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Authorised and notified according to Article 10 of the Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products

MEMBER OF EOTA

European Technical Approval ETA-13/0091

Trade name:	FU SHANG self-tapping screws
Holder of approval:	FU SHANG CO., LTD. NO. 45, LN, 69, DAPU 2ND RD. GANGSHAN TOWNSHIP KAOHSIUNG COUNTY 820 TAIWAN, R.O.C Tel. + 886-7-628 1234 Fax + 886-7-628 1088
Generic type and use of construction product:	Self-tapping screws for use in timber structures
Valid from: to:	2013-05-28 2018-05-28
Manufacturing plant:	FU SHANG CO., LTD Manufacturing Plant II
This European Technical Approval contains:	26 pages including 3 annexes which form an integral part of the document

I LEGAL BASIS AND GENERAL CONDITIONS

1 This European Technical Approval is issued by ETA-Danmark A/S in accordance with:

- Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products[1)], as amended by Council Directive 93/68/EEC of 22 July 1993[2)].

- Bekendtgørelse 559 af 27-06-1994 (afløser bekendtgørelse 480 af 25-06-1991) om ikrafttræden af EF direktiv af 21. december 1988 om indbyrdes tilnærmelse af medlemsstaternes love og administrative bestemmelser om byggevarer.

- Common Procedural Rules for Requesting, Preparing and the Granting of European Technical Approvals set out in the Annex to Commission Decision 94/23/EC[3)].

2 ETA-Danmark A/S is authorized to check whether the provisions of this European Technical Approval are met. Checking may take place in the manufacturing plant. Nevertheless, the responsibility for the conformity of the products to the European Technical Approval and for their fitness for the intended use remains with the holder of the European Technical Approval.

3 This European Technical Approval is not to be transferred to manufacturers or agents of manufacturers other than those indicated on page 1, or manufacturing plants other than those indicated on page 1 of this European Technical Approval.

4 This European Technical Approval may be withdrawn by ETA-Danmark A/S pursuant to Article 5(1) of Council Directive89/106/EEC.

5 Reproduction of this European Technical Approval including transmission by electronic means shall be in full. However, partial reproduction can be made with the written consent of ETA-Danmark A/S. In this case partial reproduction has to be designated as such. Texts and drawings of advertising brochures shall not contradict or misuse the European Technical Approval.

6 This European Technical Approval is issued by ETA-Danmark A/S in English.
This version corresponds fully to the version circulated within EOTA. Translations into other languages have to be designated as such.

1) Official Journal of the European Communities N° L40, 11 Feb 1989, p 12.
2) Official Journal of the European Communities N° L220, 30 Aug 1993, p 1.
3) Official Journal of the European Communities N° L 17, 20 Jan 1994, p 34.

II SPECIAL CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of product and intended use

Definition of the product
FU SHANG screws are self-tapping screws to be used in timber structures. FU SHANG screws shall be threaded over a part of the length. The screws shall be produced from carbon or stainless (1.4006) steel wire. Where corrosion protection is required, the material or coating shall be declared in accordance with the relevant specification given in Annex A of EN 14592.

Geometry and Material
The nominal diameter (outer thread diameter), d, shall not be less than 3,5 mm and shall not be greater than 12,0 mm. The overall length, L, of screws shall not be less than 30 mm and shall not be greater than 400 mm. Other dimensions are given in Annex A.

The ratio of inner thread diameter to outer thread diameter d_i/d ranges from 0,56 to 0,83.

The screws are threaded over a minimum length ℓ_g of 4·d (i.e. $\ell_g \geq 4 \cdot d$).

The lead p (distance between two adjacent thread flanks) ranges from 0,46·d to 1,00·d.

No breaking of screws shall be observed at a bend angle, α, of less than $(45/d^{0,7} + 20)$ degrees.

Intended use
The screws are used for connections in load bearing timber structures between members of solid timber (softwood), glued laminated timber, cross-laminated timber, and laminated veneer lumber, similar glued members, wood-based panels or steel.

Furthermore FU SHANG screws with diameters of at least 6 mm may also be used for the fixing of thermal insulation on rafters.

Steel plates and wood-based panels except solid wood panels, laminated veneer lumber and cross laminated timber shall only be located on the side of the screw head. The following wood-based panels may be used:

- Plywood according to EN 636 or European Technical Approval
- Particleboard according to EN 312 or European Technical Approval
- Oriented Strand Board according to EN 300 or European Technical Approval
- Fibreboard according to EN 622-2 and 622-3 or European Technical Approval (minimum density 650 kg/m³)
- Cement bonded particleboard according to European Technical Approval
- Solid wood panels according to EN 13353 and EN 13986 and cross laminated timber according to European Technical Approval
- Laminated Veneer Lumber according to EN 14374 or European Technical Approval
- Engineered wood products according to European Technical Approval; if the ETA of the product includes provisions for the use of self-tapping screws, the provisions of the ETA of the engineered wood product apply

The screws shall be driven into the wood without pre-drilling or after pre-drilling with a diameter not larger than the inner thread diameter for the length of the threaded part and with a maximum of the smooth shank diameter for the length of the smooth shank.

The screws are intended to be used in timber connections for which requirements for mechanical resistance and stability and safety in use in the sense of the Essential Requirements 1 and 4 of Council Directive 89/106/EEC shall be fulfilled.

The design of the connections shall be based on the characteristic load-carrying capacities of the screws. The design capacities shall be derived from the characteristic capacities in accordance with Eurocode 5 or an appropriate national code.

The screws are intended for use for connections subject to static or quasi static loading.

The scope of the screws regarding resistance to corrosion shall be defined according to national provisions that apply at the installation site considering environmental conditions. Section 2.7 of this ETA contains the corrosion protection for FU SHANG screws made from carbon steel and the material number of the stainless steel.

Assumed working life
The assumed intended working life of the screws for the intended use is 50 years, provided that they are subject to appropriate use and maintenance.

The information on the working life should not be regarded as a guarantee provided by the manufacturer or the approval body issuing the ETA. An “assumed intended working life” means that it is expected that, when this working life has elapsed, the real working life may be, in normal use conditions, considerably longer without major degradation affecting the essential requirements.

2 Characteristics of product and assessment

	Characteristic	Assessment of characteristic
2.1	**Mechanical resistance and stability*)**	
2.1.1	Tensile strength	Characteristic value $f_{tens,k}$: d = 3,5 mm: 3,8 kN d = 4,0 mm: 5,0 kN d = 4,2 mm: 5,5 kN d = 4,5 mm: 6,4 kN d = 4,8 mm: 7,2 kN d = 5,0 mm: 7,9 kN d = 6,0 mm: 11 kN d = 8,0 mm: 20 kN d = 10,0 mm: 32 kN d = 12,0 mm: 38 kN
2.1.2	Insertion moment	Ratio of the characteristic torsional strength to the mean insertion moment: $f_{tor,k} / R_{tor,mean} \geq 1,5$
2.1.3	Torsional strength	Characteristic value $f_{tor,k}$: d = 3,5 mm: 2,3 Nm d = 4,0 mm: 3,3 Nm d = 4,2 mm: 4,0 Nm d = 4,5 mm: 4,3 Nm d = 4,8 mm: 8,0 Nm d = 5,0 mm: 6,5 Nm d = 6,0 mm: 11 Nm d = 8,0 mm: 30 Nm d = 10,0 mm: 44 Nm d = 12,0 mm: 65 Nm
2.2	**Safety in case of fire**	
2.2.1	Reaction to fire	The screws are made from steel classified as **Euroclass A1** of the characteristic reaction to fire, in accordance with the provisions of EC decision 96/603/EC, amended by EC Decision 2000/605/EC.
2.3	**Hygiene, health and the environment**	
	Influence on air quality	No dangerous materials **)
2.4	**Safety in use**	Not relevant
2.5	**Protection against noise**	Not relevant
2.6	**Energy economy and heat retention**	Not relevant

Characteristic		Assessment of characteristic
2.7 Related aspects of serviceability		
2.7.1	Durability	The screws have been assessed as having satisfactory durability and serviceability when used in timber structures using the timber species described in Eurocode 5 and subject to the conditions defined by service classes 1, 2 and 3
2.7.2	Serviceability	
2.7.3	Identification	See Annex A

*) See page 6 of this ETA

**) In accordance with http://europa.eu.int-/comm/enterprise/construction/internal/dangsub/dangmain.htm In addition to the specific clauses relating to dangerous substances contained in this European Technical Approval, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the EU Construction Products Directive, these requirements need also to be complied with, when and where they apply.

2.1 Mechanical resistance and stability

The load-carrying capacities for FU SHANG screws are applicable to the wood-based materials mentioned in paragraph 1 even though the term timber has been used in the following.

