EUROPEAN ASSESSMENT DOCUMENT

EAD 130324-00-0603

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INSERTS FOR USE IN TIMBER CONSTRUCTIONS

This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

The inserts together with metric bolts or lifting devices specified by the applicant for the ETA to be used for connections in load bearing timber structures or loading applications between members of solid timber (softwood or hardwood), glued laminated timber, cross-laminated timber, and laminated veneer lumber, similar glued members, wood-based panels or steel.

The EAD covers only inserts with at least four thread flanks and for inserts made from non-hardened steel.

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 metric bolt acting as insert head.

Inserts and the metric screws are made from special stainless or carbon steel.

The outer thread diameter of the insert shall be at least 8 mm and not more than 40 mm. The inner thread diameter must be $0,75 \cdot d \leq d_1 \leq 0,94 \cdot d$. The minimum length of the outer thread l_g shall be 1,2 d.

The inserts shall be driven into the wood after pre-drilling with a diameter which is 0,5 mm - 1 mm larger than the inner thread diameter.

The insert is screwed-in flush with the surface of the member or deeper.

The minimum penetration depth of the tip of the insert is 3 d. For inserts with a length l < 3d, the insert has to be countersunk down to the required penetration depth.

For angles between insert axis and grain direction of $\alpha \leqslant 90°$ the minimum penetration depth of the tip of the insert in the timber member shall be $(3 \cdot d / \sin \alpha)$ but not more than 10d, where α is the angle between insert axis and grain direction.

The product is not covered by a harmonized technical specification.

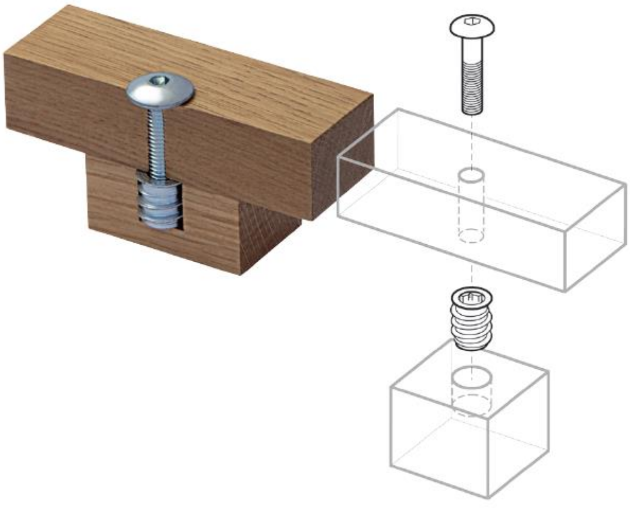
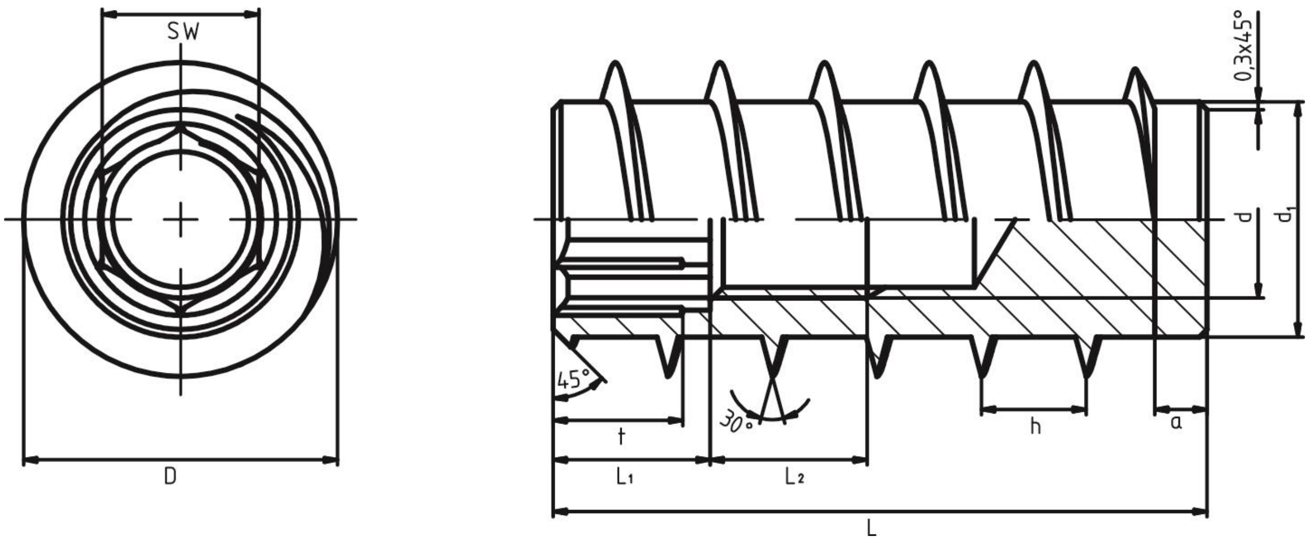


Figure 1 Example for a timber to timber connection (insert and metric screw)



L	length of the insert
D	outer thread diameter of the insert
d_1	inner thread diameter of the insert
h	pitch of the outer thread
L_1	drilling length of the hex socket drive
L_2	length of the inner metric thread
d	diameter of the inner metric thread
SW	wrench size
t	depth of the hex socket drive
a	unthreaded lead

Figure 2 Example for the geometry of an insert

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product, as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document, shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The inserts together with metric screws or other connecting systems are used for connections in timber constructions, e.g. timber/timber, wood-based panels/timber or steel/timber connections, where instead of timber also glulam, CLT or LVL may be used.

