{,}95 < 1{,}0$$

6.5 Combined stress

Overview

05



Information and boundary conditions

Connector:	XL 55	20/120/250 mm		
Installation situation:	A fire resistance check is not needed. The main beam is assumed to be sufficiently secured against distortion.			
Construction material:	Glulam	γ_M = 1.25		
Secondary beam:	GL 24h	w/h = 160/360 mm	Span width l = 5.00 m	Influence width e = 2.25 m
Exposure	Purlin weight		$g_{k,1}$ = 0.32 kN/m	
	Constant exposure		$g_{k,2}$ = 0.50 kN/m²	(based on oblique length)
	Snow (height above sea level < 1000 m)		s_k = 3.00 kN/m²	(based on plan level)
	Wind (pressure)		$w_{D,k}$ = 1.25 kN/m²	(normal on the roof area)
	Wind (suction)		$w_{S,k}$ = 0.25 kN/m²	(normal on the roof area)
NKL: KLED:	$\left.\begin{matrix}2\\ \text{kurz}\end{matrix}\right\} k_{mod} = 0{,}9$			

Measured values for exposure as per EN 1990

» Characteristic values on a purlin related to evenly distributed line load

$$g_{purlin,k} = g_{1,k} + g_{2,k} \cdot e_{SB} = 0{,}32 + 0{,}50 \cdot 2{,}25 = 1{,}45 \text{ kN/m}$$
$$s_{purlin,k} = s_k \cdot e_{SB} \cdot \cos\alpha = 3{,}0 \cdot 2{,}25 \cdot \cos 10 = 6{,}65 \text{ kN/m}$$
$$w_{purlin,D,k} = w_{D,k} \cdot e_{SB} = 1{,}25 \cdot 2{,}25 = 2{,}81 \text{ kN/m}$$
$$w_{purlin,S,k} = w_{S,k} \cdot e_{SB} = 0{,}25 \cdot 2{,}25 = 0{,}56 \text{ kN/m}$$

Remark:
In the following the effects are exclusively given for the purlin. To improve comprehensibility, please check the Purlin Index for more details.

Combined exposure 1:
Snow as the leading effect and wind as a secondary effect

» in the insertion direction

$$q_{2,d;1} = \gamma_G \cdot g_k \cdot \cos\alpha + \gamma_Q \cdot s_k \cdot \cos\alpha + \gamma_Q \cdot \psi_{0,w} \cdot w_{D,k}$$
$$= 1{,}35 \cdot 1{,}45 \cdot \cos 10 + 1{,}50 \cdot 6{,}65 \cdot \cos 10 + 1{,}50 \cdot 0{,}60 \cdot 2{,}81 = 14{,}28 \text{ kN/m}$$

» right angle to the insertion direction

$$q_{2,d;1} = \gamma_G \cdot g_k \cdot \cos\alpha + \gamma_Q \cdot s_k \cdot \cos\alpha + \gamma_Q \cdot \psi_{0,w} \cdot w_{D,k}$$
$$= 1{,}35 \cdot 1{,}45 \cdot \cos 10 + 1{,}50 \cdot 6{,}65 \cdot \cos 10 + 1{,}50 \cdot 0{,}60 \cdot 2{,}81 = 14{,}28 \text{ kN/m}$$

Combined exposure 2:
Wind as the leading effect and snow as a secondary effect

» in the insertion direction

$$q_{2,d;2} = \gamma_G \cdot g_k \cdot \cos\alpha + \gamma_Q \cdot w_{D,k} + \gamma_Q \cdot \psi_{0,s} \cdot s_k \cdot \cos\alpha$$
$$= 1{,}35 \cdot 1{,}45 \cdot \cos 10 + 1{,}50 \cdot 2{,}81 + 1{,}50 \cdot 0{,}50 \cdot 6{,}65 \cdot \cos 10 = 11{,}05$$

» right angle to the insertion direction is not authoritative!

Combined exposure 3:
Validation of the positional stability

» in the insertion direction

$$q_{2,d;3} = \gamma_G \cdot g_k \cdot \cos\alpha + \gamma_Q \cdot w_{D,k} + \gamma_Q \cdot \psi_{0,s} \cdot s_k \cdot \cos\alpha$$
$$= 1{,}00 \cdot 1{,}45 \cdot \cos 10 - 1{,}50 \cdot 0{,}56 = 0{,}59 \text{ kN/m}$$

Authoritative combined exposure:
» in the insertion direction - combined exposure1
» right angle to the insertion direction - combined exposure1
» Positional stability - no lifting stability needed

Measured values for internal forces

» Rated value for bending moment in the insertion direction

$$M_{2,d;1} = \frac{q_{2,d;1} \cdot l^2}{8} = \frac{14{,}28 \cdot 5{,}00^2}{8} = 44{,}6 \text{ kNm}$$

» Measured values for transverse force or bearing force in the insertion direction

$$V_{2,d;1} = \frac{q_{2,d;1} \cdot l}{2} = \frac{14{,}28 \cdot 5{,}00}{2} = 35{,}7 \text{ kN}$$

» Rated value for bending moment at a right angle to the insertion direction

$$M_{45,d;1} = \frac{q_{45,d;1} \cdot l^2}{8} = \frac{2{,}07 \cdot 5{,}00^2}{8} = 6{,}5 \text{ kNm}$$

» Measured values for transverse force or bearing force at a right angle to the insertion direction

$$V_{45,d;1} = \frac{q_{45,d;1} \cdot l}{2} = \frac{2{,}07 \cdot 5{,}00}{2} = 5{,}2 \text{ kN}$$

Measured values for building material properties in N/mm²

Characteristic values		Measured values	
Bending strength $f_{m,k}$	24.0	Bending strength $f_{m,d}$	17.28
Shear strength $f_{v,k}$	2.5	Shear strength $f_{v,d}$	1.8

The measured values for construction materials X_d is determined using a formula

$$X_d = \frac{k_{mod} \cdot X_k}{\gamma_M} =$$

with the modification coefficient k_{mod}= 0.9 and the partial safety coefficient γ_M= 1.25

Cross-sectional values

» Cross-sectional area

$$A_n = b \cdot h = 160 \cdot 360 = 5{,}76 \cdot 10^4 \text{ mm}^2$$

» Moment of resistance (around the y axis)

$$W_{n,y} = \frac{b \cdot h^2}{6} = \frac{140 \cdot 360^2}{6} = 3{,}46 \cdot 10^6 \text{ mm}^3$$

» Moment of resistance (around the z axis)

$$W_{n,z} = \frac{b \cdot h^2}{6} = \frac{160^2 \cdot 360}{6} = 1{,}54 \cdot 10^6 \text{ mm}^3$$

Validation of the purlin in the serviceability limit state

Remark:
We assume that the purlin is secured against tipping or that there's no tipping hazard.
The ratio of cross-sectional dimension is $h/b \leq 4$.

» Validation of bending

$$\frac{\frac{M_{2,d;1}}{W_{n,y}}}{f_{m,d}} + k_{red} \cdot \frac{\frac{M_{45,d;1}}{W_{n,z}}}{f_{m,d}} = \frac{\frac{44{,}6 \cdot 10^6}{3{,}46 \cdot 10^6}}{17{,}28} + 0{,}7 \cdot \frac{\frac{6{,}5 \cdot 10^6}{1{,}54 \cdot 10^6}}{17{,}28} = 0{,}75 + 0{,}7 \cdot 0{,}24 = 0{,}92 < 1{,}0$$

» Validation of shear

$$\left(\frac{1{,}5\cdot\frac{V_{2,d;1}}{A_n}}{f_{v,d}}\right)^2+\left(\frac{1{,}5\cdot\frac{V_{45,d;1}}{A_n}}{f_{v,d}}\right)^2=\left(\frac{1{,}5\cdot\frac{35{,}7\cdot 10^3}{5{,}76\cdot 10^4}}{1{,}8}\right)^2+\left(\frac{1{,}5\cdot\frac{5{,}2\cdot 10^3}{5{,}76\cdot 10^4}}{1{,}8}\right)^2=0{,}27+0{,}005=0{,}28<1{,}0$$

Remark:
The limit state serviceability is not validated in this example!

Validation of the SHERPA connector

The characteristic value for carrying capacity in and at a right angle to the insertion direction as per ETA-12/0067 for SHERPA XL 55 (20x120x250 mm) with GL 24h (380 kg/m³):

» $R_{2,k}$ = 65.5 kN
» $R_{45,k}$ = 27.6 kN

The main beam is sufficiently secure against distortion in and at a right angle to the insertion direction.

» $R_{2,k} = R'_{2,k}$
» $R_{45,k} = R'_{45,k}$

» Rated value of carrying capacity in the insertion direction

$$R_{2,d}=\frac{k_{mod}\cdot R_{2,k}}{\gamma_M}=\frac{0{,}9\cdot 65{,}5}{1{,}25}=47{,}16\text{ kN}$$

» Rated value of carrying capacity at a right angle to the insertion direction

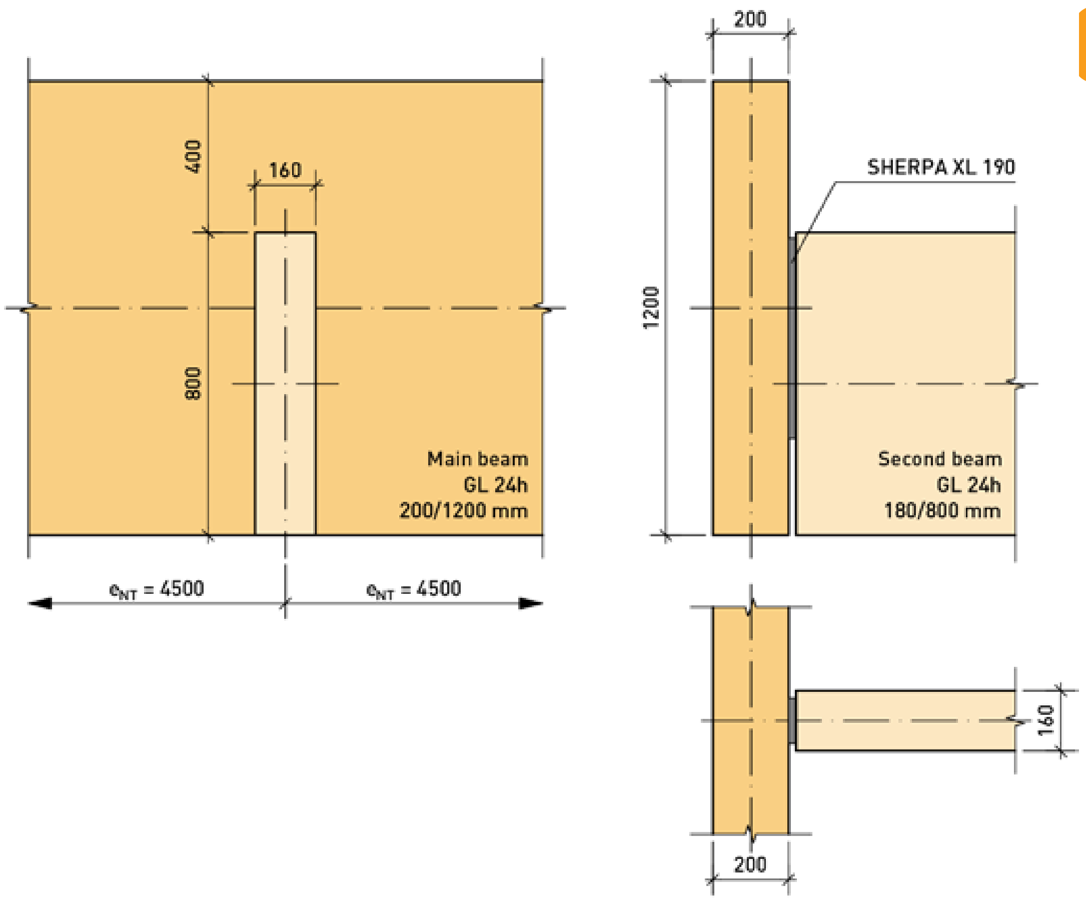
$$R_{45,d}=\frac{k_{mod}\cdot R_{45,k}}{\gamma_M}=\frac{0{,}9\cdot 27{,}6}{1{,}25}=19{,}87\text{ kN}$$