The characteristic lateral load-carrying capacities and the characteristic axial withdrawal capacities of FU SHANG screws should be used for designs in accordance with Eurocode 5 or an appropriate national code.

Point side penetration length must be $\ell_{ef} \geq 4 \cdot d$, where d is the outer thread diameter of the screw. For the fixing of rafters, point side penetration must be at least 40 mm, $\ell_{ef} \geq$ 40 mm.

European Technical Approvals for structural members or wood-based panels must be considered where applicable.

Lateral load-carrying capacity

The characteristic lateral load-carrying capacity of FU SHANG screws shall be calculated according to EN 1995-1-1:2008 (Eurocode 5) using the outer thread diameter d as the nominal diameter of the screw. The contribution from the rope effect may be considered.

The characteristic yield moment shall be calculated from:

Screw d = 3,5 mm:	$M_{y,k}$ = 2,0 Nm
Screw d = 4,0 mm:	$M_{y,k}$ = 3,0 Nm
Screw d = 4,2 mm:	$M_{y,k}$ = 3,8 Nm
Screw d = 4,5 mm:	$M_{y,k}$ = 4,3 Nm
Screw d = 4,8 mm:	$M_{y,k}$ = 5,3 Nm
Screw d = 5,0 mm:	$M_{y,k}$ = 5,9 Nm
Screw d = 6,0 mm:	$M_{y,k}$ = 9,5 Nm
Screw d = 8,0 mm:	$M_{y,k}$ = 20 Nm
Screw d = 10,0 mm:	$M_{y,k}$ = 36 Nm
Screw d = 12,0 mm:	$M_{y,k}$ = 50 Nm

Where

d outer thread diameter [mm]

The embedding strength for screws in non-pre-drilled holes arranged at an angle between screw axis and grain direction, $30° \leq \alpha \leq 90°$ is:

$$f_{h,k} = \frac{0,082 \cdot \rho_k \cdot d^{-0,3}}{2,5 \cdot \cos^2 \alpha + \sin^2 \alpha} \quad [N/mm^2]$$

and accordingly for screws in pre-drilled holes:

$$f_{h,k} = \frac{0,082 \cdot \rho_k \cdot (1 - 0,01 \cdot d)}{2,5 \cdot \cos^2 \alpha + \sin^2 \alpha} \quad [N/mm^2]$$

Where

ρ_k characteristic timber density [kg/m³];

d outer thread diameter [mm];

α angle between screw axis and grain direction.

The embedding strength for screws arranged parallel to the plane of cross laminated timber, independent of the angle between screw axis and grain direction, $0° \leq \alpha \leq 90°$, shall be calculated from:

$$f_{h,k} = 20 \cdot d^{-0,5} \quad [N/mm^2]$$

Where

d outer thread diameter [mm]

The embedding strength for screws in the wide face of cross laminated timber should be assumed as for solid timber based on the characteristic density of the outer layer. If relevant, the angle between force, screw axis and grain direction of the outer layer should be taken into account.

The direction of the lateral force shall be perpendicular to the screw axis and parallel to the wide face of the cross laminated timber.

Axial withdrawal capacity

The characteristic axial withdrawal capacity of FU SHANG screws in solid timber (softwood), glued laminated timber, cross-laminated timber or laminated veneer lumber members at an angle of $30° \leq \alpha \leq 90°$ to the grain shall be calculated according to EN 1995-1-1:2008 from:

$$F_{ax,\alpha,Rk} = \frac{n_{ef} \cdot f_{ax,k} \cdot d \cdot \ell_{ef}}{1,2 \cdot \cos^2 \alpha + \sin^2 \alpha} \cdot \left(\frac{\rho_k}{350} \right)^{0,8} \quad [N]$$

Where

$F_{ax,\alpha,RK}$ characteristic withdrawal capacity of the screw at an angle α to the grain [N]

n_{ef} effective number of screws according to EN 1995-1-1:2008

$f_{ax,k}$ Characteristic withdrawal parameter

Screw 3,5 mm ≤ d < 6,0 mm: $f_{ax,k}$ = 13,0 N/mm²

Screw 6,0 mm ≤ d ≤ 8,0 mm: $f_{ax,k}$ = 11,0 N/mm²

Screw d ≥ 10,0 mm: $f_{ax,k}$ = 10,0 N/mm²

d outer thread diameter [mm]

ℓ_{ef} Penetration length of the threaded part according to EN 1995-1-1:2008 [mm]

α Angle between grain and screw axis ($\alpha \geq 30°$)

ρ_k Characteristic density [kg/m³]

For screws penetrating more than one layer of cross laminated timber, the different layers may be taken into account proportionally.

The axial withdrawal capacity for screws arranged parallel to the plane of laminated veneer lumber and at an angle of $30° \leq \alpha \leq 90°$ to the grain shall be reduced by 20 %.

The axial withdrawal capacity is limited by the head pull-through capacity and the tensile capacity of the screw.

The axial slip modulus K_{ser} of the threaded part of a screw for the serviceability limit state should be taken independent of angle α to the grain as:

$K_{ser} = 780 \cdot d^{0,2} \cdot \ell_{ef}^{0,4}$ [N/mm],

Where

d outer thread diameter [mm]

ℓ_{ef} penetration length in the timber member [mm]

Head pull-through capacity

The characteristic head pull-through capacity of FU SHANG screws shall be calculated according to EN 1995-1-1:2008 from:

$$F_{ax,\alpha,Rk} = n_{ef} \cdot f_{head,k} \cdot d_h^2 \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \quad [N]$$

where:

$F_{ax,\alpha,RK}$ characteristic head pull-through capacity of the connection at an angle $\alpha \geq 30°$ to the grain [N]

n_{ef} effective number of screws according to EN 1995-1-1:2008

$f_{head,k}$ characteristic head pull-through parameter [N/mm²]

d_h Diameter of the screw head or the washer [mm]. Outer diameter of washers $d_k > 32$ mm shall not be considered.

ρ_k characteristic density [kg/m³], for wood-based panels $\rho_k = 380$ kg/m³

Characteristic head pull-through parameter for screws in connections with timber and in connections with wood-based panels with thicknesses above 20 mm:

Screws 3,5 mm $\leq$ d < 6,0 mm: $f_{head,k} = 20,0$ N/mm²

Screws 6,0 mm $\leq$ d $\leq$ 8,0 mm: $f_{head,k} = 14,0$ N/mm²

Screws d $\geq$ 10,0 mm: $f_{head,k} = 9,4$ N/mm²

Characteristic head pull-through parameter for screws in connections with wood-based panels with thicknesses between 12 mm and 20 mm:

$f_{head,k} = 8$ N/mm²

Screws in connections with wood-based panels with a thickness below 12 mm (minimum thickness of the wood based panels of 1,2·d with d as outer thread diameter):

$f_{head,k} = 8$ N/mm²

limited to $F_{ax,Rk} = 400$ N

The head diameter d_h shall be greater than $1,8 \cdot d_s$, where d_s is the smooth shank or the wire diameter. Otherwise the characteristic head pull-through capacity $F_{ax,\alpha,Rk} = 0$.

The minimum thickness of wood-based panels according to the clause 2.1 must be observed.

In steel-to-timber connections the head pull-through capacity is not governing.

Tensile capacity

The characteristic tensile strength $f_{tens,k}$ of FU SHANG screws is:

d = 3,5 mm:	3,8 kN
d = 4,0 mm:	5,0 kN
d = 4,2 mm:	5,5 kN
d = 4,5 mm:	6,4 kN
d = 4,8 mm:	7,2 kN
d = 5,0 mm:	7,9 kN
d = 6,0 mm:	11 kN
d = 8,0 mm:	20 kN
d = 10,0 mm:	32 kN
d = 12,0 mm:	38 kN

For screws used in combination with steel plates, the tear-off capacity of the screw head including a washer shall be greater than the tensile capacity of the screw.

Combined laterally and axially loaded screws

For screwed connections subjected to a combination of axial and lateral load, the following expression should be satisfied:

$$\left(\frac{F_{ax,Ed}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{v,Ed}}{F_{v,Rd}}\right)^2 \leq 1$$

where

$F_{ax,Ed}$ axial design load of the screw

$F_{v,Ed}$ lateral design load of the screw

$F_{ax,Rd}$ design load-carrying capacity of an axially loaded screw

$F_{v,Rd}$ design load-carrying capacity of a laterally loaded screw

2.7 Related aspects of serviceability

2.7.1 Corrosion protection.

The FU SHANG screws are produced from carbon wire. They are brass-plated, nickel-plated bronze finished or electrogalvanised and e.g. yellow or blue chromated with thicknesses of the zinc coating from 4 – 16 µm or have a zinc flake coating with thicknesses from 10 – 20 µm.