The inserts shall be used in service classes 1, 2 or 3 defined in EN 1995-1-1 and only for static or quasi-static actions.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the insert for the intended use of 50 years when installed in the works (provided that the insert is subject to appropriate installation (see 1.1)). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[1].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than the assumed working life.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 1 shows how the performance of the inserts are established in relation to the essential characteristics.

Table 1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance *(level, class, description)*
Basic Works Requirement 1: Mechanical resistance and stability			
1	Dimensions	2.2.1	Description
2	Characteristic yield moment	2.2.2	Level
3	Characteristic withdrawal parameter	2.2.3	Level
4	Characteristic tensile strength	2.2.4	Level
5	Spacing, end and edge distances of the inserts and minimum thickness of the wood based material	2.2.5	Description, level
6	Durability against corrosion	2.2.7	Description, level
Basic Works Requirement 2: Safety in case of fire			
7	Reaction to fire	2.2.8	Class
Basic Works Requirement 4: Safety and accessibility in use			
8	Same as BWR 1		

2.2 Methods and criteria for assessing and classification of the performance of the product in relation to essential characteristics of the product

The inserts are assessed on the basis of the equations given in EN 1995-1-1 for dowel-type fasteners. For the purpose of the assessments, the equations take into account the diameter and the properties of the insert as well as the corresponding metric screw. For countersunk inserts the assessment equations take into account the gap between the insert and the surface of the member.

Characterisation of the inserts to be assessed shall be done in accordance with available specifications, notably mechanical properties and chemical composition of raw materials.

Special tools and procedure prescribed by the manufacturer are used for installation of inserts when test specimens are to be prepared ensuring the installation of the insert under given conditions (pre-drilling) since these have an influence on the assessed performance of the product.

2.2.1 Dimensions

The dimensions of the inserts (see Figure 2) are measured according to the provisions in EN 14592 and documented in the test report. The tolerances are in accordance with DIN 2768MK and are specified in the ETA.

Note: The following tests and calculations have to be performed considering the most unfavourable specified tolerances.

2.2.2 Characteristic yield moment

The characteristic yield moment $M_{y,k}$ of the insert is calculated:

$$M_{y,k} = f_y \frac{\left(d_1^3 - d^3\right)}{6}$$

Where:

$M_{y,k}$ = characteristic yield moment of the insert

d_1 = inner thread diameter of the insert

d = diameter of the inner metric thread

f_y = yield stress (R_e or $R_{p0,2}$)

Alternatively, the characteristic yield moment of the inserts is determined by testing according to EN 409. The tests are carried out with a free length of the insert l_2 of 2 · d. The minimum number of specimens is 10 for every outer thread diameter.

The yield moment is the value at the plastic bending angle $\alpha = 45/d^{0.7}$ degrees with d in mm. The characteristic value of the yield moment shall be calculated according to EN 14358 and stated in the ETA.

2.2.3 Characteristic withdrawal parameter

For inserts in structural timber according to EN 14081-1 or glued laminated timber or glued solid timber according to EN 14080, laminated veneer lumber, cross laminated timber or solid wood panels the withdrawal parameter is determined according to the test method given in EN 1382 and stated in the ETA.

At least 20 tests for every influencing parameter such as the outer thread diameter, inner thread diameter, pre-drilling diameter and the angle between insert-axis and grain are required. For a chosen characteristic density ρ_k the density of the test specimens shall fulfil the requirements of EN ISO 8970.

When the specimen density ρ deviates from the associated density ρ_k., the withdrawal parameter of each test has to be corrected with a factor k_ρ.

The factor k_ρ shall be calculated as:

$$k_\rho = \left(\frac{\rho_k}{\rho}\right)^{0,8} \quad (1)$$

where:

ρ_k characteristic density of the strength class of the timber, to which the test results should be related,

ρ density of the test specimen.

From the possibly corrected withdrawal parameters of all test results the characteristic value of the withdrawal parameter shall be calculated according to EN 14358. This characteristic withdrawal parameter corresponds to the chosen characteristic density of the timber.

For angles α between insert axis and grain direction 15 °≤ α°≤ 90 ° the characteristic withdrawal capacity $F_{ax,\alpha,Rk}$ shall be determined according to equation (2):

$$F_{ax,\alpha,Rk} = k_{ax} \cdot f_{ax,90,k} \cdot d \cdot \ell_{ef} \cdot \left(\frac{\rho_k}{350}\right)^{0.8} \quad (2)$$

where

k_{ax} factor to consider the influence of the angle between insert axis and grain direction and the long-term behaviour

$k_{ax} = \min \{1; (0,3 + (0,7 \cdot \alpha)/ 45°)\}$ (3)

$f_{ax,90,k}$ short-term characteristic withdrawal parameter for an angle α between insert axis and grain direction of 90° in N/mm²

d outer thread diameter of the insert in mm

ℓ_{ef} penetration length of the insert in the timber member in mm

ρ_k characteristic density of the wood-based member in kg/m³

Equations (2) and (3) may be used for angles α between insert axis and grain direction 15°< α°≤ 0° if the following requirements are satisfied:

1. $f_{ax,0,k}/ f_{ax,90,k} \geq 0,6$

   $f_{ax,0,k}$ short-term characteristic withdrawal parameter for an angle between insert axis and grain direction of 0° determined on test specimens made from solid softwood

2. The penetration depth of the tip of the insert shall be

   $l_{ef,req} = \min\left\{\frac{3 \cdot d}{\sin\alpha}; 10 \cdot d\right\}$ for 0°≤ α ≤ 15°

The characteristic withdrawal parameter is given in the ETA together with information about the corresponding density for the wood as per equation (2)

2.2.4 Characteristic tensile strength

The characteristic tensile strength of the inserts is calculated with the tensile stress area of the insert and the respective tensile strength, and stated in the ETA

2.2.5 Spacing, end and edge distances of the inserts and minimum thickness of the wood based material

For structural timber members, minimum spacing and distances for inserts in predrilled holes are given in EN 1995-1-1 (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.