» Validation

$$\left(\frac{V_{2,d;1}}{R_{2,d}}\right)^2+\left(\frac{V_{45,d;1}}{R_{45,d}}\right)^2=\left(\frac{35{,}7}{47{,}16}\right)^2+\left(\frac{5{,}2}{19{,}87}\right)^2=0{,}64<1{,}0$$

6.6 Transverse validation for the main and secondary beam as well as validation of reinforcement measures

Overview



Information and boundary conditions

Connector:	XL 190	20/120/530 mm	
Installation situation:	A fire resistance check is not needed. The main beam is assumed to be sufficiently secured against distortion.		
Construction material:	Glulam	γ_M = 1.25	
Main beam:	GL 24h	w/h = 200/1200 mm	
Secondary beam:	GL 24h	w/h = 160/800 mm	Influence width e = 4.50 m
NKL: KLED:	$\left.\begin{matrix} 2 \\ \text{kurz} \end{matrix}\right\} k_{mod} = 0{,}9$		

Measured values for the affecting shear forces

$$V_{2,d} = 135 \text{ kN}$$

Validation of the SHERPA connector

The characteristic value for carrying capacity in the insertion direction as per ETA-12/0067 for SHERPA XL 190 (20x120x530 mm) with GL 24h (380 kg/m³):

» $R_{2,k}$ = 202.2 kN

The main beam is assumed to be sufficiently secured against distortion.

» $R_{2,k} = R'_{2,k}$

» Rated value of carrying capacity in the insertion direction

$$R_{2,d} = \frac{k_{mod} \cdot R_{2,k}}{\gamma_M} = \frac{0{,}9 \cdot 202{,}2}{1{,}25} = 145{,}6 \text{ kN}$$

» Validation

$$\frac{V_{2,d}}{R_{2,d}} = \frac{135}{145{,}6} = 0{,}93 < 1{,}0$$

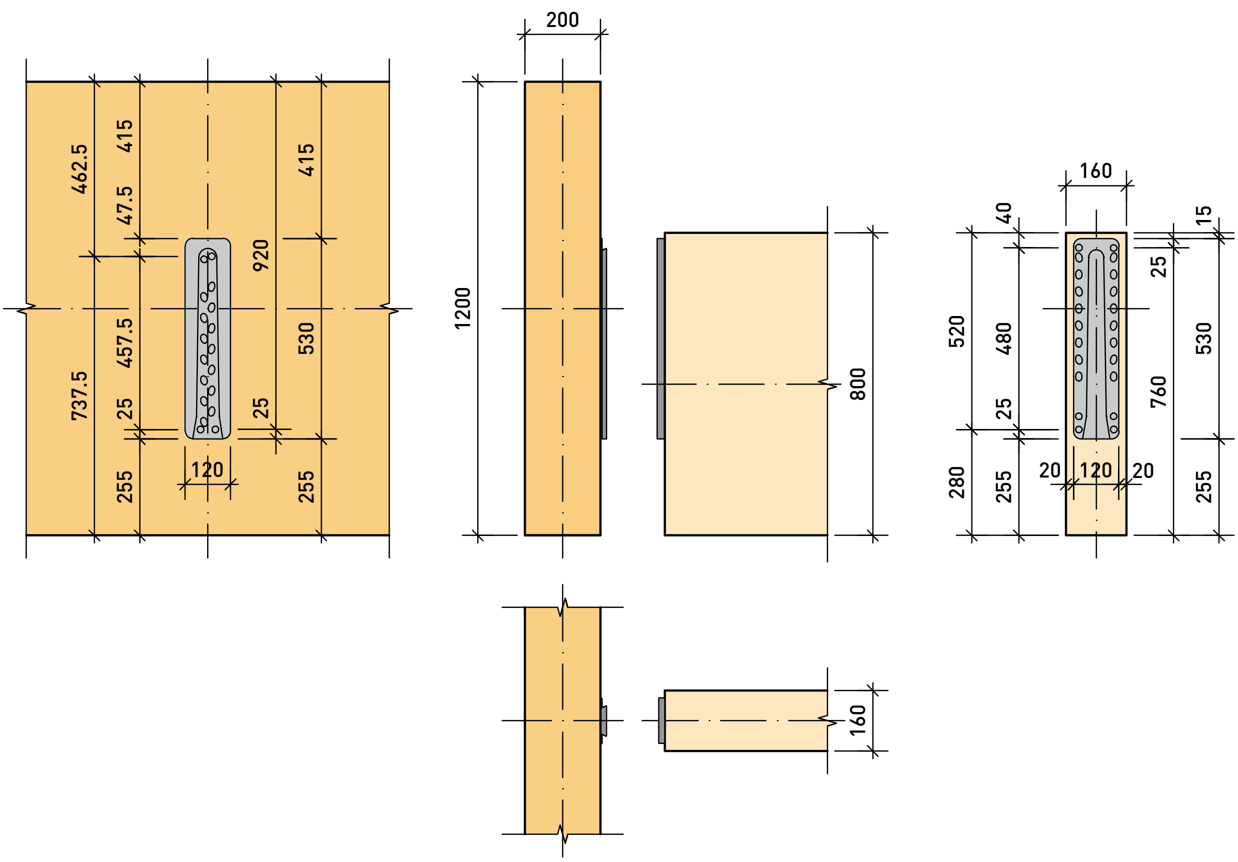
Measured values for building material properties in N/mm²

Characteristic values		Measured values	
Transverse tensile strength $f_{t,90,k}$	0.50	Transverse tensile strength $f_{t,90,d}$	0.36

The measured values for construction materials X_d is determined using a formula

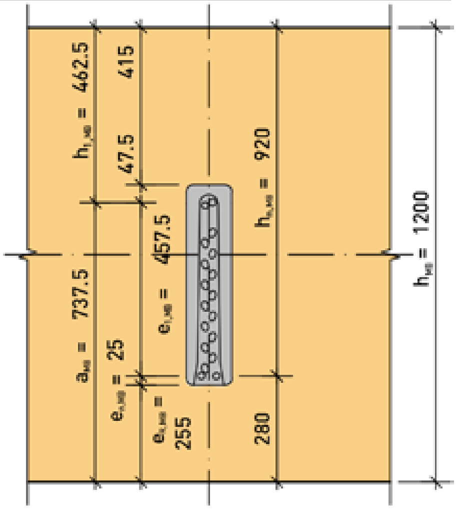
$$X_d = \frac{k_{mod} \cdot X_k}{\gamma_M} =$$

with the modification coefficient k_{mod}= 0.9 and the partial safety coefficient γ_M= 1.25



Check the a/h values for the main and secondary beams

» Connection geometry
» a/h ratio and further geometric data for the main beam



h_{MB} = 1200.0 mm
$e_{R,MB}$ = 255.0 mm
$e_{n,MB}$ = 25.0 mm
$e_{1,MB}$ = 457.5 mm

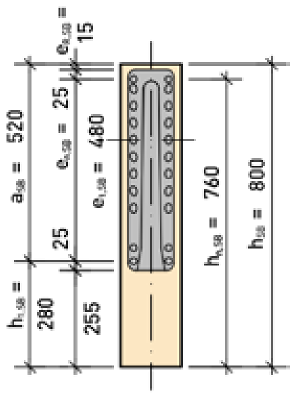
$a_{MB} = e_{R,MB} + e_{n,MB} + e_{1,MB} = 256 + 24 + 464 = 737.5$ mm

$$\Rightarrow \frac{a_{MB}}{h_{MB}} = \frac{737,5}{1200} = 0,620 < 0,7$$

It is necessary to validate the transverse tensile force for the main beam

$h_{1,MB} = h_{MB} - a_{MB} = 1200 - 737.5 = 462.5$ mm
$h_{n,MB} = h_{MB} - (e_{R,MB} + e_{n,MB}) = 1200 - (255 + 25) = 920$ mm

» a/h ratio and further geometric data for the secondary beam



h_{SB} = 800 mm
$e_{R,SB}$ = 15 mm
$e_{n,SB}$ = 25 mm
$e_{1,SB}$ = 480 mm

$a_{SB} = e_{R,SB} + e_{n,SB} + e_{1,SB} = 15 + 25 + 480 = 520$ mm

$$\Rightarrow \frac{a_{SB}}{h_{SB}} = \frac{520}{800} = 0,650 < 0,7$$

It is necessary to validate the transverse tensile force for the secondary beam

$h_{1,SB} = h_{SB} - a_{SB} = 800 - 520 = 280$ mm
$h_{n,SB} = h_{SB} - (e_{R,SB} + e_{n,SB}) = 800 - (15 + 25) = 760$ mm

Validation of the shear load carrying capacity

» Validation to be provided

for $0,2 \le \frac{a}{h} \le 0,7$ the validation must be provided that the $\frac{F_{90,d}}{R_{90,d}} \le 1$ conditions are adhered to.

with $R_{t,90,d} = k_{MB/SB} \cdot k_s \cdot k_r \cdot \left[6,5 + 18 \cdot \left(\frac{a}{h}\right)^2\right] \cdot (t_{ef} \cdot h)^{0,8} \cdot f_{t,90,d}$

Remark:
The explanation of the meaning and definition or determination of number values for individual variables can be found in Chapter 2.