Steel no. 1.4006 is used for screws made from stainless steel.

3 Attestation of Conformity and CE marking

3.1 Attestation of Conformity system

The system of attestation of conformity is 2+ described in Council Directive 89/106/EEC (Construction Products Directive) Annex III.

a) Tasks for the manufacturer:

(1) Factory production control,
(2) Initial type testing of the product,

b) Tasks for the notified body:

(1) Initial inspection of the factory and the factory production control,
(2) Continuous surveillance

3.2 Responsibilities

3.2.1 Tasks of the manufacturer

3.2.1.1 Factory production control

The manufacturer has a factory production control system in the plant and exercises permanent internal control of production. All the elements, requirements and provisions adopted by the manufacturer are documented in a systematic manner in the form of written policies and procedures. This production control system ensures that the product is in conformity with the European Technical Approval.

The manufacturer shall only use raw materials supplied with the relevant inspection documents as laid down in the control plan[4]. The incoming raw materials shall be subject to controls and tests by the manufacturer before acceptance. Check of raw materials, such as metal wire, shall include control of the inspection documents presented by suppliers (comparison with nominal values) by verifying dimension and determining material properties.

The manufactured components shall be subject to the following checks:

- Raw material specification;
- Dimension of the screws;
- Characteristic tensile strength $f_{tens,k}$;
- Characteristic torsional strength $f_{tor,k}$;
- Characteristic insertion moment $R_{tor,k}$;
- Durability;
- Marking.

The control plan, which is part of the technical documentation of this European Technical Approval, includes details of the extent, nature and frequency of testing and controls to be performed within the factory production control and has been agreed between the approval holder and ETA Danmark.

The results of factory production control are recorded and evaluated. The records include at least the following information:

- Designation of the product, basic material and components;
- Type of control or testing;
- Date of manufacture of the product and date of testing of the product or basic material and components;
- Result of control and testing and, if appropriate, comparison with requirements;
- Signature of person responsible for factory production control.

The records shall be presented to ETA Danmark on request.

3.2.1.1 Initial type testing of the product

For initial type-testing the results of the tests performed as part of the assessment for the European Technical Approval shall be used unless there are changes in the production line or plant. In such cases the necessary initial type testing has to be agreed between ETA Danmark and the notified body.

The initial type testing shall be subject to the following checks:

- Raw material specification;
- Dimension of the screws;
- Characteristic yield moment $M_{y,k}$;
- Characteristic withdrawal parameter $f_{ax,k}$;
- Characteristic head pull-through parameter $f_{head,k}$;
- Characteristic tensile strength $f_{tens,k}$;
- Characteristic yield strength if relevant;
- Characteristic torsional strength $f_{tor,k}$;
- Characteristic insertion moment $R_{tor,k}$;
- Durability.

3.2.2. Tasks of notified bodies

3.2.2.1 Initial inspection of the factory and the factory production control

4 The control plan has been deposited at ETA-Danmark and is only made available to the approved bodies involved in the conformity attestation procedure.

The approved body should ascertain that, in accordance with the control plan, the factory, in particular the staff and equipment, and the factory production control, are suitable to ensure a continuous and orderly manufacturing of the screws with the specifications given in part 2.

3.2.2.2 Continuous surveillance

The approved body shall visit the factory at least once a year for routine inspections. It shall be verified that the system of factory production control and the specified manufacturing processes are maintained, taking account of the control plan.

The results of product certification and continuous surveillance shall be made available on demand by the certification body to ETA Danmark. Where the provisions of the European Technical Approval and the control plan are no longer fulfilled, the certificate of conformity shall be withdrawn by the approved body.

3.3 CE marking

The CE marking shall be affixed on each packaging of screws. The initials "CE" shall be followed by the identification number of the notified body and shall be accompanied by the following information:

- Name or identifying mark of the manufacturer
- The last two digits of the year in which the marking was affixed
- Number of the European Technical Approval
- Name of product
- Outer thread diameter and length of the self-tapping screws
- Type and mean thickness of the corrosion protection, if relevant
- Stainless steel including the material number, if relevant
- Number of the EC Certificate of Conformity

4 Assumptions under which the fitness of the product for the intended use was favourably assessed

4.1 Manufacturing

The screws are manufactured in accordance with the provisions of the European Technical Approval using the automated manufacturing process as identified during the inspection of the plant by the approval body issuing the ETA and the approved body and laid down in the technical documentation.

4.2 Installation

4.2.1 The installation shall be carried out in accordance with Eurocode 5 or an appropriate national code unless otherwise is defined in the following. Instructions from FU SHANG Co. Ltd. should be considered for installation.

4.2.2 The screws are used for connections in load bearing timber structures between members of solid timber (softwood), glued laminated timber, cross-laminated timber (minimum diameter d = 6,0 mm), and laminated veneer lumber, similar glued members, wood-based panels or steel members.

The screws may be used for connections in load bearing timber structures with structural members according to an associated European Technical Approval, if according to the associated European Technical Approval of the structural member a connection in load bearing timber structures with screws according to a European Technical Approval is allowed.

FU SHANG screws with diameters of at least 6 mm may also be used for the fixing of thermal insulation material on top of rafters.

A minimum of two screws should in general be used for connections in load bearing timber structures.

The minimum penetration depth in structural members made of solid, glued or cross-laminated timber is 4·d.

Wood-based panels and steel plates should only be arranged on the side of the screw head. The minimum thickness of wood-based panels should be 1,2·d. Furthermore the minimum thickness for following wood-based panels should be:

- Plywood, Fibreboards: 6 mm
- Particleboards, OSB, Cement Particleboards: 8 mm
- Solid wood panels: 12 mm

For structural members according to European Technical Approvals the terms of the European Technical Approvals must be considered.

If screws with an outer thread diameter $d \geq 8$ mm are used in load bearing timber structures, the structural solid or glued laminated timber, laminated veneer lumber and similar glued members must be from spruce, pine or fir. This does not apply for screws in pre-drilled holes.

The minimum angle between the screw axis and the grain direction is $\alpha = 30°$.

4.2.3 The screws shall be driven into the wood with or without pre-drilling. The maximum pre-drilling diameters are the inner thread diameter for the length of the threaded part and the smooth shank diameter for the depth of the smooth shank. The hole diameter in steel members must be predrilled with a suitable diameter.

Only the equipment prescribed by FU SHANG Co. Ltd. shall be used for driving the screws.

In connections with screws with countersunk head according to Annex A the head must be flush with the surface of the connected structural member. A deeper countersink is not allowed.

4.2.4 For structural timber members, minimum spacing and distances for screws in predrilled holes are given in EN 1995-1-1:2008 (Eurocode 5) clause 8.3.1.2 and table 8.2 as for nails in predrilled holes. Here, the outer thread diameter d must be considered.

For FU SHANG screws in non-predrilled holes, minimum spacing and distances are given in EN 1995-1-1:2004 (Eurocode 5) clause 8.3.1.2 and table 8.2 as for nails in non-predrilled holes. Here, the outer thread diameter d must be considered.

For Douglas fir members minimum spacing and distances parallel to the grain shall be increased by 50%.

Minimum distances from loaded or unloaded ends must be 15·d for screws in non-predrilled holes with outer thread diameter $d \geq 8$ mm and timber thickness $t < 5 \cdot d$.

Minimum distances from the unloaded edge perpendicular to the grain may be reduced to 3·d also for timber thickness $t < 5 \cdot d$, if the spacing parallel to the grain and the end distance is at least 25·d.

Minimum distances and spacing for screws in the plane surface of cross laminated timber members with a minimum thickness $t = 10 \cdot d$ may be taken as (see Annex B):

Spacing a_1 parallel to the grain	$a_1 = 4 \cdot d$
Spacing a_2 perpendicular to the grain	$a_2 = 2{,}5 \cdot d$
Distance $a_{3,c}$ from centre of the screw-part in	

timber to the unloaded end grain	$a_{3,c} = 6 \cdot d$
Distance $a_{3,t}$ from centre of the screw-part in timber to the loaded end grain	$a_{3,t} = 6 \cdot d$
Distance $a_{4,c}$ from centre of the screw-part in timber to the unloaded edge	$a_{4,c} = 2{,}5 \cdot d$
Distance $a_{4,t}$ from centre of the screw-part in timber to the loaded edge	$a_{4,t} = 6 \cdot d$

Minimum distances and spacing for screws in the edge surface of cross laminated timber members with a minimum thickness t = 10·d and a minimum penetration depth perpendicular to the edge surface may be taken as (see Annex B):

Spacing a_1 parallel to the CLT plane	$a_1 = 10 \cdot d$
Spacing a_2 perpendicular to the CLT plane	$a_2 = 4 \cdot d$
Distance $a_{3,c}$ from centre of the screw-part in timber to the unloaded end	$a_{3,c} = 7 \cdot d$
Distance $a_{3,t}$ from centre of the screw-part in timber to the loaded end	$a_{3,t} = 12 \cdot d$
Distance $a_{4,c}$ from centre of the screw-part in timber to the unloaded edge	$a_{4,c} = 3 \cdot d$
Distance $a_{4,t}$ from centre of the screw-part in timber to the loaded edge	$a_{4,t} = 6 \cdot d$

Minimum distances and spacing for FU SHANG screws in cross laminated timber are given in Annex B.