The spacing, end and edge distances and the minimum thickness of the wood based material are taken from EN 1995-1-1. The outer thread diameter of the insert d is used to determine the spacing, end and edge distances and the minimum thickness of the wood based material.

For spacings, end and edge distances smaller than given in EN 1995-1-1 tests on the basis of Annex A is performed. The timber has to be pre-drilled with the minimum required pre-drilling diameter stated in the ETA.

If the spacing, end and edge distances less than the distances and thicknesses given in EN 1995-1-1 the assessment of resistance according to EN 1995-1-1:2004 +AC:2006 + A1:2008, clause 8.7.2 (1) the failure along the circumference of a group of inserts has to be considered also for connections without steel plates. That has to be stated in the European Technical Assessment of the inserts.

2.2.6 Durability against corrosion

The type and thickness of the corrosion protection shall be described in the European Technical Assessment.

Corrosion protection according to the examples given in EN 1995-1-1

Note. Examples of the minimum corrosion protection for inserts used in load-bearing timber structures are given in EN 1995-1-1 or in relevant national standards, depending upon the service conditions. The admissible service conditions and the admissible corrosive category according to EN ISO 12944-2 shall be considered.

If a hot dip galvanized zinc coating according to EN ISO 1461 is used its thickness shall be determined by EN ISO 1460 – gravimetric method – or by EN ISO 2178 – non-destructive magnetic method -.

In the case of using electroplated zinc coating according to EN ISO 4042 its thickness shall be determined by EN ISO 4042.

If stainless steel is used the steel shall be classified according to EN 1993-1-4 in conjunction with EN ISO 3506-1.

It should be considered that some type of hardwood has substances which cause corrosion of the inserts under certain service conditions. In the case hardwood is used the durability of the corrosion protection or the stainless steel shall be verified.

Contact between inserts and other components of the joint made from metal shall not result in corrosion in the intended use.

Contact between inserts and timber preservative treated against biological attack or fire retardants shall not result in corrosion in the intended use. If inserts are used in preservative treated timber the compatibility has to be verified.

Alternative corrosion protection

If the existing corrosion protection is deviating from the examples according to EN 1995-1-1 the equivalence of the corrosion protection shall be verified considering the admissible corrosive category according to EN ISO 12944-2.

When assessing the equivalence of corrosion protection coatings with the corrosion protection given in EN 1995-1-1, the part of the insert passing through the timber member and the one exposed to the atmosphere shall be assessed separately. It is assumed that the minimum requirements for the building materials or the corrosion protection of fasteners according to EN 1995-1-1:2004 + AC:2006 + A1:2008, table 4.1 in the different service classes in accordance with footnote b, apply only for insignificant or low corrosion loads (corrosive categories C1 and C2 according to EN ISO 12944-2:1998).

For the test specimens the steel shall be used from which the inserts are made. The following aspects shall, inter alia, be taken into account:

- the real thickness of the corrosion protection coating; here the entire insert shall be included
- application process of the coating, defects shall be taken into account when carrying out the tests
- abrasion of the coating when the inserts are turned in
- environmental conditions according to EN ISO 12944-2 in which the inserts are to be used

Outdoor exposure tests shall be carried out. In this process the inserts shall be stored over a period of at least 5 years in the highest corrosive category desired according to EN ISO 12944-2. The inserts shall, however, be stored at least in corrosive category C4. At least 5 inserts shall be provided for each exposure period. The taking of test specimens prior to the expiry of the entire exposure time shall be taken into account. For example, if inserts are taken on an annual basis, at least 5 inserts per year shall be exposed.

The existing corrosion of the test specimens shall be assessed by means of a metallographic cross-section taken at the points which are subject to the highest corrosive attack.

If a corrosion protection deviating from EN 1995-1-1:2004 + AC:2006 + A1:2008 was verified it shall be declared that the alternative corrosion protection was successfully tested. The admissible service class according to EN 1995-1-1 and the admissible corrosive category according to EN ISO 12944-2 shall be given.

Alternative to the above described test procedure the alternative corrosion protection may be considered as not existing. In this case type and thickness of the alternative corrosion protection shall also be described in the European Technical Assessment.

2.2.7 Reaction to fire

The inserts shall be tested using the test method(s) referred to in EN 13501-1 and relevant for the corresponding reaction to fire class. The product shall be classified according to Commission Delegated Regulation (EU) No 2016/364. The class is given in the ETA.

The inserts are considered to satisfy the requirements for performance class A1 of the characteristic reaction to fire in accordance with the EC Decision 96/603/EC (as amended) without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Decision 97/638//EC.

The applicable AVCP system is 2+

3.2 Tasks of the manufacturer

The corner stones of the actions to be undertaken by the manufacturer of the inserts in the procedure of assessment and verification of constancy of performance are laid down in Table 2.