Validation of shear load carrying capacity for the main beam

» Determination of the transmitted forces without reinforcement measures with

$$k_{MB} = 1{,}0$$

$$k_{s,MB} = \max\begin{Bmatrix} 1 \\ 0{,}7 + \dfrac{1{,}4 \cdot a_{r,MB}}{h_{MB}} \end{Bmatrix} = \max\begin{Bmatrix} 1 \\ 0{,}7 + \dfrac{1{,}4 \cdot 15}{1200} \end{Bmatrix} = \max\begin{Bmatrix} 1 \\ 0{,}718 \end{Bmatrix} = 1$$

Remark:
The distance $a_{r,MB}$ with a stress in the insertion direction corresponds to the distance of both of outermost screws of the SHERPA XL connector in the main beam's grain direction.
This is for all SHERPA XL connectors $a_{r,MB}$ = 15 mm.
The lowest torque screws are not considered

$$k_{r,MB} = \frac{n_{MB}}{\sum_{i=}^{n_{MB}} \left(\dfrac{h_{1,MB}}{h_{i,MB}}\right)^2} = \frac{18}{8{,}67} = 2{,}08$$

$$\sum_{i=1}^{18} \left(\frac{h_{1,MB}}{h_{i,MB}}\right)^2 = \left(\frac{462{,}5}{462{,}5}\right)^2 + \left(\frac{462{,}5}{470}\right)^2 + \left(\frac{462{,}5}{542{,}5}\right)^2 + \left(\frac{462{,}5}{570}\right)^2 + \left(\frac{462{,}5}{597{,}5}\right)^2 + \left(\frac{462{,}5}{625}\right)^2 +$$
$$+ \left(\frac{462{,}5}{652{,}5}\right)^2 + \left(\frac{462{,}5}{680}\right)^2 + \left(\frac{462{,}5}{707{,}5}\right)^2 + \left(\frac{462{,}5}{735}\right)^2 + \left(\frac{462{,}5}{762{,}5}\right)^2 + \left(\frac{462{,}5}{790}\right)^2 +$$
$$+ \left(\frac{462{,}5}{817{,}5}\right)^2 + \left(\frac{462{,}5}{845}\right)^2 + \left(\frac{462{,}5}{872{,}5}\right)^2 + \left(\frac{462{,}5}{900}\right)^2 + 2 \cdot \left(\frac{462{,}5}{920}\right)^2 = 8{,}67$$

or simplified for practical application,

$$k_{r,MB} \approx \frac{h_{n,MB}}{h_{1,MB}} \approx \frac{920}{462{,}5} \approx 1{,}99$$

this produces the transferable transverse force without reinforcements:

$$R_{90,d;MB} = 1{,}0 \cdot 1{,}0 \cdot 1{,}99 \cdot \left[6{,}5 + 18 \cdot \left(\frac{737{,}5}{1200}\right)^2\right] \cdot (100 \cdot 1200)^{0{,}8} \cdot 0{,}36 = 110233\ \text{N} \approx 110\ \text{kN}$$

The clearance distance between the SHERPA XL connectors is:

$$\bar{e} = e_{SB} - b_{SB} = 4500 - 120 = 4380\ \text{mm} > 2 \cdot h_{SB} = 2 \cdot 1200 = 2400\ \text{mm}$$

This means that a reduction in the carrying capacity is not needed.

» Validation

$$\frac{F_{90,d}}{R_{90,d;MB}} = \frac{135}{86} = 1{,}57 > 1{,}0$$

A suitable reinforcement measure is needed for the main beam in the area of the SHERPA XL connector.

Validation of shear load carrying capacity for the secondary beam

» Determination of the transmitted forces without reinforcement measures with

$$k_{SB} = 0{,}5$$

$$k_{s,SB} = \max\left\{\begin{matrix} 1 \\ 0{,}7 + \dfrac{1{,}4 \cdot a_{r,SB}}{h_{SB}} \end{matrix}\right\} = \max\left\{\begin{matrix} 1 \\ 0{,}7 + \dfrac{1{,}4 \cdot 100}{800} \end{matrix}\right\} = \max\left\{\begin{matrix} 1 \\ 0{,}875 \end{matrix}\right\} = 1$$

Remark:
Distance $a_{r,SB}$ is to be reduced in insertion direction for the affected secondary SHERPA XL connectors by $a_{r,SB}$ = 100 mm
This is empirically determined, and does not correspond to geometric dimensions

$$k_{r,SB} = \frac{n_{SB}}{\sum_{i=}^{n_{s,SB}} \left(\frac{h_{1,SB}}{h_{i,SB}}\right)^2} = \frac{22}{8{,}01} = 2{,}74$$

$$\sum_{i=1}^{22} \left(\frac{h_{1,SB}}{h_{i,SB}}\right)^2 = 2 \cdot \left(\frac{280}{280}\right)^2 + 2 \cdot \left(\frac{280}{315}\right)^2 + 2 \cdot \left(\frac{280}{420}\right)^2 + 2 \cdot \left(\frac{280}{465}\right)^2 + 2 \cdot \left(\frac{280}{510}\right)^2 + 2 \cdot \left(\frac{280}{555}\right)^2 +$$
$$+ 2 \cdot \left(\frac{280}{600}\right)^2 + 2 \cdot \left(\frac{280}{645}\right)^2 + 2 \cdot \left(\frac{280}{690}\right)^2 + 2 \cdot \left(\frac{280}{735}\right)^2 + 2 \cdot \left(\frac{280}{760}\right)^2 = 8{,}01$$

or simplified for practical application,

$$k_{r,SB} \approx \frac{h_{n,SB}}{h_{1,SB}} \approx \frac{760}{280} \approx 2{,}71$$

this produces at the transferable transverse force without reinforcements:

$$R_{90,d;SB} = 0{,}5 \cdot 1{,}0 \cdot 2{,}71 \cdot \left[6{,}5 + 18 \cdot \left(\frac{520}{800}\right)^2\right] \cdot (120 \cdot 800)^{0{,}8} \cdot 0{,}36 = 66593 \text{ N} \approx 66{,}6 \text{ kN}$$

Remark:
The effective connection depth $t_{ef,SB}$ is determined for the affected secondary beam in the insertion direction with SHERPA XL and XXL connectors at $t_{ef,SB}$ = width of the SHERPA XL and XXL connector, and does not correspond to geometric dimensions.

» Validation

$$\frac{F_{90,d}}{R_{90,d;SB}} = \frac{135}{66{,}6} = 2{,}03 > 1{,}0$$

A suitable reinforcement measure is needed for the main beam in the area of the SHERPA XL connector.

Recommendation and validation of reinforcement measures

The main options for reinforcement measures can be differentiated between

» outside reinforcements (e.g. in the form of nail press bonding of wood products, such as plywood or multi-layer panels, pressed in nail plates and the like)

and

» interior reinforcements (e.g. in the form of full-thread screws, screw rods or glued threaded rods and the like)

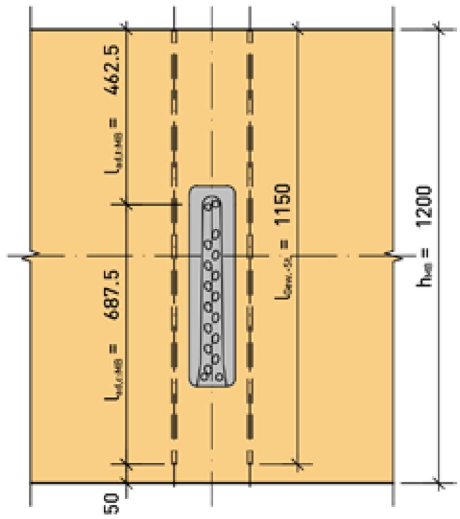
In the framework of the example treated here, for teaching reasons, the validation of the reinforcement measures will be shown for two different, internal reinforcements in the form of glued threaded rods (main beam) and for screw rods (secondary beam).

Validation of reinforcement mechanisms for the main beam

» Forces to be accommodated by reinforcement measures

$$F_{t,90,d;MB} = \left[1-3\cdot\left(\frac{a_{MB}}{h_{MB}}\right)^2+2\cdot\left(\frac{a_{MB}}{h_{MB}}\right)^3\right]\cdot F_{90,d} = \left[1-3\cdot\left(\frac{737,5}{1200}\right)^2+2\cdot\left(\frac{737,5}{1200}\right)^3\right]\cdot 135 = 44,7\ \text{kN}$$

» Chosen connectors
2 x glued threaded rods Ø 12 mm
Steel quality 8.8, outside diameter d_r = 12 mm
Stress cross-section A_{ef} = 84 mm²



» Minimum intervals
reg. a_1 = 3.0 · d_r = 36 mm < current a_2 = 200 mm
reg. $a_{2,c}$ = 3.0 · d_r = 36 mm < current $a_{2,c}$ = 100 mm

» Effective bonding length $l_{ad,MB}$

$$l_{ad,MB} = \min\begin{Bmatrix} l_{ad,t;MB} \\ l_{ad,c;MB} \end{Bmatrix} = \min\begin{Bmatrix} 462,5 \\ 687,5 \end{Bmatrix} = 462,5\ \text{mm}$$

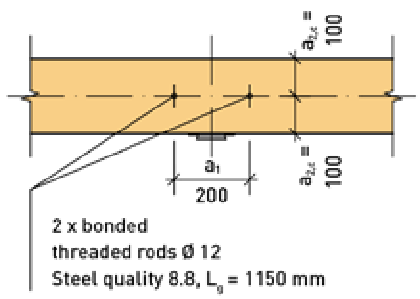
» Rated value of the equally distributed glued joint stress

$$\tau_{ef,d;MB} = \frac{F_{t,90,d;MB}}{n\cdot d_r\cdot\pi\cdot l_{ad,MB}} = \frac{44,7\cdot 10^3}{2\cdot 12\cdot\pi\cdot 462,5} = 1,28\ \text{N/mm}^2$$

» Characteristic strength of the glued joint with

$$250\ \text{mm} < l_{ad,MB} = 462,5\ \text{mm} \leq 500\ \text{mm}$$

$$f_{k,1,k;MB} = 5,25-0,005\cdot l_{ad,MB} = 5,25-0,005\cdot 462,5 = 2,94\ \text{N/mm}^2$$



» rated value of glued joint strength

$$f_{k,1,d;MB} = \frac{k_{mod} \cdot f_{k,1,k;MB}}{\gamma_M} = \frac{0{,}9 \cdot 2{,}94}{1{,}25} = 2{,}12 \text{ N/mm}^2$$

» Validation of the glued joint

$$\frac{\tau_{ef,d;MB}}{f_{k,1,d;MB}} = \frac{1{,}28}{2{,}12} = 0{,}60 \leq 1{,}0$$

» Validation of the tensile carrying capacity of the threaded rods

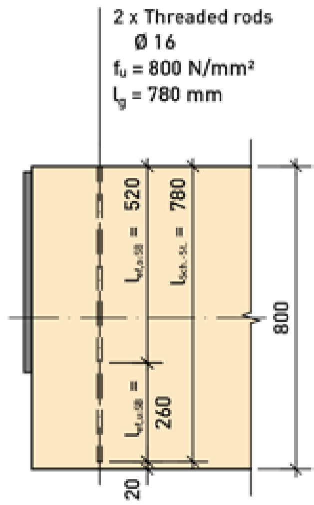
$$\frac{\sigma_{t,90,d;ST}}{f_{t,d;ST}} = \frac{\frac{F_{t,90,d;MB}}{n \cdot A_{ef}}}{\frac{f_{u;ST} \cdot 0{,}9}{\gamma_{M2}}} = \frac{\frac{44{,}7 \cdot 10^3}{2 \cdot 84}}{\frac{800 \cdot 0{,}9}{1{,}25}} = \frac{266}{576} = 0{,}46 < 1{,}0$$

Validation of reinforcement measure for the main beam

» Forces to be accommodated by the reinforcement measures

$$F_{t,90,d;SB} = \left[1 - 3 \cdot \left(\frac{a_{SB}}{h_{SB}}\right)^2 + 2 \cdot \left(\frac{a_{SB}}{h_{SB}}\right)^3\right] \cdot F_{90,d} = \left[1 - 3 \cdot \left(\frac{520}{800}\right)^2 + 2 \cdot \left(\frac{520}{800}\right)^3\right] \cdot 135 = 38{,}0 \text{ kN}$$

