



TECHNICAL REPORT

**Method of testing  
Three-Dimensional Nailing  
Plates with examples**

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# Method of testing three-dimensional nailing plates with examples

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## Foreword

*EOTA Technical Reports are developed as supporting reference documents to European Technical Approval Guidelines and can also be applicable to a Common Understanding of Assessment Procedures, an EOTA Comprehension Document or a European Technical Approval, as far as reference is made therein.*

*EOTA Technical Reports go into detail in some aspects and express the common understanding of existing knowledge and experience of the EOTA bodies at a particular point in time.*

*Where knowledge and experience is developing, especially through approval work, such reports can be amended and supplemented.*

*When this happens, the effect of the changes upon the European Technical Approval Guidelines will be laid down in the relevant comprehension documents, unless the European Technical Approval Guideline is revised.*

*This EOTA Technical Report has been prepared by the EOTA Working Group 06.03/01 — “Three-Dimensional Nailing Plates” and endorsed by EOTA.*

## 1 Scope

This Technical Report gives methods of testing three-dimensional nailing plates with examples when used to join end grain to side grain (Figure 1) and side grain to side grain (see Figures from 2 to 6) of timber members, and specifies the form and dimensions of the test specimens.

The general testing procedures are detailed in clause 2.4.1.1.3 of the ETAG 015.

## 2 Timber members

The timber members shall have the depth and width specified by the manufacturer. The density of the wood members shall fulfil EN ISO 8970. However, if the densities deviate from this requirement the load-carrying capacity of each test result shall be determined as indicated in clause 4.

## 3 Test specimen

Examples of test specimens used to determine load and slip characteristics are shown in Figures 1 to 6.

The specimen shall include gaps and wane as appropriate, as described in clause 2.4.1.1.3.2.1 of ETAG 015.

For end grain to side grain joints (see Figure 1) for solid timber headers to ensure that the compressive forces at the supports do not counteract splitting of the header the length “a” has been set as greater than 3 times the header depth  $h_{\text{header}}$  or 4 times the connector depth  $h_{\text{connector}}$ . When I-joist headers are used they are less susceptible to splitting in the web. However, there may be a risk of splitting between the flange and the web. The risk of splitting will depend on how the connection between the joist and the header is constructed:

- If the connector is fastened to timber based plates which are fastened directly to the web then the length “a” can be reduced to a minimum of 1,5 times header depth or 2 times connector depth  $h_{\text{connector}}$ .
- If the connector is fastened to a timber plate which is fastened only to the top and bottom flange then the length “a” shall be a minimum of 10 times the depth of the flange
- If the connector is fastened directly to one flange and the force is acting away from the beam then the length “a” shall be a minimum of 10 times the depth of the flange. This also applies to the case where the connector is fastened to both the upper and the lower flange

For end grain to side grain joints the side grain member may be either fully restrained against rotation or simply supported as specified by the manufacturer.

If specified, lateral restraint may be applied to the end grain member.

## 4 Modification of the load-carrying capacity

If the properties of the test specimens deviate from those of the declared materials or those of the timber strength class to which the results are intended to be applied each test result shall be modified to take this deviation into account. For some cases the modified load-carrying capacity of each individual test result shall be calculated from the following formula, which can be used as guidance for other cases..

4.1 If the load carrying capacity is governed by fastener withdrawal:

$$F_{\max,\text{mod}} = F_{\max} \left( \frac{\rho_{\text{mean}}}{\rho} \right)^{c_w}$$

where  $c_w$  is given in clause 6

4.2 If the load-carrying capacity is governed by tensile failure of the fastener then:

$$F_{\max,\text{mod}} = F_{\max} \left( \frac{F_{t,k}}{F_t} \right)$$

4.3 If the load-carrying capacity is governed by tensile failure of the three-dimensional nailing plate:

$$F_{\max,\text{mod}} = F_{\max} \left( \frac{f_{t,k}}{f_t} \right) \left( \frac{t_{ef,k}}{t_{ef}} \right)$$

4.4 If the load-carrying capacity is governed by shear of the fastener:

$$F_{\max,\text{mod}} = F_{\max} \left( \frac{\rho_{\text{mean}}}{\rho} \right)^{c_s} \left( \frac{M_{y,k}}{M_y} \right)^{0,5} \left( \frac{d_d}{d} \right)^{0,5}$$

where  $c_s$  is given in clause 6

4.5 If the load-carrying capacity is governed by bending of the steel plates and contact compression:

$$F_{\max,\text{mod}} = F_{\max} \left( \frac{\rho_{\text{mean}}}{\rho} \right)^{0,5} \left( \frac{M_{y,k,NP}}{M_{y,NP}} \right)^{0,5}$$

4.6 In the case that the load-slip relation continues to increase up to the limit of 15 mm and the contributions to the slip originate from lateral force on fasteners and/or compression perpendicular to the grain:

$$F_{\max,\text{mod}} = F_{\max} \left( \frac{\rho_{\text{mean}}}{\rho} \right)^{0,5}$$

4.7 In the case that the failure takes place only in yielding hinges in the connector:

$$F_{\max,\text{mod}} = F_{\max} \frac{M_{y,k,NP}}{M_{y,NP}}$$

which for a connector with rectangular cross section can be written as

$$F_{\max,\text{mod}} = F_{\max} \left( \frac{f_{y,k}}{f_y} \right) \left( \frac{t_{ef,k}}{t_{ef}} \right)^{0,5}$$

4.8 In the case that the failure takes place as a combination of yielding hinges in the connector and withdrawal of the nails, which occurs e.g. for a lifting force on an angle bracket connection with angle brackets on both sides of the purlin,

$$F_{\max, \text{mod}} = F_{\max} \left( \frac{\rho_{\text{mean}}}{\rho} \right)^{0,5} \left( \frac{M_{y,k,NP}}{M_{y,NP}} \right)^{0,5}$$

## 5 Consideration of the natural variation of the wood density

The intention behind the requirement in EN ISO 8970 to the wood density is that the natural variation of the density should be represented by the selection of the wood for the test specimens for a specific test, i.e. a test for the determination of a property for a certain force direction. However, there is no requirement in EN ISO 8970 that the density of the wood specimens shall have a coefficient of variation similar to what is indicated in EN 338 for the strength classes where the characteristic density has been determined using a Coefficient of Variation, COV of 10%.