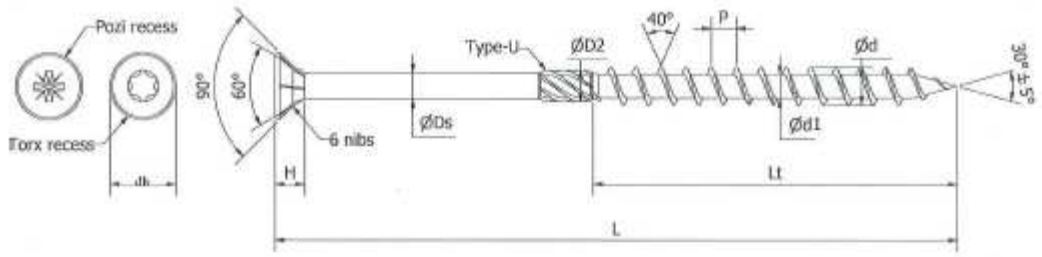
Minimum thickness for structural members is t = 24 mm for screws with outer thread diameter d < 8 mm, t = 30 mm for screws with outer thread diameter d = 8 mm, and t = 40 mm for screws with outer thread diameter d = 10 mm.

4.3 Maintenance and repair

Maintenance is not required during the assumed intended working life. Should repair prove necessary, it is normal to replace the screw.

Thomas Bruun
Manager, ETA-Danmark

Annex A
Drawings of Fu Shang screws

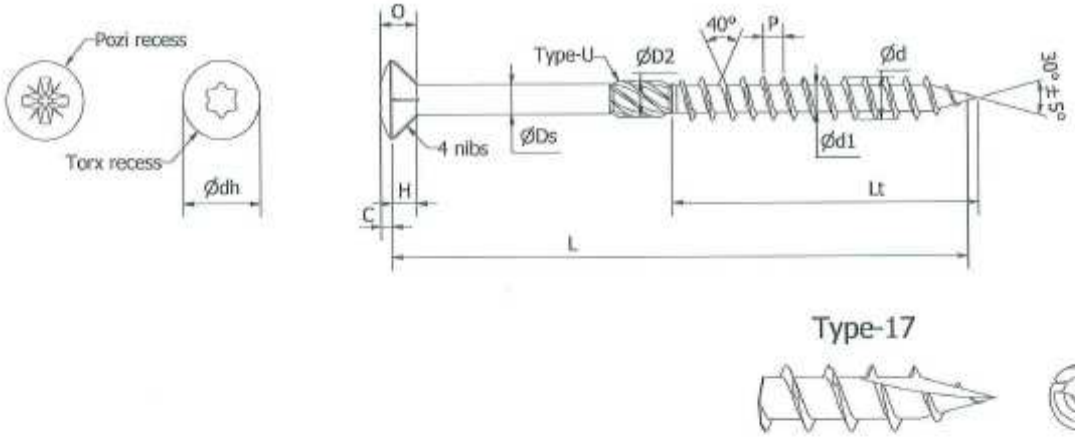


Type-17

Material:SAE1018/1022、SAE10B21 、Stainless Steel :1.4006

SIZE	M3.5	M4	M4.5	M5	M6	M8	M10	M12
dh	6.50	7.50	8.50	9.50	11.50	14.00	18.00	19.00
	7.00	8.00	9.00	10.00	12.00	15.00	19.00	21.00
H	3.30Ref	3.70Ref	4.10Ref	4.50Ref	5.70Ref	7.00Ref	8.00Ref	9.70Ref
D2	2.60	2.80	3.30	3.80	4.50	6.50	8.30	9.50
	2.90	3.20	3.60	4.10	5.50	7.10	8.80	9.80
d	3.30	3.80	4.30	4.70	5.75	7.60	9.70	11.30
	3.60	4.10	4.60	5.15	6.15	8.20	10.30	12.00
d1	2.00	2.20	2.55	3.00	3.80	5.10	6.00	6.90
	2.30	2.80	2.90	3.45	4.20	5.50	6.50	7.40
P	2.02	2.27	2.52	2.79	4.41	5.04	5.94	5.94
	2.46	2.77	3.08	3.41	5.39	6.16	7.26	7.26
Ds	2.40	2.60	2.80	3.50	4.20	5.70	6.90	7.80
	2.60	2.80	3.20	3.70	4.45	5.90	7.20	8.00

	Lt							
L	¢ 3.5	¢ 4.0	¢ 4.5	¢ 5.0	¢ 6.0	¢ 8.0	¢ 10.0	¢ 12.0
30	18	18	18					
40	24	24	24	24				
45	27	27	27	27				
50	30	30	30	30	30			
60		36	36	36	36			
70		42	42	42	42			
80		48	48	48	48	48/50	48/50	
90				54	54		-	
100				60	60	80/60	80/60	
110				66	70			
120				70	70	80/70	80/70	80
130					70			80
140					70	80	80	80
150					70			80
160					70	80/90	80/90	80
180					70	80/100	80/100	80
200					70	80/100	80/100	80
+20 mm steps					70	80/100	80/100	100
300					70	80/100	80/100	100
+20 mm steps						80/100	80/100	120
400						80/100	80/100	120



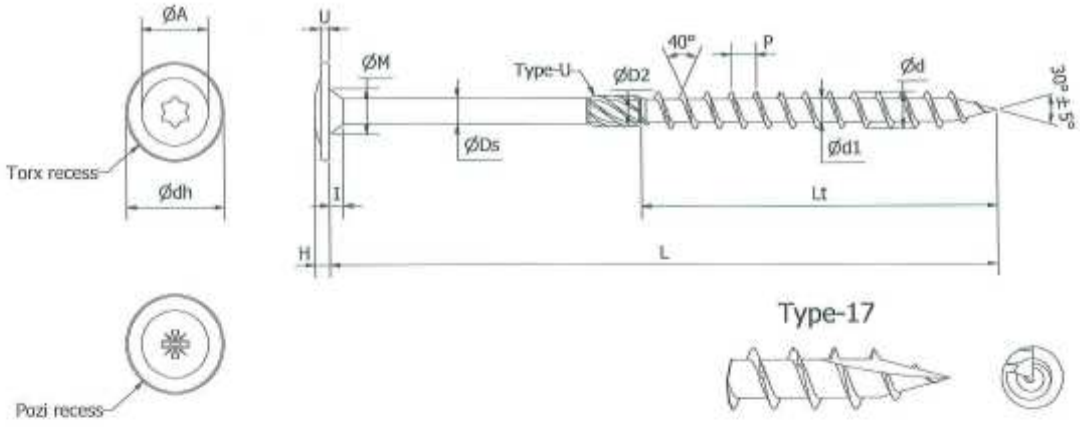
Type-17

Material :Stainless Steel 1.4006

SIZE	M4	M4.5	M5
dh	5.80	6.80	7.30
	6.20	7.20	7.70
O	3.40	4.20	4.65
	3.70	4.40	4.95
D2	3.30	3.80	4.28
	3.68	4.20	4.73
d1	3.90	4.40	4.90
	4.10	4.60	5.10
d	2.30	2.50	2.90
	2.50	2.70	3.10
P	1.62	1.80	1.98
	1.98	2.20	2.42
Ds	2.60	3.00	3.50
	2.80	3.20	3.70

Lt

L	¢ 4.0	¢ 4.5	¢ 5.0
30	18		
35	24	24	24
40	26	26	26
45	28	28	28
50	30	30	30
60	36	36	36
70		42	42
80		48	48
90			54
100			60
110			
120			