» Chosen connectors
2 x threaded rods Ø 16 mm with threads as per DIN 7998
over the entire shaft length, tensile strength f_u = 800 N/mm²,
core cross section A_{ef} = 113 mm²



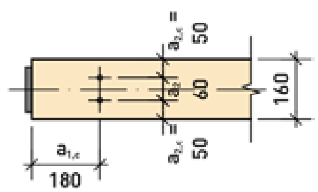
» Minimum intervals
reg. a_2 = 3.0 · d = 48 mm < current a_2 = 60 mm
reg. $a_{1,c}$ = 7.0 · d = 112 mm < current $a_{1,c}$ = 180 mm
reg. $a_{2,c}$ = 3.0 · d = 48 mm < current $a_{2,c}$ = 50 mm

» Characteristic value of the extraction parameter

$$f_{1,k} = 70 \cdot 10^{-6} \cdot \rho_k = 70 \cdot 10^{-6} \cdot 380^2 = 10{,}1 \text{ N/mm}^2$$

» Effective embedment length $l_{ef,SB}$

$$l_{ef,SB} = \min\begin{Bmatrix} l_{ef,o;SB} \\ l_{ef,u;SB} \end{Bmatrix} = \min\begin{Bmatrix} 520 \\ 260 \end{Bmatrix} = 260 \text{ mm}$$



» Characteristic extraction strength of a threaded rod in wood

$$R_{ax,k} = f_{1,k} \cdot d \cdot l_{ef} = 10{,}1 \cdot 16 \cdot 260 = 42016 \text{ N} = 42 \text{ kN}$$

» Measured extraction strength of a threaded rod in wood

$$R_{90,d;SB} = \frac{k_{mod} \cdot R_{ax,d}}{\gamma_M} = \frac{0,9 \cdot 42}{1,25} = 30,2\ kN$$

» Validation of extraction strength of a threaded rod in wood

$$\frac{F_{90,d;SB}}{n \cdot R_{90,d;SB}} = \frac{38,0}{2 \cdot 30,2} = 0,63 < 1$$

» Rated value of tensile carrying capacity of a threaded rod

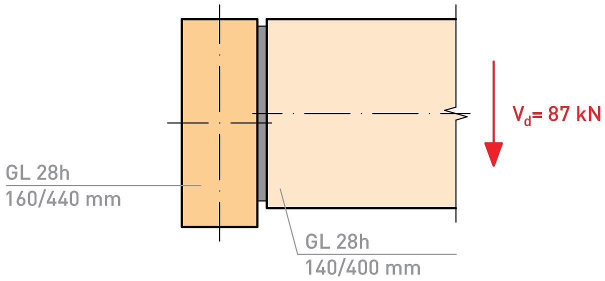
$$R_{t,d;ST} = \frac{0,9 \cdot f_u \cdot A_{ef}}{\gamma_{M2}} = \frac{0,9 \cdot 800 \cdot 113}{1,25} = 65088\ N = 65,1\ kN$$

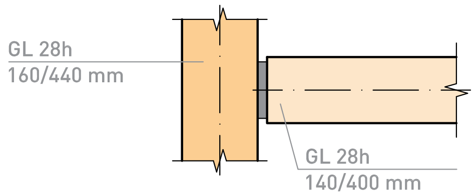
» Validation value of tensile carrying capacity of a threaded rod

$$\frac{F_{90,d;SB}}{n \cdot R_{t,d;ST}} = \frac{38,0}{2 \cdot 65,1} = 0,29 < 1,0$$

6.7 Use of variable screw lengths in the SHERPA XL Series

Overview





Information and boundary conditions

Connector:	XL 100	20/120/370 mm

Installation situation:	A fire resistance check is not needed. The main beam is assumed to be sufficiently secured against distortion.

Construction material:	Glulam	γ_M = 1.25
Main beam:	GL 28h	w/h = 160/440 mm
Secondary beam:	GL 28h	w/h = 140/400 mm

NKL: KLED:	$\left.\begin{matrix} 2 \\ \text{kurz} \end{matrix}\right\} k_{mod} = 0{,}9$

Measured values for the effect

$$V_d = 87 \text{ kN}$$

Validation of the SHERPA connector

The characteristic value for carrying capacity in the insertion direction as per ETA-12/0067 for SHERPA XL 100 (20x120x370 mm) with GL 24h (350 kg/m³):

» $R_{2,k}$ = 88.2 kN

The factor k_{dens} must be determined in order to calculate the characteristic carrying capacity at GL 28h:

$$k_{dens} = k_{sys} \cdot \left(\frac{\rho_k}{350}\right)^{0,8}$$

$$k_{dens} = 1{,}15 \cdot \left(\frac{410}{350}\right)^{0{,}8} = 1{,}31$$

k_{dens}... Factor to consider variations in component density
ρ_k...... Characteristic wood density in kg/m³
k_{sys}.... Factor to consider system effects
k_{sys} = 1.0 for solid wood
k_{sys} = 1.15 for glulam and similar wood materials

» Characteristic value for carrying capacity in the insertion direction with GL 28h

$$R_{2,k;GL28h} = R_{2,k;C24} \cdot k_{dens;GL28h} = 88{,}2 \cdot 1{,}31 = 115{,}5 \text{ kN}$$

» Rated value for carrying capacity in the insertion direction with GL 28h

$$R_{2,d} = \frac{R_{2,k} \cdot k_{mod}}{\gamma_M} = \frac{115{,}5 \cdot 0{,}9}{1{,}25} = 83{,}16 \text{ kN}$$

» Validation

$$\frac{V_{2,d}}{R_{2,d}} = \frac{87}{83{,}16} = 1{,}05 > 1{,}0$$

Validation is not provided

Fulfilment of the validation by adjusting screw length

The basic value for characteristic carrying capacity is related to a screw length of l = 160 mm for the SHERPA XL and XXL series. When changing the screw lengths to 120, 140 or 180 mm, the carrying capacity must be adjusted using the η_{screw} factor.

» Calculating the η_{screw} for a screw length of 180 mm

$$\eta_{screw} = \frac{(l-21)}{139} = \frac{(180-21)}{139} = \frac{159}{139} = 1{,}144$$

» Characteristic value for carrying capacity in the insertion direction with 8 x 180 mm

$$R_{2,k;180} = R_{2,k;160} \cdot \eta_{screw} = 115{,}5 \cdot 1{,}144 = 132 \text{ kN}$$

» Rated value of carrying capacity in the insertion direction with 8 x 180 mm

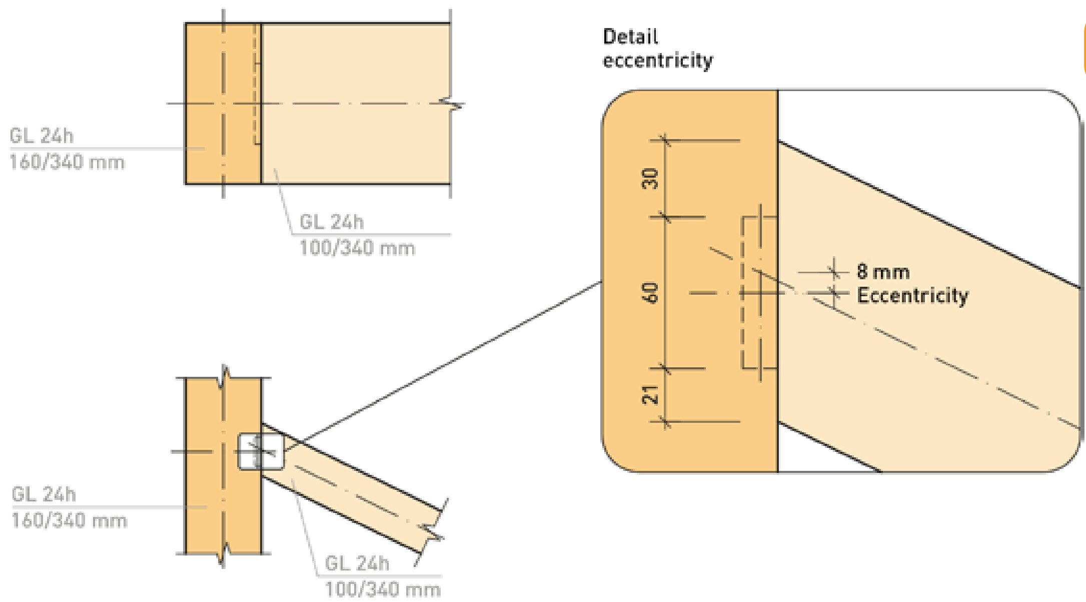
$$R_{2,d;180} = \frac{R_{2,k;180} \cdot k_{mod}}{\gamma_M} = \frac{180 \cdot 0{,}9}{1{,}25} = 95 \text{ kN}$$

» Validation with 8 x 180 mm

$$\frac{V_{2,d}}{R_{2,d;180}} = \frac{87}{95} = 0{,}92 < 1{,}0$$

6.8 Oblique connection with eccentric loads in the insertion direction

Overview



Information and boundary conditions

Connector:	M 40	14/60/170 mm

Installation situation:	A fire resistance check is not needed. The main beam is assumed to be sufficiently secured against distortion.

Construction material:	Glulam	γ_M = 1.25
Main beam:	GL 24h	w/h = 160/340 mm
Secondary beam:	GL 24h	w/h = 100/340 mm

NKL: KLED:	$\left.\begin{matrix} 2 \\ \text{kurz} \end{matrix}\right\} k_{mod} = 0{,}9$

Rated value of stress in the insertion direction

$$V_{2,d} = 20\ \text{kN}$$

Validation of carrying capacity in the insertion direction

The characteristic value for carrying capacity in the insertion direction as per ETA-12/0067 for SHERPA M 40 (14x60x170 mm) with GL 24h (380 kg/m³):

» $R_{2,k}$ = 40.1 kN

» Rated value for carrying capacity in the insertion direction with GL 24h

$$R_{2,d} = \frac{R_{2,k} \cdot k_{mod}}{\gamma_M} = \frac{40{,}1 \cdot 0{,}9}{1{,}25} = 28{,}87\ \text{kN}$$

» Validation

$$\frac{V_{2,d}}{R_{2,d}} = \frac{20}{28,87} = 0,70 < 1,0$$

Validation of torsion carrying capacity

The use of the SHERPA connector with this existing oblique connection adhering to the lateral minimum edge intervals is only possible when related to an eccentric position, based on the secondary beam lengthwise axis. Hence sufficient torsional carrying capacity around the secondary beam lengthwise axis must be validated additionally.