Table 2 Control plan for the manufacturer; corner stones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [**including testing of samples taken at the factory in accordance with a prescribed test plan**]					
1	Raw material specification	Suppliers declaration according to EN 10204	As defined in the control plan	-	Per material batch
2	Dimensions of the inserts	2.2.1	As defined in the control plan	5 per production batch	Daily
3	Characteristic tensile strength	2.2.4	As defined in the control plan	Inspection certificate according to EN 10204 - 3.1	
4	Durability (Corrosion protection)	Suppliers declaration	As defined in the control plan	5	Per corrosion treatment batch

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for the inserts are laid down in Table 3.

Table 3: Tasks for the notified body;

Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control				
Initial inspection of the manufacturing plant and of factory production control carried out by the manufacturer	As defined in the control plan	As defined in the control plan	As defined in the control plan	As defined in the control plan
Continuous surveillance, assessment and evaluation of factory production control				
Continuous surveillance, assessment and evaluation of the factory production control carried out by the manufacturer	As defined in the control plan	As defined in the control plan	As defined in the control plan	As defined in the control plan

4 REFERENCE DOCUMENTS

As far as no edition date is given in the list of standards thereafter, the standard in its current version at the time of issuing the European Technical Assessment, is of relevance.

EN 409:2009	Timber structures – Test methods – Determination of the yield moment of dowel type fasteners – nails
EN 1382:1999	Timber structures – Test methods – Withdrawal capacity of timber fasteners
EN 1995-1-1:2004+A1:2008	Design of timber structures – Part 1-1: General – Common rules and rules for buildings
EN 14080	Timber structures - Glued laminated timber – Requirements
EN 14081-1	Timber structures – Strength graded structural timber with rectangular cross section – Part 1: General requirements
EN 14358:2006	Timber structures – Calculation of characteristic 5-percentile values and acceptance criteria for a sample
EN ISO 1460:1994	Metallic coatings – Hot dip galvanized coatings on ferrous materials – Gravimetric determination of the mass per unit area
EN ISO 1461:2009	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
EN ISO 2178:1995	Non-magnetic coatings on magnetic substrates – Measurement of coating thickness – Magnetic method
EN ISO 3506-1	Mechanical properties of corrosion-resistant stainless steel fasteners – Part 1: Bolts, screws and studs
EN ISO 4042:1999	Fasteners - Electroplated coatings
EN ISO 8970:2010	Timber structures – Testing of joints made with mechanical fasteners – Requirements for wood density
EN ISO 10666: 1999	Drilling screws with tapping screw threads – Mechanical and functional properties
EN ISO 12944-2: 1998	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 2: Classifications of environments
ISO 6892-1:2009	Metallic materials – Tensile testing – Part 1: Method of test at room temperature

ANNEX A DETERMINATION OF MINIMUM TIMBER CROSS-SECTION AND MINIMUM SPACING, END AND EDGE DISTANCES FOR INSERTS

1 Test method for axially loaded inserts

The minimum timber width and thickness as well as the minimum spacing, end and edge distance requirements are determined by screw-in tests, where the inserts are driven into specimens perpendicular to the grain. Subsequently, the splitting area caused by inserting the inserts is evaluated. The test results are valid for the timber species, the insert and the diameter used in the test and for:

- Timber with a thickness equal or larger than the thickness used in the tests,
- Timber with a width equal or larger than the width used in the tests,
- The minimum end and edge distances used in the tests,
- The minimum spacing used in the tests.

The spacing parallel to the grain shall not be less than a_1 = 5 d, where d is the outer thread diameter.

Test results with sawn timber are valid also for glued laminated timber. For wood-based materials like LVL, separate tests are required. The test specimens shall fulfil the following requirements:

- The sawn timber density shall not be less than 480 kg/m³ for Picea abies (Norway spruce) or Abies alba (Fir), 550 kg/m³ for Pinus sylvestris (Scots pine) and 650 kg/m³ for Pseudotsuga menziesii (Douglas-fir) or Larix decidua (Larch),
- The angle between the insert axis and the annual ring orientation shall be about 0° (tangential) or about 90° (radial),
- There shall be 10 specimens with a radial and 10 specimens with a tangential annual ring orientation,
- The specimens shall be conditioned prior to inserting in the inserts at a temperature of (20 ± 2) °C and a relative humidity of (65 ± 2) %,

A minimum of 3 inserts per specimen in a row parallel to the grain are driven into the timber conditioned at 20°C/65%. The insert should be flush with the timber surface or with a deeper countersunk. Friction effects reducing the splitting tendency should be eliminated (see Fig. 1 to 2).