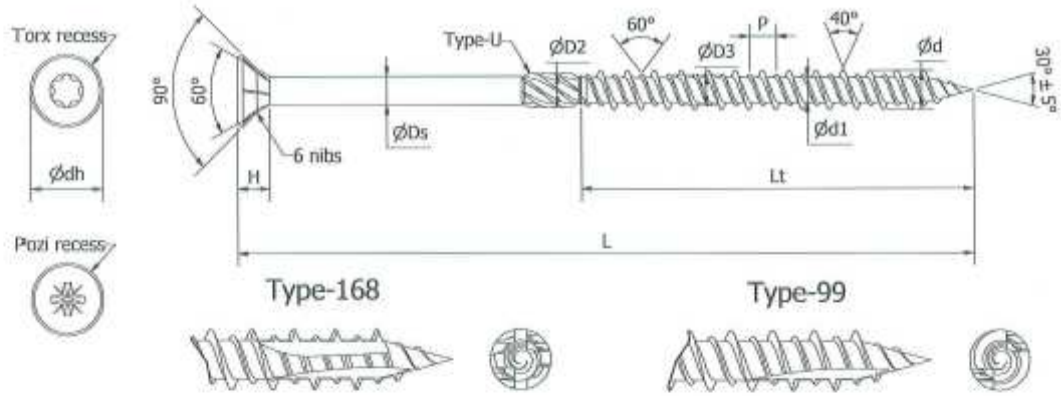


SIZE	M6	M8	M10
ψ A	10.00	14.50	18.50
	11.00	18.00	22.00
ψ dh	13.00	20.00	23.00
	15.00	24.00	27.00
U	0.70	1.50	1.70
	1.30	2.10	2.30
I	2.70	3.20	3.60
	3.40	4.00	4.40
ψ M	6.00	9.00	11.00
	8.00	11.00	12.00
ds	4.20	5.60	6.90
	4.40	6.00	7.10
P	4.41	4.68	5.94
	5.39	6.05	7.26
d	5.75	7.80	9.80
	6.15	8.10	10.20

SIZE	M6	M8	M10
ψ d1	3.80	5.20	6.10
	4.15	5.50	6.40
D2	4.50	6.70	8.00
	5.10	7.20	8.80

Material:SAE10B21 、

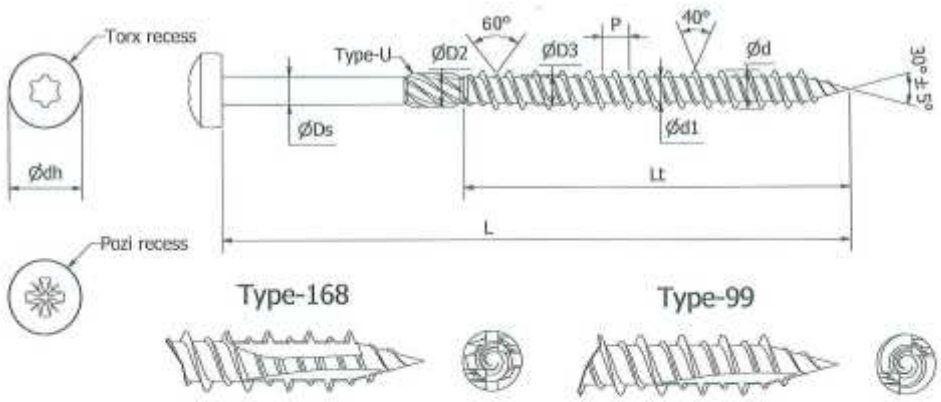
	Lt		
L	¢ 6.0	¢ 8.0	¢ 10.0
50	30		
60	36		
70	42		-
80	48	48/50	48/50
90	54	-	-
100	60	80/60	80/60
110	70	-	-
120	70	80/70	80/70
130	70	-	-
140	70	80	80
150	70		
160	70	80/90	80/90
180	70	80/100	80/100
200	70	80/100	80/100
+20 mm steps	70	80/100	80/100
300	70	80/100	80/100
+20 mm steps		80/100	80/100
400		80/100	80/100



Material:SAE1018/1022、SAE10B21 、Stainless Steel :1.4006

SIZE	M3.5	M4	M4.5	M5	M6	M8	M10	M12
dh	6.50	7.50	8.50	9.50	11.50	14.00	18.00	20.00
	7.00	8.00	9.00	10.00	12.00	15.00	19.00	21.00
H	3.30Ref	3.70Ref	4.10Ref	4.50Ref	5.70Ref	7.00Ref	8.00Ref	9.70Ref
D2	2.85	3.30	3.80	4.28	4.50	6.50	8.00	8.36
	3.15	3.68	4.20	4.73	5.00	6.80	8.50	9.24
d	3.30	3.80	4.30	4.70	5.75	7.80	9.80	11.50
	3.50	4.00	4.50	5.15	6.15	8.10	10.20	12.00
D3	2.60	3.00	3.30	3.85	4.70	6.40	7.80	8.70
	2.80	3.20	3.50	4.15	5.00	6.70	8.20	9.20
d1	2.00	2.20	2.55	3.00	3.70	5.10	6.00	6.50
	2.25	2.45	2.80	3.45	4.15	5.50	6.40	6.95
P	2.25	2.52	2.70	2.79	4.41	5.04	5.94	7.20
	2.75	3.08	3.30	3.41	5.39	6.16	7.26	8.80
Ds	2.40	2.60	3.00	3.50	4.20	5.70	6.90	7.80
	2.60	2.80	3.20	3.70	4.40	5.90	7.20	8.00

	Lt							
L	¢ 3.5	¢ 4.0	¢ 4.5	¢ 5.0	¢ 6.0	¢ 8.0	¢ 10.0	¢ 12.0
30	18	18	18					
40	24	24	24	24				
45	27	27	27	27				
50	30	30	30	30	30			
60		36	36	36	36			
70		42	42	42	42			
80		48	48	48	48	48/52	48/52	
90			54	54	54	54	54	
100				60	60	60	60	60
110				66	70	60	60	60
120				70	70	60	60	60
130					80	60	80	80
140					80	80	80	80
150					80	80	80	80
160					80	80	80	80
180					80	80	80	80
200					120	120	120	120
+20 mm steps					120	120	120	120
300					120	120	120	120
+20 mm steps						120	120	120
400						120	120	120

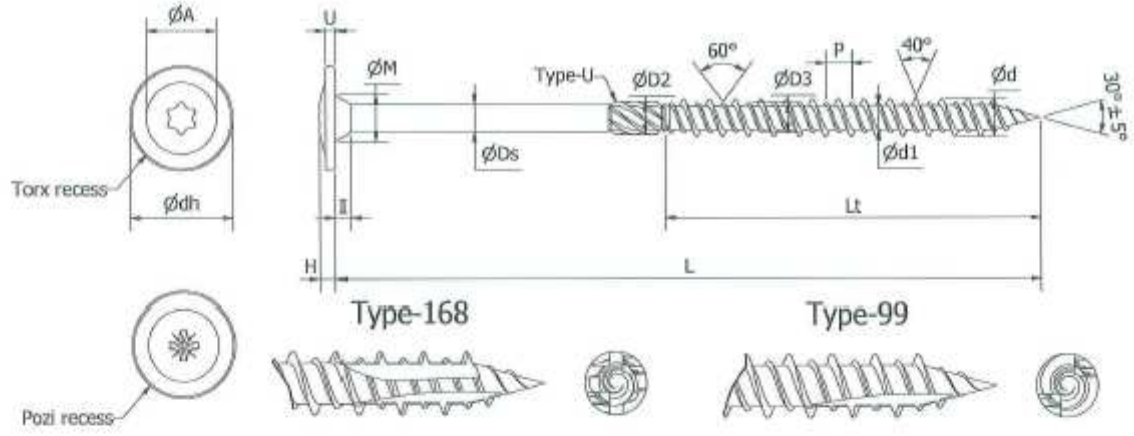


SIZE	M3.5	M4	M4.5	M5	M6
dh	6.64	7.64	8.65	9.64	11.57
	7.00	8.00	9.00	10.00	12.00
H	2.58	2.95	3.35	3.65	4.45
	2.82	3.25	3.65	3.95	4.75
D2	2.85	3.30	3.80	4.28	4.50
	3.15	3.68	4.20	4.73	5.00
d	3.30	3.80	4.30	4.70	5.75
	3.50	4.00	4.50	5.15	6.15
D3	2.60	3.00	3.30	3.85	4.70
	2.80	3.20	3.50	4.15	5.00
d1	2.00	2.20	2.55	3.00	3.70
	2.25	2.45	2.80	3.45	4.15
P	2.25	2.52	2.70	2.79	4.41
	2.75	3.08	3.30	3.41	5.39
Ds	2.40	2.60	3.00	3.50	4.20
	2.60	2.80	3.20	3.70	4.40

Material:SAE1018/1022、SAE10B21

Lt

L	¢ 3.5	¢ 4.0	¢ 4.5	¢ 5.0	¢ 6.0
30	18	18	18		
35	18	18	18		
40	24	24	24	24	
45	24	24	24	24	
50	30	24	24	24	24
60		30	30	30	30
70		35	35	35	35
80		52	52	52	52
90			52	52	52
100			52	52	52
110				60	60
120				60	60
130					60
140					60
150					80
160					80
180					80
200					80
+20 mm steps					80
300					100