» Rated value of torsion stress around the secondary beam lengthwise axis

$$V_{tor,d} = V_d \cdot e = 20 \cdot 8 = 160 \text{ kNmm}$$

e....... Degree of eccentricity between the connector and the secondary beam lengthwise axis

The characteristic value for torsional carrying capacity as per ETA-12/0067
for SHERPA M 40 (14x60x170 mm) with GL 24h (380 kg/m³):

» $R_{tor,k}$ = 848 kNmm

» Rated value for torsion carrying capacity with GL 24h

$$R_{tor,d} = \frac{R_{tor,k} \cdot k_{mod}}{\gamma_M} = \frac{848 \cdot 0,9}{1,25} = 610,56 \text{ kNmm}$$

» Validation

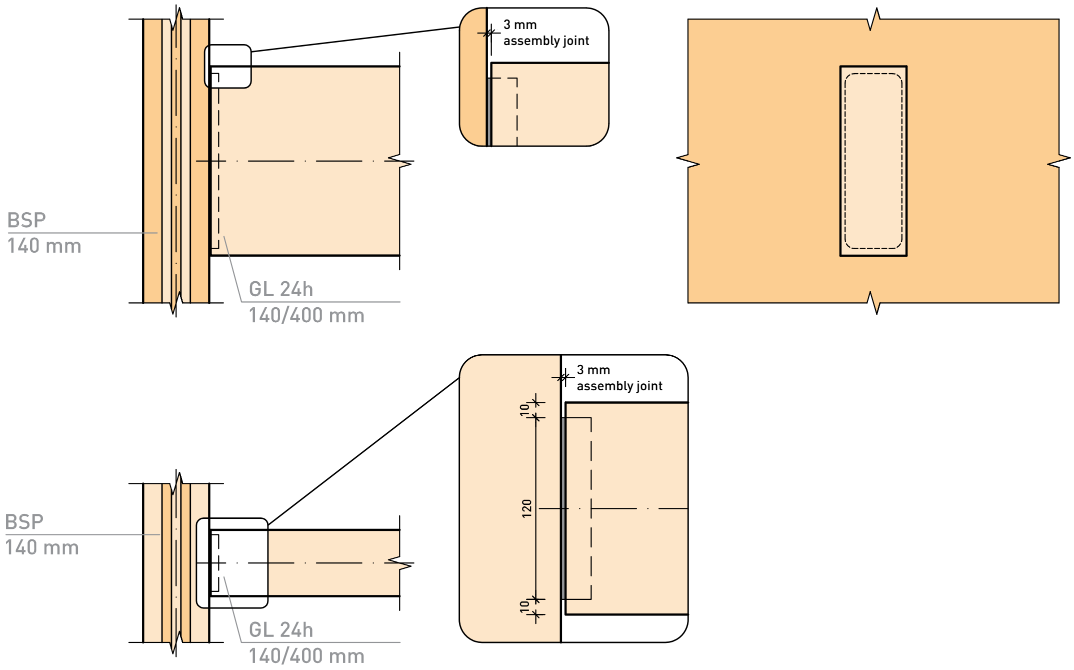
$$\frac{V_{tor,d}}{R_{tor,d}} = \frac{160}{610,56} = 0,26 < 1,0$$

Validation of combined stresses

$$\left(\frac{V_{2,d}}{R_{2,d}}\right)^2 + \frac{V_{tor,d}}{R_{tor,d}} = \left(\frac{20}{28,87}\right)^2 + \frac{160}{610,56} = 0,74 < 1,0$$

6.9 Connection to glulam with adjusted screw lengths

Overview



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Information and boundary conditions

Connector:	XL 100	20/120/370 mm

Installation situation:	A fire resistance check is not needed. The main beam is assumed to be sufficiently secured against distortion.

Construction material:	BSH & BSP	γ_M = 1.25
BSP wall:	Raw strip, C24	b = 140 mm
Secondary beam:	GL 24h	w/h = 140/400 mm

NKL: KLED:	$\left.\begin{matrix} 2 \\ \text{kurz} \end{matrix}\right\} k_{mod} = 0{,}9$

Measured values for the exposure

$$V_{2,d} = 55 \text{ kN}$$

Validation of the SHERPA connector

The characteristic value for carrying capacity in the insertion direction as per ETA-12/0067 for SHERPA XL 100 (20x120x370 mm) with BSP (referred raw density 380 kg/m³):

» $R_{2,k}$ = 108.4 kN

The given characteristic carrying capacity value in the insertion direction is based on standard SHERPA XL series 8 x 160 mm screws. Since the current 140 mm thick BSP wall does not allow for the use of an 8 x 160 screw, SHERPA 8 x 140 mm special screws are used.

Fulfilment of the validation by adjusting screw length

» Calculating the η_{screw} for a screw length of 140 mm

$$\eta_{screw} = \frac{(l-21)}{139} = \frac{(140-21)}{139} = \frac{119}{139} = 0{,}86$$

» Characteristic value for carrying capacity in the insertion direction with 8 x 140 mm

$$R_{2,k;140} = R_{2,k;160} \cdot \eta_{screw} = 108{,}4 \cdot 0{,}86 = 93{,}2 \text{ kN}$$

» Rated value of carrying capacity in the insertion direction with 8 x 140 mm

$$R_{2,d;140} = \frac{R_{2,k;140} \cdot k_{mod}}{\gamma_M} = \frac{93{,}2 \cdot 0{,}9}{1{,}25} = 67{,}1 \text{ kN}$$

» Validation with 8 x 140 mm

$$\frac{V_{2,d}}{R_{2,d;140}} = \frac{55}{67{,}1} = 0{,}82 < 1{,}0$$

Increasing mounting tolerances through joint formation

A mounting joint of 3 mm is provided, as seen in the system diagram. This "space" between the end grain wood of the secondary beam and the side surfaces of the glulam wall prevents excessive friction from occurring during assembly.

Basically, SHERPA XS to M Series are recommended to have at least 1 mm less milling depth, and series L to XXL should have 3 mm less milling depth. This recommendation applies not only to BSP construction, but equally to all connectors that are required to satisfy ease of installation specifications.

The shadow joints produced must on all accounts be subjected to more stringent visual and fire safety inspections.

In no accounts may the milling be deeper than the total connection depth.

7 Product Range

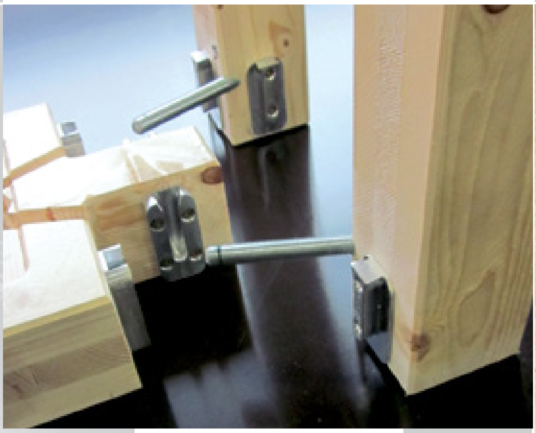
INSTALLATION SERIES

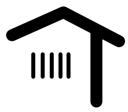
FOR PROFESSIONALS AND DIY ENTHUSIASTS

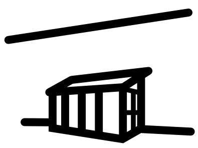
EASY TO HANDLE

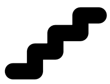
SAFE AND RELIABLE

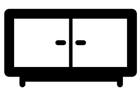
FOR FAST PREPARATION AND INSTALLATION











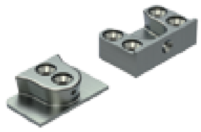
The practical installation series is well-suited for the safe and easy construction of winter gardens, carports, stairs, balconies, platforms and much more.

INSTALLATION SERIES

Mini 10

Dimensions: 10 x 40 mm
Thickness: 10 mm

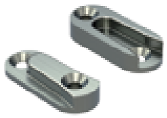
Screws
4 units, 3 x 35



WTS 3 special

Dimensions: 55 x 35 mm
Thickness: 20 mm
1 x locking screw

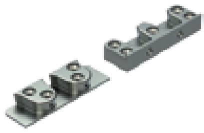
Screws
6 units, 5 x 60



Mini 17

Dimensions: 17 x 40 mm
Thickness: 10 mm

Screws
4 units, 3.5 x 35



WTS 5 special

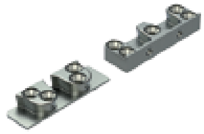
Dimensions: 110 x 35 mm
Thickness: 20 mm
2 x locking screws

Screws
9 units, 5 x 60

WTS 1

Dimensions: 32 x 30 mm
Thickness: 17 mm

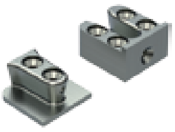
Screws
6 units, 5 x 60



WTS 6 special

Dimensions: 110 x 35 mm
Thickness: 20 mm
2 x locking screws

Screws
9 units, 8 x 80



WTS 1 special

Dimensions: 32 x 35 mm
Thickness: 20 mm
1 x locking screw

Screws
6 units, 5 x 60

A 3

Dimensions: 40 x 80 mm
Thickness: 20 mm

Screws
6 units, 5 x 60

SPECIAL PRODUCTS

Fire-stop 2.5 Fire-resistantlaminate

Roller lengths [m]: 25
Width/thickness [mm]: 20/2.5

Routing template case

1 x routing templates,
1 x Allen key,
2 x cutters, including spacer disk

SHERPA sample case

Dimensions:
100 x 320 x 370

SHERPA tree

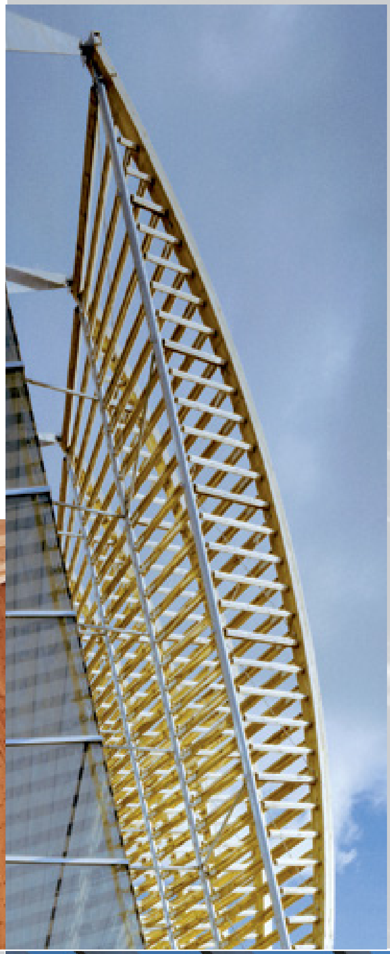
XS - XXL SERIES

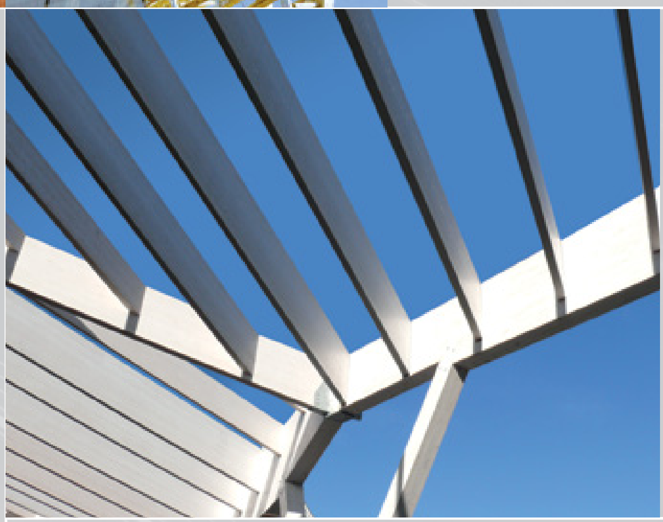
SAFETY PROVIDED BY CERTI-FICATION AND MONITORING

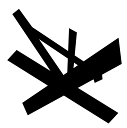
SIMPLE AND FAST CALCULATION

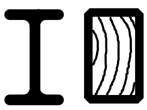
HIGHDEGREE OF PREFABRICATION

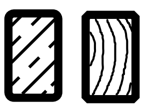
QUICK INSTALLATION











The innovative connectors are suitable for use in many different fields of construction. From working with nodal points in timber construction or roof and wall components to mixed and special structures with steel or concrete – everything is possible.