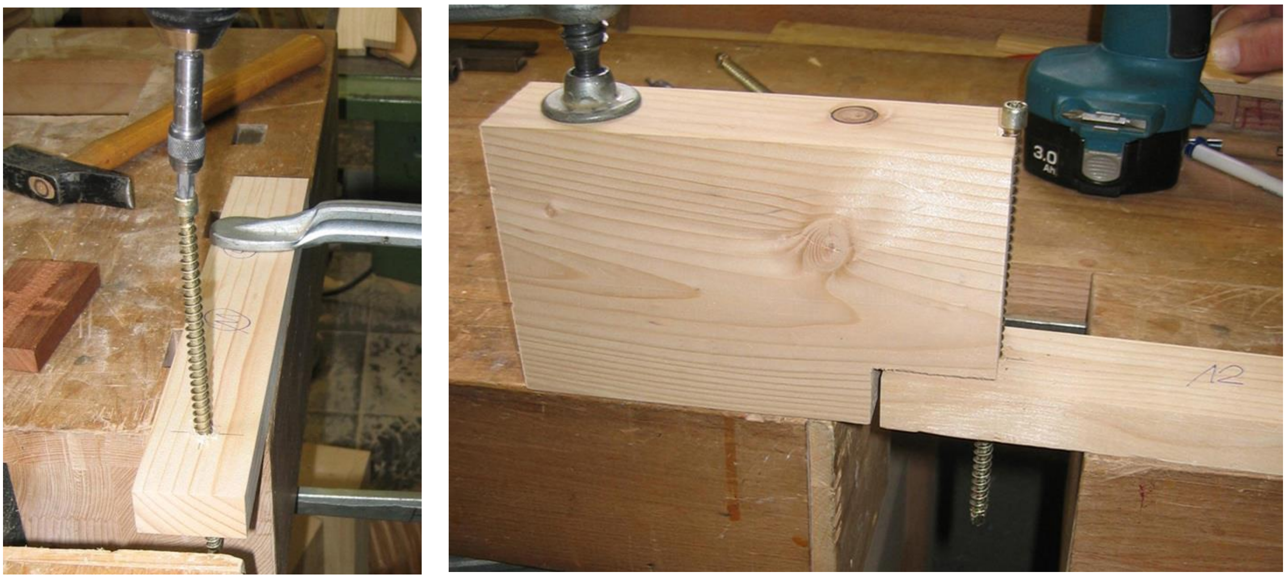


Fig. 1: Inserting an insert using a template made of timber.

Fig. 2: Inserting an insert (left), specimens with 2 rows of 3 inserts (right).

After storing the specimens containing the inserts at a temperature of (20 ± 2) °C and a relative humidity of (65 ± 2) % for at least 24 h, the inserts are unscrewed.

The opening caused by the exit of the insert point closest to the end grain is sealed at the timber surface, e.g. by using a tape. Subsequently, the low-viscosity dye wood stain "COLOR-Beize" shade No. 7704 of the company CLOU is filled into the hole caused by the insert (see Fig. 3).

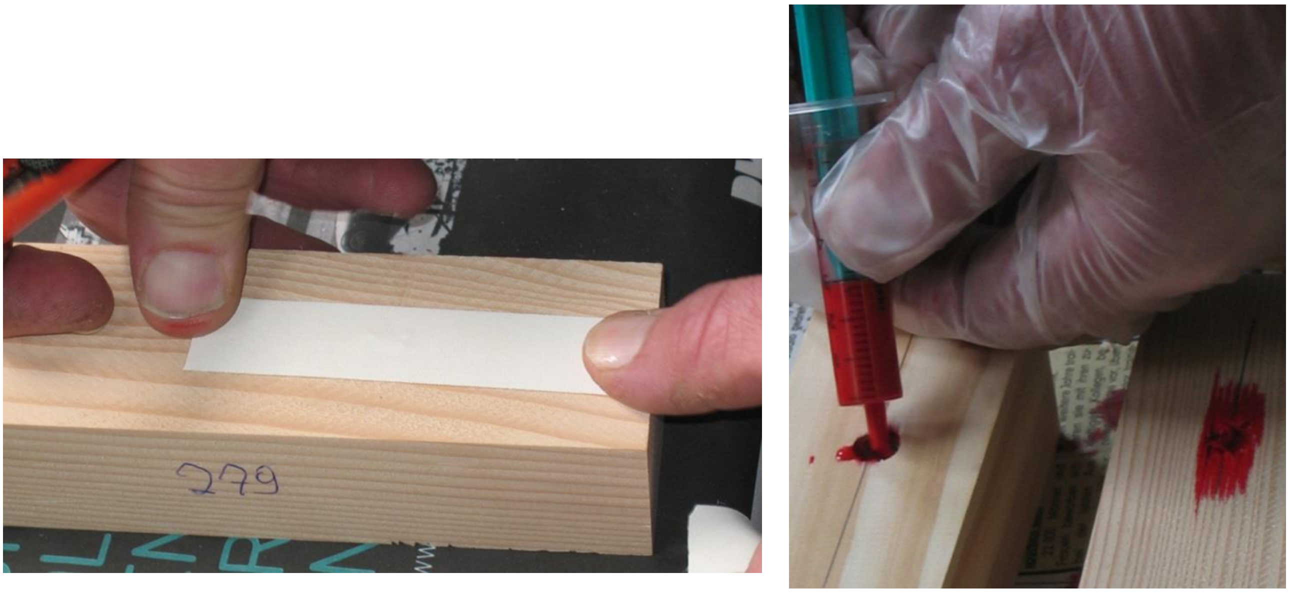


Fig. 3: Sealing a specimen and pouring the dye.

The distribution of the dye by capillary action colours the split area. After the dye has dried, the coloured split areas are made visible by opening the specimens along the split surface (see Fig. 4).