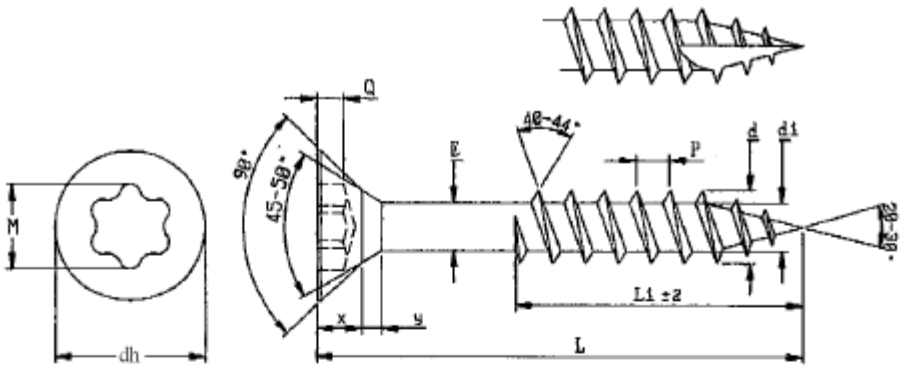


SIZE	M6	M8	M10
ψ A	10,00	14,50	18,50
	11,00	16,00	20,00
ψ dh	13,50	20,50	23,50
	14,50	23,50	26,50
U	0,70	1,50	1,70
	1,30	2,10	2,30
I	2,70	3,20	3,60
	3,40	4,00	4,40
ψ M	6,00	9,00	11,00
	8,00	11,00	12,00
ds	4,20	5,60	6,90
	4,40	6,00	7,10
P	4,41	5,04	5,94
	5,39	6,16	7,26
d	5,75	7,80	9,80
	6,15	8,10	10,20

SIZE	M6	M8	M10
D3	4,70	6,40	7,80
	5,00	6,70	8,20
ψ d1	3,70	5,10	6,00
	4,15	5,50	6,40

Material:SAE10B21

	Lt		
L	¢ 6,0	¢ 8,0	¢ 10,0
50	24		
60	30		
70	35		
80	52	52	52
90	52	52	52
100	52	60	60
110	60	60	60
120	60	60	60
130	60	60	80
140	60	60	80
150	80	80	80
160	80	80	80
180	80	80	80
200	80	80	80
+20 mm steps	80	80	80
300	100	100	100
+20 mm steps	120	120	120
400	120	120	120

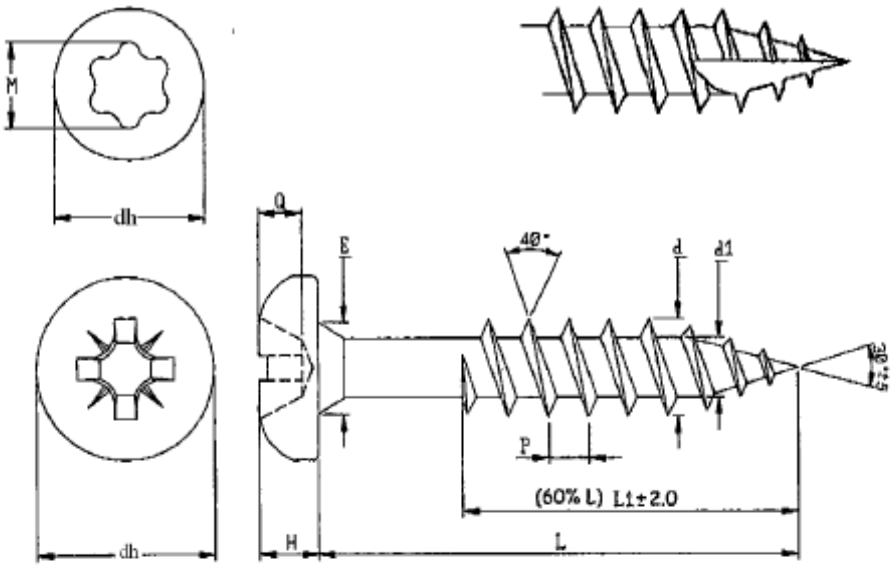


Material:C1018/1022, 410 Stainless Steel

SIZE	M3.5	M4	M4.5	M5	M6
dh	6.40	7.40	8.40	9.40	11.30
	7.00	8.00	9.00	10.00	12.00
Q	1.30	1.40	1.60	1.60	2.00
	1.50	1.60	1.80	1.80	2.20
M	2.8 Ref	3.95Ref	3.95 Ref	4.50 Ref	4.5 Ref
d	3.20	3.70	4.20	4.70	5.70
	3.50	4.00	4.50	5.00	6.00
d1	2.00	2.30	2.50	2.80	3.50
	2.30	2.60	2.85	3.30	3.80
E	2.35	2.75	3.10	3.45	4.20
	2.55	2.95	3.30	3.65	4.40
x	2.02 Ref	2.12 ref	2.54ref	2.9ref	3.39ref
y	1.80ref	2.00ref	2.20ref	2.50ref	2.70ref
P	1.40	1.60	1.80	2.00	2.30
	1.80	2.00	2.20	2.40	2.90

L1

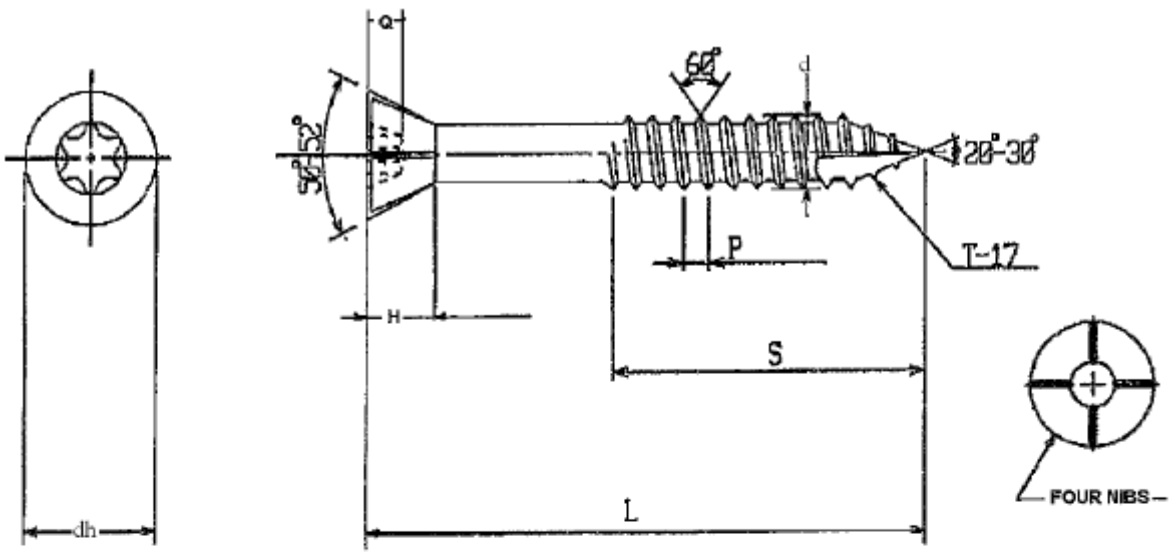
L	¢ 3.5	¢ 4.0	¢ 4.5	¢ 5.0	¢ 6.0
20	17	17			
25 -30	18	18	18		
35-40	24	24	24	24	24
45-50	30	30	30	30	30
55-60		36	36	36	36
65-70		42	42	42	42
75-80		50	50	50	50
90-100				60	60
110-120				68	68
130-300					68



SIZE	M3.5	M4	M4.5	M5	M6
dh	6.60	7.55	8.55	9.55	11.45
	7.00	8.00	9.00	10.00	12.00
H	2.40	2.60	2.90	3.35	3.85
	2.70	2.90	3.20	3.65	4.25
d	3.30	3.75	4.25	4.70	5.70
	3.50	4.00	4.50	5.00	6.00
d1	2.00	2.30	2.50	2.80	3.50
	2.20	2.50	2.70	3.00	3.70
Q	1.65	2.00	2.64	2.89	3.02
	2.11	2.46	3.10	3.35	3.48
P	1.35 Ref	1.80ref	2.00ref	2.20ref	2.60ref
E	1.60	3.60	4.00	4.40	5.30
	3.65	4.15	4.65	5.20	6.25

L1

L	¢ 3.5	¢ 4.0	¢ 4.5	¢ 5.0	¢ 6.0
20	17	17			
25 - 30	18	18	18		
35-40	24	24	24	24	24
45-50	30	30	30	30	30
55-60		36	36	36	36
65-70		42	42	42	42
75-80		50	50	50	50
90-100				60	60
110-120				68	68
130-300					68