XS - SERIES[1]

XS 5	
Dimensions: 30 x 50 mm Thickness: 12 mm Minimum cross-section: MB: 50 x 80 mm, SB: 50 x 80 mm	
Screws	characteristic carrying capability (GL 24h)
12 units, 4.5 x 50	approx. 5 kN

XS 10	
Dimensions: 30 x 70 mm Thickness: 12 mm Minimum cross-section: MB: 50 x 100 mm, SB: 50 x 100 mm	
Screws	characteristic carrying capability (GL 24h)
18 units, 4.5 x 50	approx. 10 kN

XS 15	
Dimensions: 30 x 90 mm Thickness: 12 mm Minimum cross-section: MB: 50 x 120 mm, SB: 50 x 120 mm	
Screws	characteristic carrying capability (GL 24h)
21 units, 4.5 x 50	approx. 15 kN

XS 20	
Dimensions: 30 x 110 mm Thickness: 12 mm Minimum cross-section: MB: 50 x 140 mm, SB: 50 x 140 mm	
Screws	characteristic carrying capability (GL 24h)
25 units, 4.5 x 50	approx. 20 kN

Minimum cross-section: minimum cross-sections apply if the upper edge of the main and secondary beams are mounted flush
MB ... Main beam
SB ... Secondary beam
[1)] including standard drill hole for a locking screw

S - SERIES[1]

S 5	
Dimensions: 40 x 50 mm Thickness: 12 mm Minimum cross-section: MB: 60 x 80 mm, SB: 60 x 80 mm	
Screws	characteristic carrying capability (GL 24h)
12 units, 4.5 x 50	approx. 5 kN

S 10	
Dimensions: 40 x 70 mm Thickness: 12 mm Minimum cross-section: MB: 60 x 100 mm, SB: 60 x 100 mm	
Screws	characteristic carrying capability (GL 24h)
18 units, 4.5 x 50	approx. 10 kN

S 15	
Dimensions: 40 x 90 mm Thickness: 12 mm Minimum cross-section: MB: 60 x 120 mm, SB: 60 x 120 mm	
Screws	characteristic carrying capability (GL 24h)
21 units, 4.5 x 50	approx. 15 kN

S 20	
Dimensions: 40 x 110 mm Thickness: 12 mm Minimum cross-section: MB: 60 x 140 mm, SB: 60 x 140 mm	
Screws	characteristic carrying capability (GL 24h)
25 units, 4.5 x 50	approx. 20 kN

XS - S

M - SERIES[1]

M 15	
Dimensions: 60 x 90 mm Thickness: 14 mm Minimum cross-section: MB: 65 x 120 mm, SB: 80 x 120 mm	
Screws	characteristic carrying capability (GL 24h)
16 units, 6.5 x 65	approx. 15 kN

M 20	
Dimensions: 60 x 110 mm Thickness: 14 mm Minimum cross-section: MB: 65 x 140 mm, SB: 80 x 140 mm	
Screws	characteristic carrying capability (GL 24h)
20 units, 6.5 x 65	approx. 20 kN

M 25	
Dimensions: 60 x 130 mm Thickness: 14 mm Minimum cross-section: MB: 65 x 160 mm, SB: 80 x 160 mm	
Screws	characteristic carrying capability (GL 24h)
23 units, 6.5 x 65	approx. 25 kN

M 30	
Dimensions: 60 x 150 mm Thickness: 14 mm Minimum cross-section: MB: 65 x 180 mm, SB: 80 x 180 mm	
Screws	characteristic carrying capability (GL 24h)
26 units, 6.5 x 65	approx. 30 kN

M 40	
Dimensions: 60 x 170 mm Thickness: 14 mm Minimum cross-section: MB: 65 x 200 mm, SB: 80 x 200 mm	
Screws	characteristic carrying capability (GL 24h)
30 units, 6.5 x 65	approx. 40 kN

Minimum cross-section: minimum cross-sections apply if the upper edge of the main and secondary beams are mounted flush
MB ... Main beam
SB ... Secondary beam

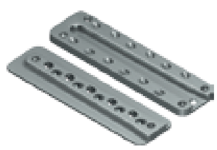
L - SERIES[2]

L 30	
Dimensions: 80 x 150 mm Thickness: 18 mm Minimum cross-section: MB: 100 x 180 mm, SB: 100 x 180 mm	
Screws	characteristic carrying capability (GL 24h)
15 units, 8 x 100, fully threaded	approx. 30 kN

L 40	
Dimensions: 80 x 170 mm Thickness: 18mm Minimum cross-section: MB: 100 x 200 mm, SB: 100 x 200 mm	
Screws	characteristic carrying capability (GL 24h)
18 units, 8 x 100, fully threaded	approx. 40 kN

L 50	
Dimensions: 80 x 210 mm Thickness: 18 mm Minimum cross-section: MB: 100 x 240 mm, SB: 100 x 240 mm	
Screws	characteristic carrying capability (GL 24h)
21 units, 8 x 100, fully threaded	approx. 50 kN

L 60	
Dimensions: 80 x 250 mm Thickness: 18 mm Minimum cross-section: MB: 100 x 280 mm, SB: 100 x 280 mm	
Screws	characteristic carrying capability (GL 24h)
25 units, 8 x 100, fully threaded	approx. 60 kN



L 80	
Dimensions: 80 x 290 mm Thickness: 18 mm Minimum cross-section: MB: 100 x 320 mm, SB: 100 x 320 mm	
Screws	characteristic carrying capability (GL 24h)
29 units, 8 x 100, fully threaded	approx. 80 kN

1) including standard drill hole for a locking screw
2) including standard drill holes for 2 locking screws

M - L

XL - SERIES[2]

XL 55

Dimensions: 120 x 250 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 280 mm, SB: 140 x 280 mm

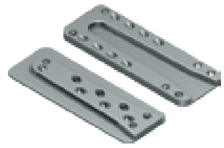
Screws	characteristic carrying capability (GL 24h)
18 units, 8 x 160 Full threads	approx. 55 kN*

XL 70

Dimensions: 120 x 290 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 320 mm, SB: 140 x 320 mm

Screws	characteristic carrying capability (GL 24h)
21 units, 8 x 160 Full threads	approx. 70 kN*

XL 80



Dimensions: 120 x 330 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 360 mm, SB: 140 x 360 mm

Screws	characteristic carrying capability (GL 24h)
24 units, 8 x 160 Full threads	approx. 80 kN*

XL 100

Dimensions: 120 x 370 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 400 mm, SB: 140 x 400 mm

Screws	characteristic carrying capability (GL 24h)
25 units, 8 x 160 Full threads	approx. 100 kN*

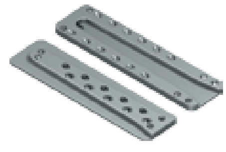
XL 120

Dimensions: 120 x 410 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 400 mm, SB: 140 x 440 mm

Screws	characteristic carrying capability (GL 24h)
29 units, 8 x 160 Full threads	approx. 120 kN*

Minimum cross-section: minimum cross-sections apply if the upper edge of the main and secondary beams are mounted flush
MB ... Main beam
SB ... Secondary beam

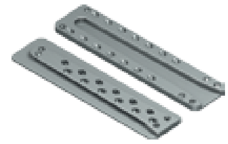
XL 140



Dimensions: 120 x 450 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 480 mm, SB: 140 x 480 mm

Screws	characteristic carrying capability (GL 24h)
32 units, 8 x 160 Full threads	approx. 140 kN*

XL 170



Dimensions: 120 x 490 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 520 mm, SB: 140 x 520 mm

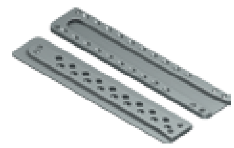
Screws	characteristic carrying capability (GL 24h)
36 units, 8 x 160 Full threads	approx. 170 kN*

XL 190

Dimensions: 120 x 530 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 560 mm, SB: 140 x 560 mm

Screws	characteristic carrying capability (GL 24h)
40 units, 8 x 160 Full threads	approx. 190 kN*

XL 250



Dimensions: 120x 610 mm
Thickness: 20 mm
Minimum cross-section:
MB: 160 x 640 mm, SB: 140 x 640 mm

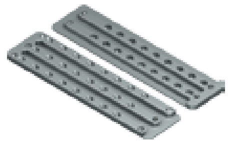
Screws	characteristic carrying capability (GL 24h)
48 units, 8 x 160 Full threads	approx. 250 kN*

[2] including standard drill holes for 2 locking screws
* with SHERPA special screws, 8 x 160
Alternative screw lengths are 120/140/180 mm

XL

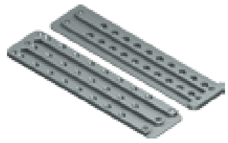
XXL - SERIES[2]

XXL 170	
Dimensions: 140 x 410 mm Thickness: 20 mm Minimum cross-section: MB: 160 x 440 mm, SB: 160 x 440 mm	
Screws	**characteristic carrying capability (GL 24h)**
37 units, 8 x 160, fully threaded	approx. 170 kN*

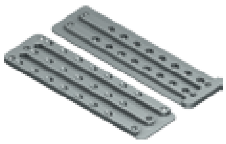


XXL 250	
Dimensions: 140 x 530 mm Thickness: 20 mm Minimum cross-section: MB: 160 x 560 mm, SB: 160 x 560 mm	
Screws	**characteristic carrying capability (GL 24h)**
52 units, 8 x 160, fully threaded	approx. 250 kN*

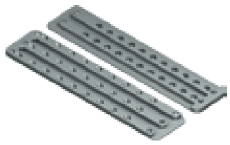
XXL 190	
Dimensions: 120x 450 mm Thickness: 20 mm Minimum cross-section: MB: 160 x 480 mm, SB: 160 x 480 mm	
Screws	**characteristic carrying capability (GL 24h)**
42 units, 8 x 160, fully threaded	approx. 190 kN*



XXL 280	
Dimensions: 140 x 570 mm Thickness: 20 mm Minimum cross-section: MB: 160 x 600 mm, SB: 160 x 600 mm	
Screws	**characteristic carrying capability (GL 24h)**
54 units, 8 x 160, fully threaded	approx. 280 kN*



XXL 220	
Dimensions: 140 x 490 mm Thickness: 20 mm Minimum cross-section: MB: 160 x 520 mm, SB: 160 x 520 mm	
Screws	**characteristic carrying capability (GL 24h)**
47 units, 8 x 160, fully threaded	approx. 220 kN*