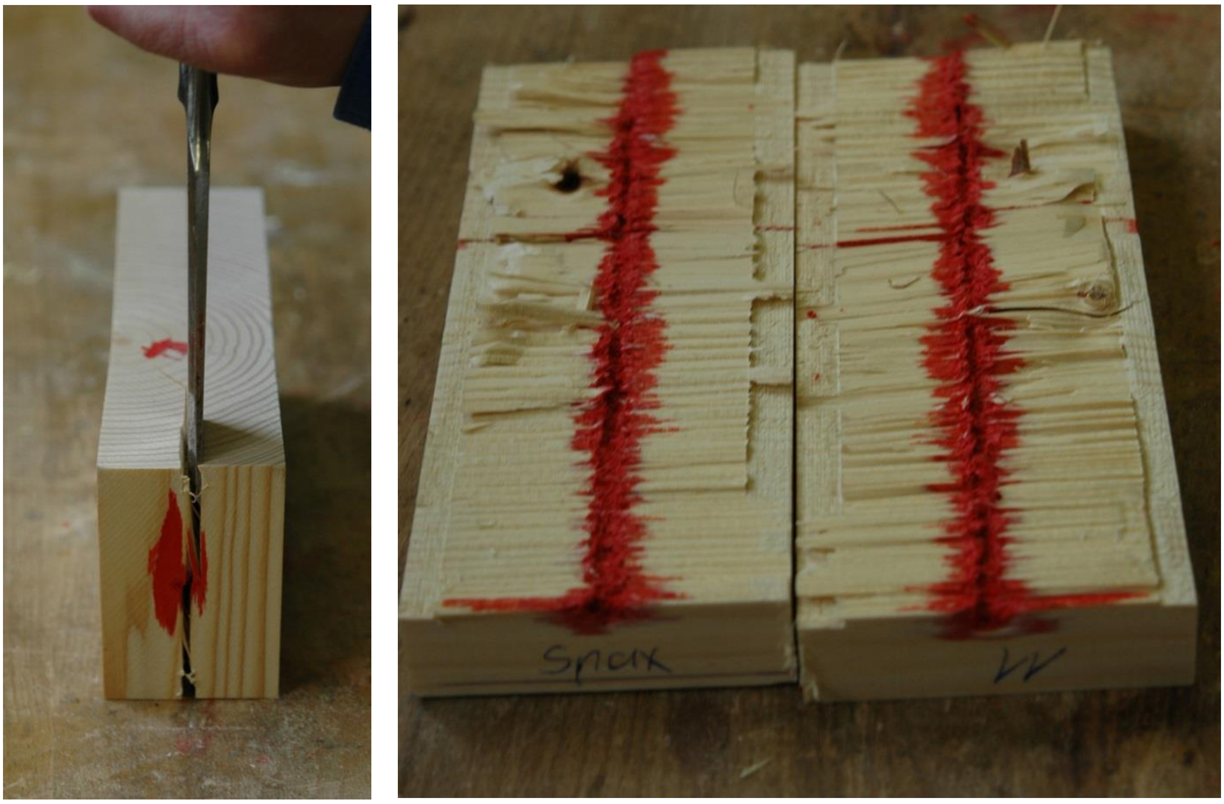


Fig. 4: Opening of the specimens (left) and opened specimens (right).

The size of the split caused by driving in the insert into the timber is quantified e.g. using a digital image recorder. Fig. 5 shows a typical split image of a specimen with blue lines showing the borders of the split area.

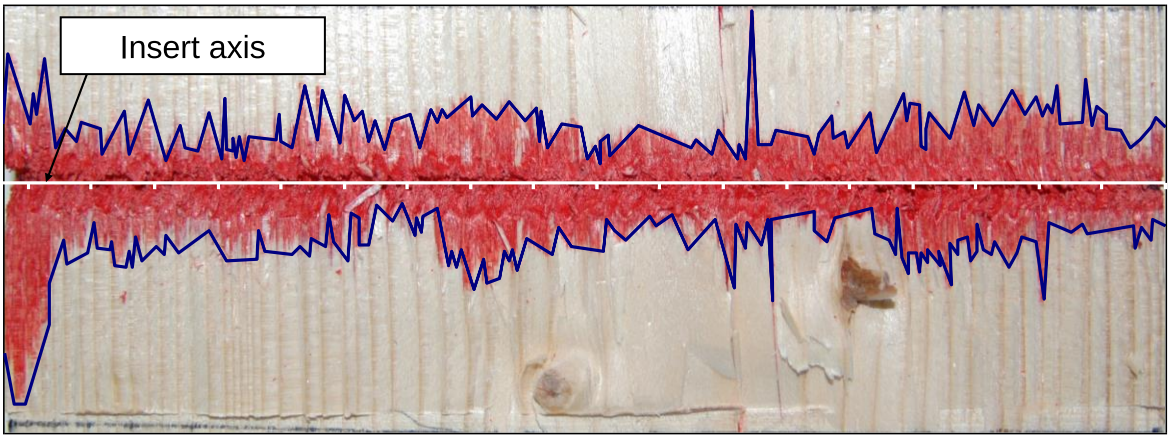


Fig. 5: Opened specimen with red coloured split area and blue lines indicating the borders of the split area.

For the evaluation of the split area the definitions in Fig. 6 are used:

- $A_{Ri,1}$: Split area between the insert axis and the end grain,
- $A_{Ri,3}$: Split area away from the end grain,
- $a_{1,c}$: End distance,
- $a_{Ri,1}$: Maximum split length towards the end grain,
- $a_{Ri,3}$: Maximum split length away from the end grain.