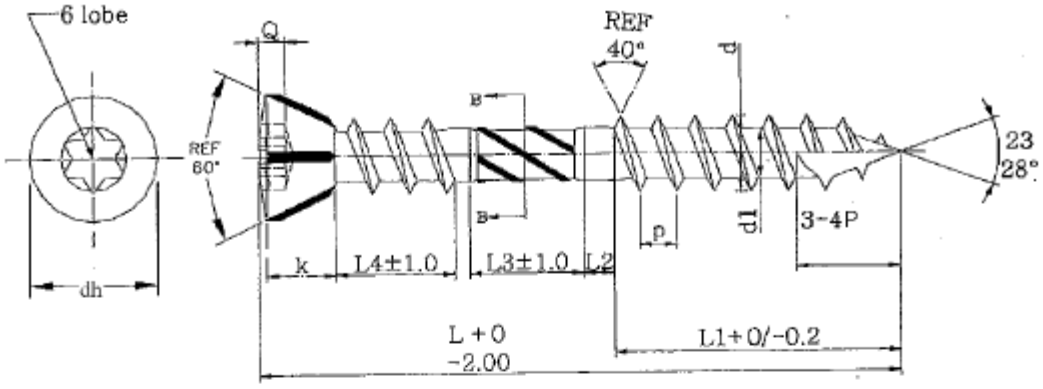


Material:C1018/1022, 410 Stainless Steel

SIZE	M4.2	M4.8
dh	6.80	8.00
	7.30	8.50
Q	1.60	2.10
	2.10	2.65
H	4.90Ref	5.80Ref
d	4.10	4.70
	4.40	5.00
P	2.52	2.52
	3.08	3.08

S

L	¢ 4.2	¢ 4.8
45	32	32
55	36	36
75	52	52
90		54



Material :Stainless Steel 1.4006

SIZE	M4	M4.5	M5
dh	5.80	6.80	7.30
	6.20	7.20	7.70
O	3.40	4.20	4.65
	3.70	4.40	4.95
B	3.30	3.80	4.28
	3.68	4.20	4.73
d	3.90	4.40	4.90
	4.10	4.60	5.10
d1	2.30	2.50	2.90
	2.50	2.70	3.10
P	1.62	1.80	1.98
	1.98	2.20	2.42
Ds	2.60	3.00	3.50
	2.80	3.20	3.70

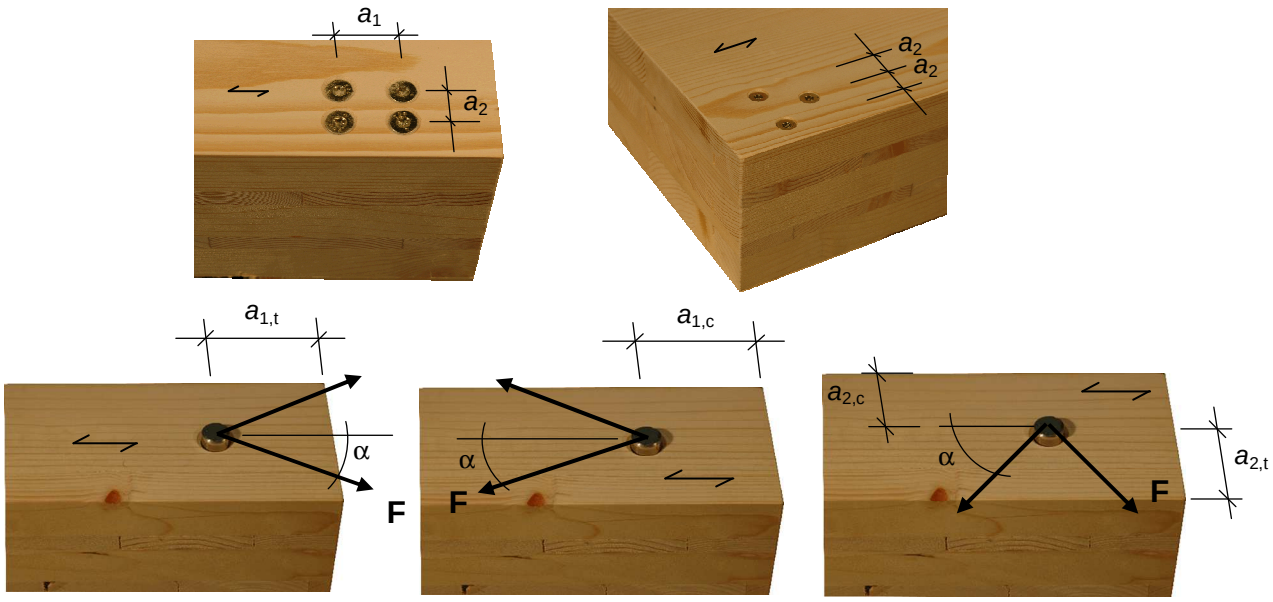
L1

L	¢ 4.0	¢ 4.5	¢ 5.0
30	18	18	
35	24	24	24
40	26	26	26
45	28	28	28
50	30	30	30
60	36	36	36
70		42	42
80		48	48
90			54
100			60
110			
120			

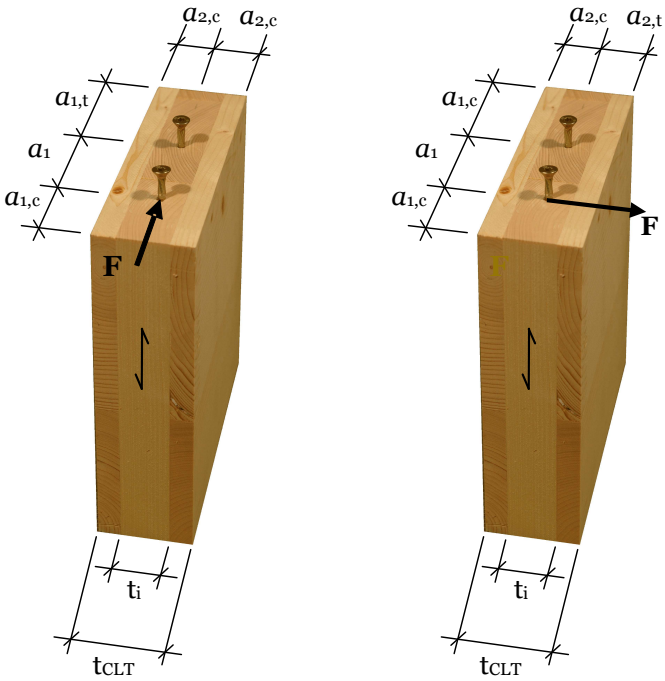
Annex B
Minimum distances and spacing

Axially or laterally loaded screws in the plane or edge surface of cross laminated timber

Definition of spacing, end and edge distances in the plane surface:



Definition of spacing, end and edge distances in the edge surface:



Annex C
Thermal insulation material on top of rafters

FU SHANG screws with an outer thread diameter 6 mm ≤ d ≤ 12 mm may be used for the fixing of thermal insulation material on top of rafters.

The thickness of the insulation shall not exceed 300 mm. The rafter insulation must be placed on top of solid timber or glued laminated timber rafters or cross-laminated timber members and be fixed by battens arranged parallel to the rafters or by wood-based panels on top of the insulation layer. The insulation of vertical facades is also covered by the rules given here.

Screws must be screwed in the rafter through the battens or panels and the insulation without pre-drilling in one sequence.

The angle α between the screw axis and the grain direction of the rafter should be between 30° and 90°.

The rafter consists of solid timber (softwood) according to EN 338, glued laminated timber according to EN 14081, cross-laminated timber, or laminated veneer lumber according to EN 14374 or to European Technical Approval or similar glued members according to European Technical Approval.

The battens must be from solid timber (softwood) according to EN 338:2003-04. The minimum thickness t and the minimum width b of the battens is given as follows:

Screws d ≤ 8,0 mm: b_{min} = 50 mm t_{min} = 30 mm
Screws d = 10 mm: b_{min} = 60 mm t_{min} = 40 mm
Screws d = 12 mm: b_{min} = 100 mm t_{min} = 60 mm

The insulation must comply with a European Technical Approval. The thermal insulation material shall be applicable as insulation on top of rafters according to national provisions that apply at the installation site.

Friction forces shall not be considered for the design of the characteristic axial capacity of the screws.