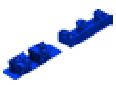
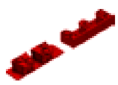
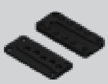
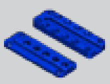
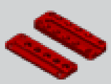
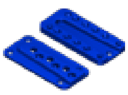
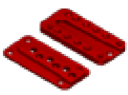


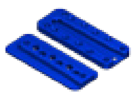
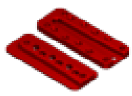
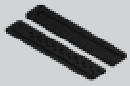
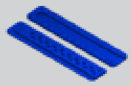
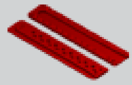
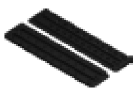
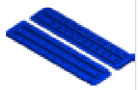
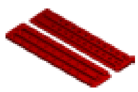
XXL 300	
Dimensions: 140 x 610 mm Thickness: 20 mm Minimum cross-section: MB: 160 x 640 mm, SB: 160 x 640 mm	
Screws	**characteristic carrying capability (GL 24h)**
59 units, 8 x 160, fully threaded	approx. 300 kN*

Minimum cross-section: minimum cross-sections apply if the upper edge of the main and secondary beams are mounted flush
MB ... Main beam
SB ... Secondary beam

[2] including standard drill holes for 2 locking screws
* with SHERPA special screws, 8 x 160
Alternative screw lengths are 120/140/180 mm

COLOUR ANODISING**

Type	black	blue	red
Installation series			
XS - S Series			
M - Series			

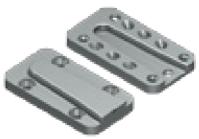
Type	black	blue	red
L - Series			
XL Series			
XXL - Series			

** not in stock Price applies to a minimum volume order of 50 pairs Delivery on request.
These are standard colours; further colours available on request

XXL

CS CONNECTOR for STEEL-REINFORCED CONCRETE and STEEL

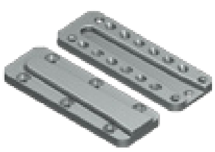
	M 15 CS
	Dimensions: 60 x 90 mm Thickness: 20 mm Minimum cross-section SB: 80 x 120 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 9 units, 6.5 x 65 **Concrete:** 4 units, MMS-F 7.5 x 60	approx. 12.10 kN



	M 20 CS
	Dimensions: 60 x 110 mm Thickness: 20 mm Minimum cross-section SB: 80 x 140 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 11 units, 6.5 x 65 **Concrete:** 4 units MMS-F 7.5 x 60	approx. 13.60 kN

	M 25 CS
	Dimensions: 60 x 130 mm Thickness: 20 mm Minimum cross-section SB: 80 x 160 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 13 units, 6.5 x 65 **Concrete:** 4 units MMS-F 7.5 x 60	approx. 15.10 kN

	M 30 CS
	Dimensions: 60 x 150 mm Thickness: 20 mm Minimum cross-section SB: 80 x 180 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 15 units, 6.5 x 65 **Concrete:** 6 units MMS-F 7.5 x 60	approx. 16.60 kN



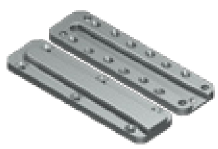
	M 40 CS
	Dimensions: 60 x 170 mm Thickness: 20 mm Minimum cross-section SB: 80 x 200 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 17 units, 6.5 x 65 **Concrete:** 6 units MMS-F 7.5 x 60	approx. 18.10 kN

	L 30 CS
	Dimensions: 80 x 150 mm Thickness: 29 mm Minimum cross-section SB: 100 x 180 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 9 units, 8.0 x 100 **Concrete:** 4 units MMS-F 10 x 80	approx. 39.50 kN

	L 40 CS
	Dimensions: 80 x 170 mm Thickness: 29 mm Minimum cross-section SB: 100 x 200 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 11 units, 8.0 x 100 **Concrete:** 4 units MMS-F 10x80	approx. 42.70 kN

	L 50 CS
	Dimensions: 80 x 210 mm Thickness: 29 mm Minimum cross-section SB: 100 x 240 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 13 units, 8.0 x 100 **Concrete:** 6 units MMS-F 10 x 80	approx. 49.70 kN

	L 60 CS
	Dimensions: 80 x 250 mm Thickness: 29 mm Minimum cross-section SB: 100 x 280 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 15 units, 8.0 x 100 **Concrete:** 6 units MMS-F 10 x 80	approx. 56.50 kN



	L 80 CS
	Dimensions: 80 x 290 mm Thickness: 29 mm Minimum cross-section SB: 100 x 320 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 17 units, 8.0 x 100 **Concrete:** 6 units MMS-F 10 x 80	approx. 63.30 kN

* Measured values with HECO MMS-F concrete screws in kN with steel-reinforced concrete quality C 25/30, adhering to the minimum edge distances and minimum component thicknesses. The connection to the wood cross-section must be considered and assessed depending on the wood quality.

Minimum cross-section SB | minimum cross-section, secondary wood beam

M - L CS

CS CONNECTOR for STEEL-REINFORCED CONCRETE and STEEL

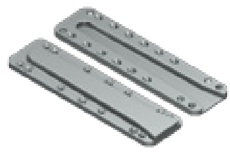
XL 55 CS	
Dimensions: 120 x 250 mm Thickness: 29 mm Minimum cross-section SB: 140 x 280 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 10 units, 8 x 160 **Concrete:** 6 units MMS-F 10 x 80	approx. 63.60 kN

XL 70 CS	
Dimensions: 120 x 290 mm Thickness: 29 mm Minimum cross-section SB: 140 x 320 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 12 units, 8 x 160 **Concrete:** 6 units MMS-F 10 x 80	approx. 64.00 kN

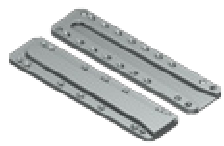
XL 80 CS	
Dimensions: 120 x 330 mm Thickness: 29 mm Minimum cross-section SB: 140 x 360 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 14 units, 8 x 160 **Concrete:** 8 units MMS-F 10 x 80	approx. 79.30 kN

XL 100 CS	
Dimensions: 120 x 370 mm Thickness: 29 mm Minimum cross-section SB: 140 x 400 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 14 units, 8 x 160 **Concrete:** 8 units MMS-F 10 x 80	approx. 85.30 kN

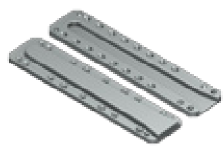
XL 120 CS	
Dimensions: 120 x 410 mm Thickness: 29 mm Minimum cross-section SB: 140 x 440 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 16 units, 8 x 160 **Concrete:** 8 units MMS-F 10 x 80	approx. 85.30 kN



XL 140 CS	
Dimensions: 120 x 450 mm Thickness: 29 mm Minimum cross-section SB: 140 x 480 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 18 units, 8 x 160 **Concrete:** 8 units MMS-F 10 x 80	approx. 85.30 kN



XL 170 CS	
Dimensions: 120 x 490 mm Thickness: 29 mm Minimum cross-section SB: 140 x 520 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 20 units, 8 x 160 **Concrete:** 8 units MMS-F 10 x 80	approx. 85.30 kN



XL 190 CS	
Dimensions: 120 x 530 mm Thickness: 29 mm Minimum cross-section SB: 140 x 560 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 22 units, 8 x 160 **Concrete:** 10 units MMS-F 10 x 80	approx. 106.70 kN

XL 250 CS	
Dimensions: 120 x 610 mm Thickness: 29 mm Minimum cross-section SB: 140 x 640 mm	
Screws	Rated value for carrying capability for C 25/30*
Wood: 26 units, 8 x 160 **Concrete:** 10 units MMS-F 10 x 80	approx. 106.70 kN

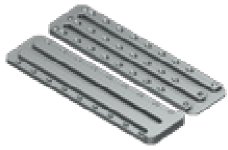
Minimum cross-section SB | minimum cross-section, secondary wood beam

* Measured values with HECO MMS-F concrete screws in kN with steel-reinforced concrete quality C 25/30, adhering to the minimum edge distances and minimum component thicknesses. The connection to the wood cross-section must be considered and assessed depending on the wood quality.

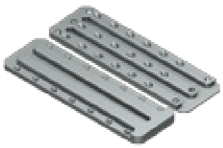
XL CS

CS CONNECTOR for STEEL-REINFORCED CONCRETE and STEEL

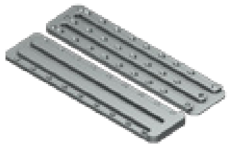
	XXL 170 CS
	Dimensions: 140 x 410 mm Thickness: 29 mm Minimum cross-section SB: 160 x 440 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 21 units, 8 x 160 **Concrete:** 14 units MMS-F 10 x 80	approx. 85.30 kN



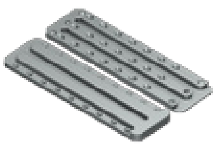
	XXL 250 CS
	Dimensions: 140 x 530 mm Thickness: 29 mm Minimum cross-section SB: 160 x 560 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 30 units, 8 x 160 **Concrete:** 18 units MMS-F 10 x 80	approx. 106.70 kN



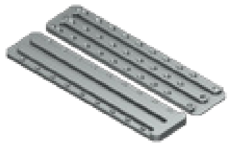
	XXL 190 CS
	Dimensions: 140 x 450 mm Thickness: 29 mm Minimum cross-section, SB: 160 x 480 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 24 units, 8 x 160 **Concrete:** 14 units MMS-F 10 x 80	approx. 85.30 kN



	XXL 280 CS
	Dimensions: 140 x 570 mm Thickness: 29 mm Minimum cross-section SB: 160 x 600 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 30 units, 8 x 160 **Concrete:** 18 units MMS-F 10 x 80	approx. 106.70 kN



	XXL 220 CS
	Dimensions: 140 x 490 mm Thickness: 29 mm Minimum cross-section SB: 160 x 520 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 27 units, 8 x 160 **Concrete:** 18 units MMS-F 10 x 80	approx. 106.70 kN



	XXL 300 CS
	Dimensions: 140 x 610 mm Thickness: 29 mm Minimum cross-section SB: 160 x 640 mm
Screws	**Rated value for carrying capability for C 25/30***
Wood: 33 units, 8 x 160 **Concrete:** 18 units MMS-F 10 x 80	approx. 106.70 kN

Minimum cross-section SB | minimum cross-section, secondary wood beam

* Measured values with HECO MMS-F concrete screws in kN with steel-reinforced concrete quality C 25/30, adhering to the minimum edge distances and minimum component thicknesses. The connection to the wood cross-section must be considered and assessed depending on the wood quality.

XXL CS

SHERPA SPECIAL SCREWS

Depending upon the connector type, the relevant special screws must be used as defined in the ETA-12/0067 certification in order to ensure the specified characteristic carrying capability values.
These system screws are yellow zinc galvanised or, if requested, can be obtained with a zinc-nickel layer, and have a strengthened screw head. The head stamping also allows for monitoring even when screwed in.

SHERPA special screws with a rated diameter of 8 mm have a patented half tip which reduces the danger of cracking, and provides optimum screw bite.