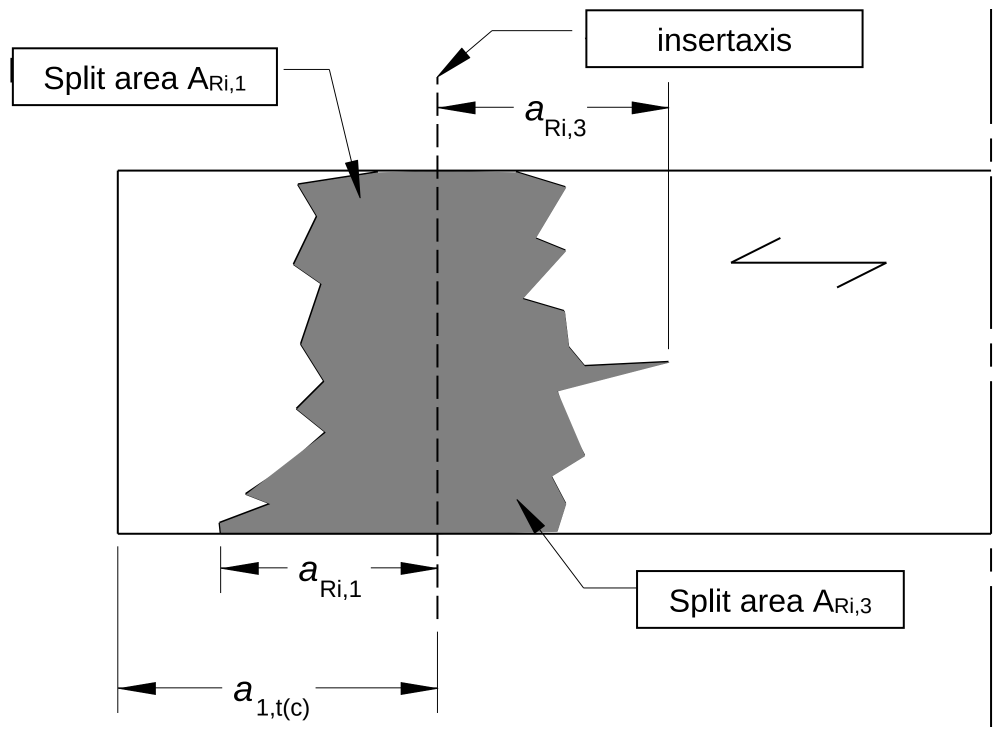


Fig. 6: Definition and notation of split dimensions.

A further parameter e_{085} is defined to describe the split expansion, see Fig. 7. 85 % of the respective split areas $A_{Ri,1}$ or $A_{Ri,3}$ are within a distance of $e_{085,1}$ or $e_{085,3}$ from the insert axis.

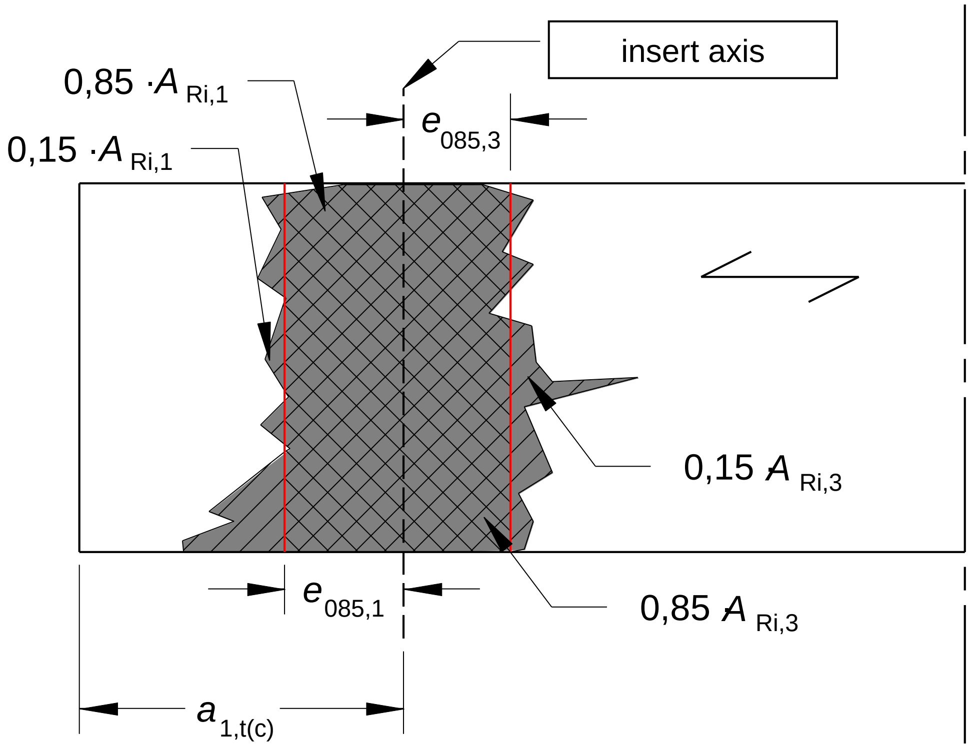


Fig. 7: Definition of split dimensions e_{085}.

Fig. 8 shows as an example the split dimensions $e_{085,1}$ and $e_{085,3}$.