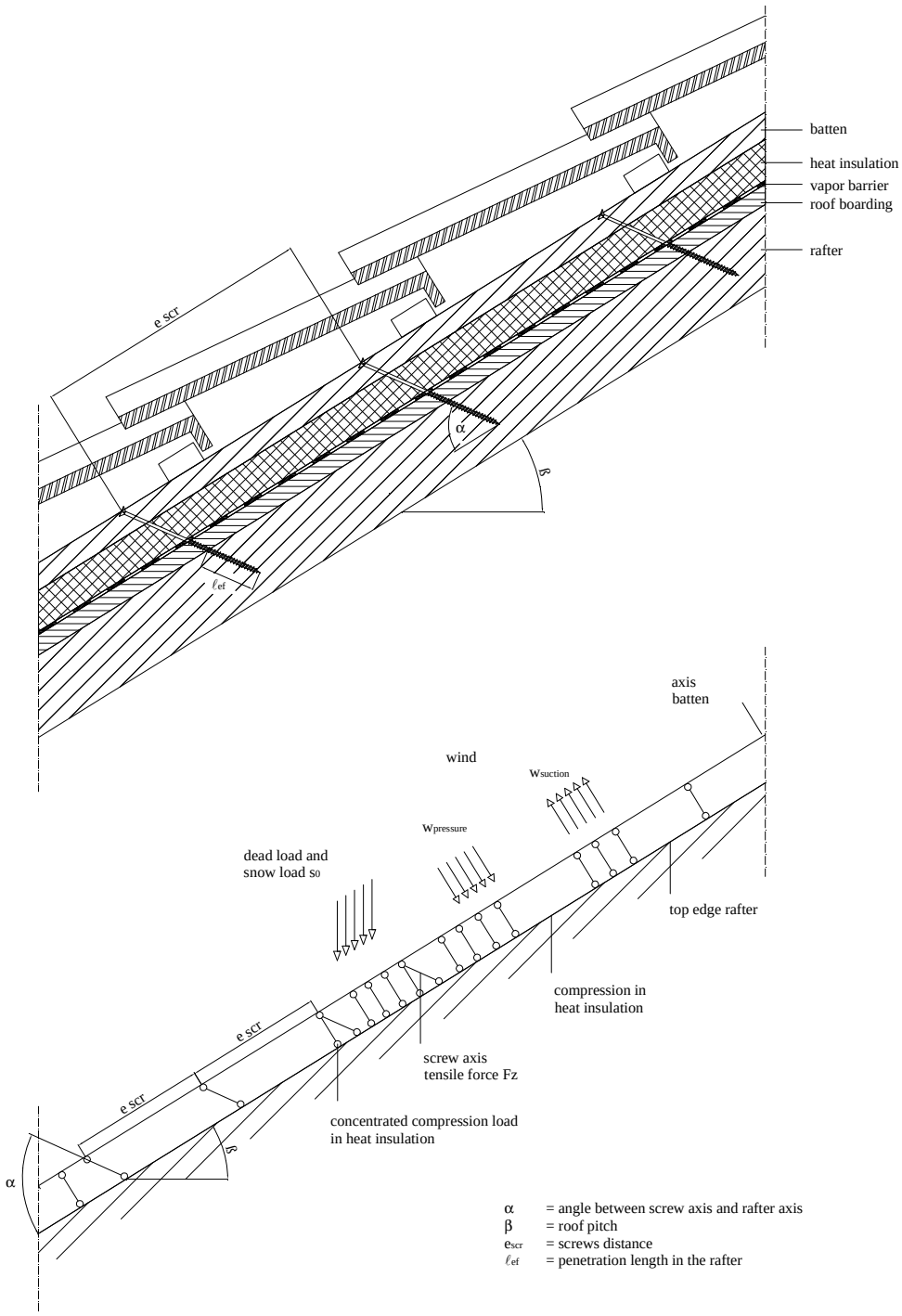
The anchorage of wind suction forces as well as the bending stresses of the battens or the boards, respectively, shall be considered in design. Additional screws perpendicular to the grain of the rafter (angle α = 90°) may be arranged if necessary.

The maximum screw spacing is e_S = 1,75 m.

Thermal insulation material on rafters with parallel inclined screws

Mechanical model

The system of rafter, thermal insulation on top of rafter and battens parallel to the rafter may be considered as a beam on elastic foundation. The batten represents the beam, and the thermal insulation on top of the rafter the elastic foundation. The minimum compression stress of the thermal insulation at 10 % deformation, measured according to EN 826[2], shall be $\sigma_{(10\,\%)} = 0{,}05$ N/mm². The batten is loaded perpendicular to the axis by point loads F_b. Further point loads F_s are from the shear load of the roof due to dead and snow load, which are transferred from the screw heads into the battens.



[2] EN 826:1996 Thermal insulating products for building applications - Determination of compression behaviour

Design of the battens

The bending stresses are calculated as:

$$M = \frac{(F_b + F_s) \cdot \ell_{char}}{4}$$

Where

ℓ_{char} = characteristic length $\ell_{char} = \sqrt[4]{\frac{4 \cdot EI}{w_{ef} \cdot K}}$

EI = bending stiffness of the batten
K = coefficient of subgrade
w_{ef} = effective width of the thermal insulation
F_b = Point loads perpendicular to the battens
F_s = Point loads perpendicular to the battens, load application in the area of the screw heads

The coefficient of subgrade K may be calculated from the modulus of elasticity E_{HI} and the thickness t_{HI} of the thermal insulation if the effective width w_{ef} of the thermal insulation under compression is known. Due to the load extension in the thermal insulation the effective width w_{ef} is greater than the width of the batten or rafter, respectively. For further calculations, the effective width w_{ef} of the thermal insulation may be determined according to:

$$w_{ef} = w + t_{HI} / 2$$

where
w = minimum width of the batten or rafter, respectively
t_{HI} = thickness of the thermal insulation

$$K = \frac{E_{HI}}{t_{HI}}$$

The following condition shall be satisfied:

$$\frac{\sigma_{m,d}}{f_{m,d}} = \frac{M_d}{W \cdot f_{m,d}} \le 1$$

For the calculation of the section modulus W the net cross section has to be considered.

The shear stresses shall be calculated according to:

$$V = \frac{(F_b + F_s)}{2}$$

The following condition shall be satisfied:

$$\frac{\tau_d}{f_{v,d}} = \frac{1,5 \cdot V_d}{A \cdot f_{v,d}} \le 1$$

For the calculation of the cross section area the net cross section has to be considered.

Design of the thermal insulation

The compressive stresses in the thermal insulation shall be calculated according to:

$$\sigma = \frac{1,5 \cdot F_b + F_s}{2 \cdot \ell_{char} \cdot w}$$

The design value of the compressive stress shall not be greater than 110 % of the compressive stress at 10 % deformation calculated according to EN 826.

Design of the screws

The screws are loaded predominantly axially. The axial tension force in the screw may be calculated from the shear loads of the roof R_s:

$$T_S = \frac{R_S}{\cos \alpha}$$

The load-carrying capacity of axially loaded screws is the minimum design value of the axial withdrawal capacity of the threaded part of the screw, the head pull-through capacity of the screw and the tensile capacity of the screw.

In order to limit the deformation of the screw head for thermal insulation material thicknesses over 200 mm or with compressive strength below 0,12 N/mm², respectively, the axial withdrawal capacity of the screws shall be reduced by the factors k_1 and k_2:

$$F_{ax,\alpha,Rd} = \min\left\{\frac{f_{ax,d}\cdot d\cdot \ell_{ef}\cdot k_1\cdot k_2}{1.2\cdot\cos^2\alpha+\sin^2\alpha}\cdot\left(\frac{\rho_k}{350}\right)^{0.8};f_{head,d}\cdot d_h^2\cdot\left(\frac{\rho_k}{350}\right)^{0.8};\frac{f_{tens,k}}{\gamma_{M2}}\right\}$$

Where:

$f_{ax,d}$	design value of the axial withdrawal parameter of the threaded part of the screw
d	outer thread diameter of the screw
ℓ_{ef}	Point side penetration length of the threaded part of the screw in the batten, $l_{ef} \geq 40$ mm
α	Angle between grain and screw axis ($\alpha \geq 30°$)
ρ_k	characteristic density of the wood-based member [kg/m³]
$f_{head,d}$	design value of the head pull-through capacity of the screw
d_h	head diameter
$f_{tens,k}$	characteristic tensile capacity of the screw
γ_{M2}	partial factor according to EN 1993-1-1 or to the particular national annex
k_1	min {1; $200/t_{HI}$}
k_2	min {1; $\sigma_{10\%}/0,12$}
t_{HI}	thickness of the thermal insulation [mm]
$\sigma_{10\%}$	compressive stress of the thermal insulation under 10 % deformation [N/mm²]

If k_1 and k_2 are considered, the deflection of the battens does not need to be considered. Alternatively to the battens, panels with a minimum thickness of 20 mm from plywood according to EN 636, particle board according to EN 312, oriented strand board according to EN 300 or European Technical Approval and solid wood panels according to EN 13353 or cross laminated timber may be used.