SCREWS for SHERPA SERIES XS TO XXL

YELLOW ZINC GALVANISED

X and S series
Dimensions: 4.5 x 50 mm

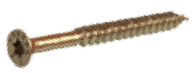
Installation series
Dimensions: 5.0 x 60 mm

M series
Dimensions: 6.5 x 65 mm

Installation series
Dimensions: 8.0 x 80 mm

L series
Dimensions: 8.0 x 100 mm

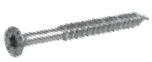
Installation series
Dimensions: 8.0 x 120 mm



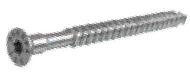
XL and XXL series
Dimensions: 8.0 x 120 mm 8.0 x 140 mm 8.0 x 160 mm 8.0 x 180 mm

! Yellow zinc galvanised for moderate stress - corrosiveness categories C1, C2 and C3 as per EN ISO 12944-2.

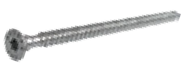
ZINC-NICKEL:



X and S series
Dimensions: 4.5 x 50 mm



L series
Dimensions: 8.0 x 100 mm



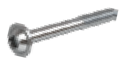
XL and XXL series
Dimensions: 8.0 x 160 mm

! Zinc-nickel plated, for severe load exposure – corrosive categories C1 to C5 M long as per EN ISO 12944-2.

SELF-TAPPING LOCKING SCREWS

If the connection requires it, the two connecting plates can be held together through the use of specially developed locking screws.

Because these are self-tapping screws, there is an optimum ideal fit between aluminium and the thread edges. This ensures high safety against independent loosening, even when exposed to relatively high stresses. Installation of the locking screws requires little effort.

	**XS series**	Dimensions: 3 x 12 mm
	**L series**	Dimensions: 5 x 47.8/20 mm
	**S series**	Dimensions: 3 x 20/9 mm
	**XL and XXL series**	Dimensions: 6 x 100/55 mm
	**M series**	Dimensions: 4 x 20/12 mm

FASTENERS for CS SERIES

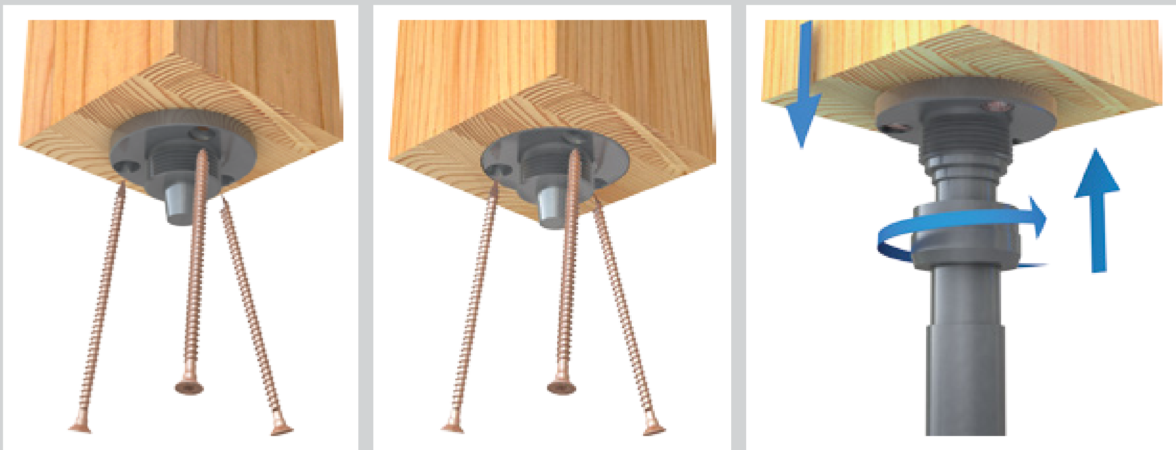
Used for the M series	Multi-Monti MMS-F 7.5 x 60
Used for the L, XL and XXL series	Multi-Monti MMS-F 10 x 80
Used for the XL series **Alternative to MMS-F 10x80**	HL anchor, FH II 12/15 SK Dimensions: 12 x 90 mm

SHERPA POWER BASE

The team centred around our Managing Director and founder, Vinzenz Harrer, has collaborated with the Graz Technical University to develop a high-performance supporting foot. This cooperation has produced the SHERPA Power Base, available now in two sizes Type L can be used for heights from 140 to 200 mm. Type XL can be used in a range from 200 to 300 mm.

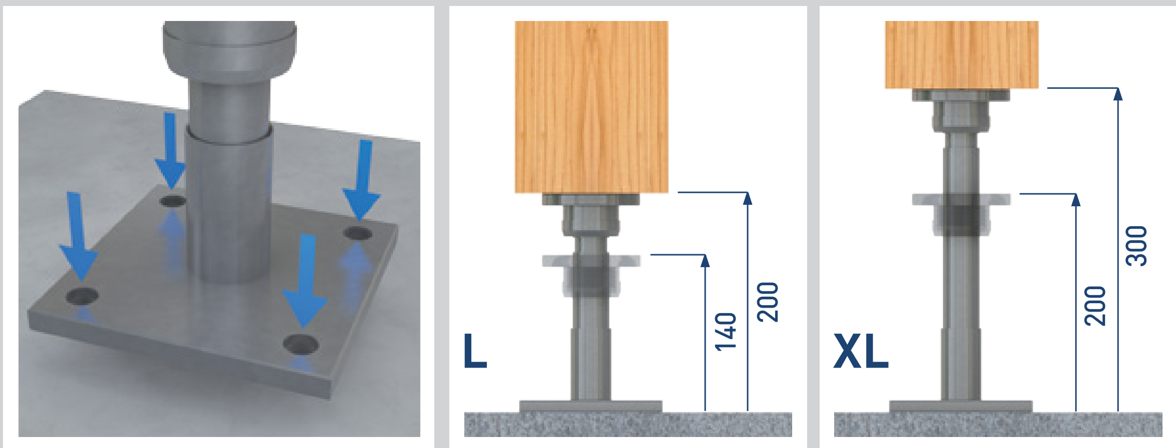
Combined with the reinforced special screws the centring tip, provides for simple and precise installation. The Power Base is suitable for solid wood and glulam. In addition to rectangular cross-sections, the system is suitable for handling round wood without any restrictions. The minimum wood dimensions here are 120 x 120 mm, or a diameter of 120 mm Non-visible screws can be used in the area of a removable headplate to achieve an attractive look and effective weather protection.

INSTALLING THE HEADPLATE



The headplate must be centred on the front, and attached with three special SHERPA screws, 8 x 160 or 8 x 180 mm, at an angle of approx. 25 degrees. The structural wood protection improves sinking the headplate into the support. (thickness= 12 mm / Ø 96 mm). The cone is used to precisely fit the headplate on the substructure. A union nut (55 mm flat spanner) is used to make the connection with between the two parts.

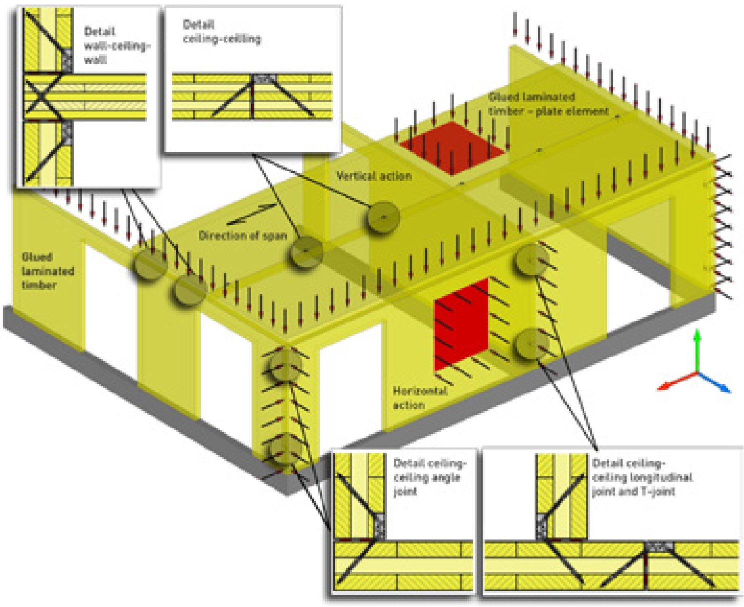
INSTALLING THE BASE PLATE



The base plate is anchored either with four metal spreading anchor bolts or concrete screws. Manufacturing tolerances and building subsidence can also be balanced under load (32 mm flat spanner)
Possible height settings are: L.....140 - 200 mm
XL...200 - 300 mm

Designation	Height adjustment	Wood screws	Minimum wood dimension	Headplate	base plate	Concrete anchor bolt	$R_{2,k}$
Power Base L	140 - 200 mm	3 units, 8 x 160 mm	120 x 120 / Ø 120 mm	Ø 96 mm	140 x 140 mm	4 units	approx. 140 kN
		3 units, 8 x 180 mm	140 x 140 / Ø 140 mm				
Power Base XL	200 - 300 mm	3 units, 8 x 160 mm	120 x 120 / Ø 120 mm	Ø 96 mm	140 x 140 mm	4 units	approx. 140 kN
		3 units, 8 x 180 mm	140 x 140 / Ø 140 mm				

SHERPA CLT CONNECTOR



The use of plywood board elements has increased rapidly in wood construction, and has also brought permanent changes to the sector. But 'concurrent development' or adaptation of classic connecting materials available at the moment in line with this technology.
This prompted Sherpa Connection Systems GmbH and the Chair of Wood Construction at Innsbruck University to develop a system connector specifically designed for plywood.

Optimised for 3- and 5-layer plywood elements, the SHERPA CLT Connector is suitable for flush installation in solid wood panels in the preparatory phase.

SHERPA CLT connectors fully satisfy all requirements listed in the following:

MANUFACTURING	PROCESSING	CALCULATING
Fit	Simple handling	Simple measuring
Screw arrangement on the side surfaces	Installation from the inside without scaffolding	Optimised connector geometry
Easy adjustment	Easy disassembly	Ductile failure
One connector for corner, T and longitudinal joints	Compensates usual tolerances	Reliability of the Euro design

XS CLT Connector in set, with plug-in	
Dimensions of the XS CLT Connector	20 x 40 x 70 mm
Plug-in	15 x 40 x 60 mm
Fasteners	5 units, 6.5 x 65 mm 4 units, 8.0 x 100 mm

CLT Connector S in the set with a plug-in	
Dimensions of the S CLT Connector	20 x 40 x 100 mm
Plug-in	15 x 40 x 60 mm
Fasteners	5 units, 6.5 x 65 mm 8 units, 8.0 x 100 mm

XS CLT Connector	
Dimensions of the S CLT Connector	20 x 40 x 70 mm
Fasteners	4 units, 8.0 x 100 mm

S CLT Connector	
Dimensions of the S CLT Connector	20 x 40 x 100 mm
Fasteners	8 units, 8.0 x 100 mm

Construction tower in the Bavarian Forest National Park
(Archives: Josef Stöger, Photo: Jan Sommer)
Carried out by: WIEHAG

8 Literature & Standards

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"Wood construction for supporting purposes - strength classes"
Austrian Standards Institute (ON), Vienna, 2009

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THE ADVANTAGES ARE CLEAR:

SAFETY THROUGH AN APPROVED SYSTEM

MULTIFUNCTIONAL IN STRENGTH AND USE

STANDARDIZED AND SIMPLE EVALUATION

A HIGH DEGREE OF PRE-FABRICATION

QUICK ASSEMBLY

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