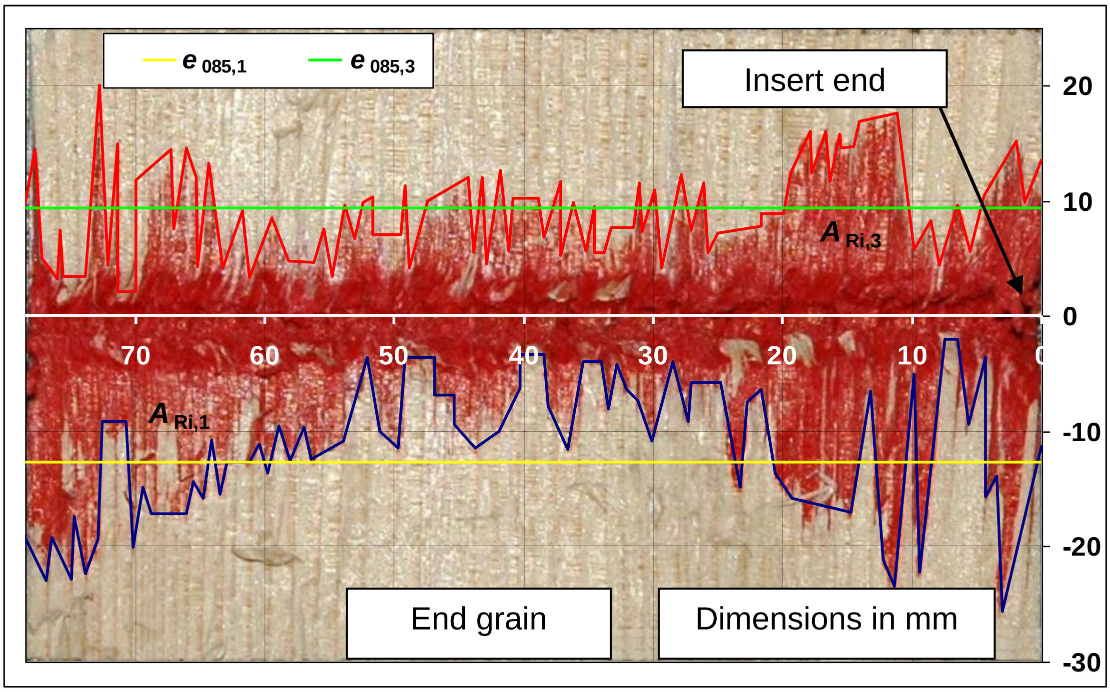


Fig. 8: Example of split dimensions e_{085}.

The cross-section dimensions and the spacing, end and edge distances used in the tests may be assumed as minimum dimensions for the insert and timber species tested, if the following conditions are fulfilled:

Maximum split dimension $e_{085,1,max}$ of 20 test specimens: $e_{085,1,max} \leq 0,4 \cdot a_{1,c}$

Mean split dimension $e_{085,1,mean}$ of 20 test specimens: $e_{085,1,mean} \leq 0,25 \cdot a_{1,c}$

Here, $a_{1,c}$ is the end distance used in the tests.

If at least three different diameters of a insert lead to similar results, e.g. to a minimum end distance of 5 d, the respective minimum dimension for other insert diameters between the tested diameters may be assumed to be the same multiple of the outer thread diameter.

2 Test method for laterally loaded inserts

Since the splitting of timber in the connection area may be caused by both, the insertion of the inserts as well as the lateral loading in connections with laterally loaded fasteners, the test method shown for axially loaded inserts is not sufficient to determine minimum requirements for laterally loaded inserts. However, the minimum timber width and thickness and the minimum spacing, end and edge distances determined for laterally loaded inserts may also be used for axially loaded inserts.

The minimum timber width and thickness as well as the minimum spacing, end and edge distance requirements are determined by tensile tests according to EN 1380, where the inserts are driven perpendicular to the grain into specimens. Subsequently, the load-deformation behaviour of the tested connections is evaluated. The test results are valid for the timber species, the insert and the diameter used in the test and for:

- Timber with a thickness equal or larger than the thickness of the side members used in the tests,
- Timber with a width equal or larger than the width of the side members used in the tests,
- The minimum end and edge distances in the side members used in the tests,
- The minimum spacing in the side members used in the tests.

Test results with sawn timber are valid also for glued laminated timber and vice versa. For wood-based materials like LVL, separate tests are required. The test specimens shall fulfil the following requirements:

- The sawn timber density shall not be less than 480 kg/m³ for Picea abies (Norway spruce) or Abies alba (Fir), 550 kg/m³ for Pinus sylvestris (Scots pine) and 650 kg/m³ for Pseudotsuga menziesii (Douglas-fir) or Larix decidua (Larch),
- The angle between the insert axis and the annual ring orientation shall be about 0° (tangential) or about 90° (radial),
- There shall be 3 specimens with a radial and 3 specimens with a tangential annual ring orientation,

- The specimens shall be conditioned prior to inserting in the inserts at a temperature of (20 ± 2) °C and a relative humidity of (65 ± 2) %,

A minimum of 3 inserts per row parallel to the grain are used. The insert should be flush with the timber surface.

After storing the specimens containing the inserts at a temperature of (20 ± 2) °C and a relative humidity of (65 ± 2) % for at least 24 h, the connections are tested according to EN 26891.

The cross-section dimensions and the spacing, end and edge distances used in the tests may be assumed as minimum dimensions for the insert and timber species tested, if one of the following conditions is fulfilled:

- A relative displacement of 10 mm is reached between side and middle member before the connection load falls below 80 % of the maximum load reached before 10 mm displacement. If the specimens contain two identical connections in series, this condition must be fulfilled for the connection which first reaches a deformation of 10 mm.
- A ductility ratio of D ≥ 10 according to EN 12512 is reached

If at least three different diameters of a insert lead to similar results, e.g. to a minimum end distance of 5 d, the respective minimum dimension for other insert diameters between the tested diameters may be assumed to be the same multiple of the outer thread diameter.

Alternatively, the absolute minimum timber thickness determined for a insert may be used for smaller diameters of the same insert. If an insert with a diameter d = 20 mm was e.g. successfully tested with a minimum thickness of 3 d = 60 mm, a minimum thickness of 60 mm may also be used for smaller diameters of the same insert.