### Test specimens fulfil EN ISO 8970

Since the densities of the wood specimens fulfil EN ISO 8970 the measured load-carrying capacities shall not be modified.

Frequently the variation of the wood density in the test specimens is less than indicated in EN 338. If COV of the density of the actual wood members for the test specimens is less than 10% then the standard deviation of the load-carrying capacity of the connection according to EN 14358:2006 shall be increased by the factor  $k_{\text{COV}}$ . This applies also to the case where the coefficient of variation of the capacities is less than 0,05 as required in EN 14358:2006, clause 4.7.  $k_{\text{COV}}$  is determined from the following expressions:

$$COV_R^2 = (COV_\delta^2 + 1) \left( \frac{c_p \cdot 0,1^2 + 1}{c_p \cdot COV_\rho^2 + 1} \right) - 1$$

where  $c_p$  is the power to the density modification term in the previous expressions, either  $c_w$  or  $c_s$  depending on the failure mode.

$$k_{\text{COV}} = \frac{COV_R}{COV_\delta}$$

So, the standard deviation  $s_y$  to be employed for the determination of the characteristic load-carrying capacity according to EN 14358:2006 becomes

$$s_y = \text{MAX} \left[ k_{\text{COV}} \sqrt{\frac{1}{n-1} \sum_{i=1}^n (\ln m_i - y_{\text{mean}})^2}; 0,05 \right]$$

### Test specimens do not fulfil EN ISO 8970

If the wood members for the test specimens do not fulfil EN ISO 8970 the load-carrying capacities of each test result shall be modified as indicated in clause 4.

Further, the standard deviation of the modified load-carrying capacity of the connection according to EN 14358:2006 shall be increased by the factor  $k_{\text{COV}}$  on the standard deviation  $s_y$ . This applies also to the case where the coefficient of variation of the capacities is less than 0,05 as required in EN 14358:2006, clause 4.7.  $k_{\text{COV}}$  is determined from the following expressions:

$$COV_R^2 = (COV_\delta^2 + 1)(c_p \cdot 0,1^2 + 1) - 1.$$

where  $c_p$  is the power to the density modification term in the previous expressions depending on the failure mode.

$$k_{COV} = \frac{COV_R}{COV_\delta}$$

So, the standard deviation  $s_y$  to be employed for the determination of the characteristic load-carrying capacity according to EN 14358:2006 becomes

$$s_y = \text{MAX} \left[ k_{COV} \sqrt{\frac{1}{n-1} \sum_{i=1}^n (\ln m_i - y_{mean})^2}; 0,05 \right]$$

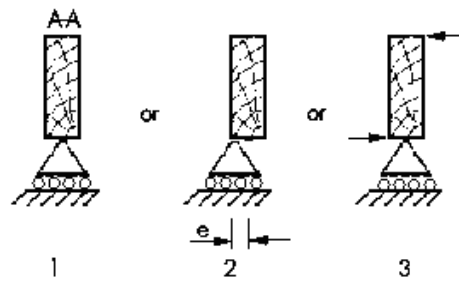
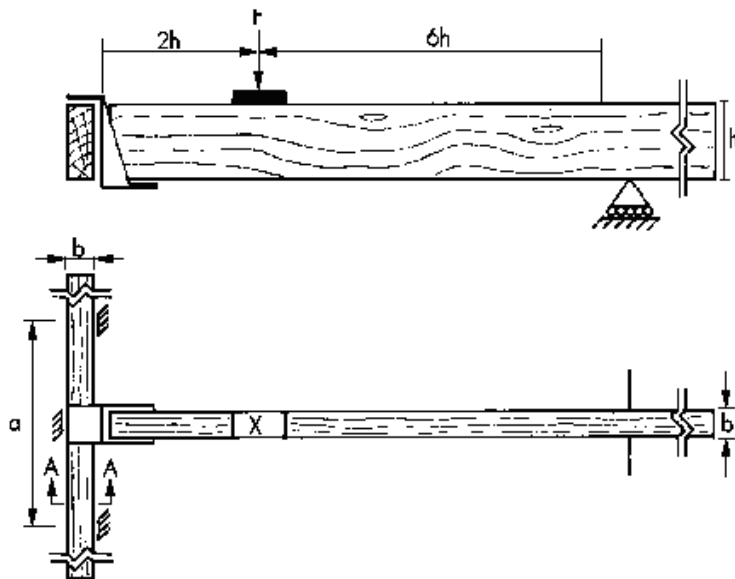
## 6 Symbols

$F_{max}$  = maximum load of an individual test result on the three-dimensional nailing plate connection, in Newtons;  
 $C_s$ ;  $C_w$  = are non-dimensional parameters. For modification from a higher density to a lower density the values given in the table below are applicable. For modification from a lower density to a higher density the values given in the table below are applicable.

Power	Fastener type	From higher to lower density	From lower to higher density
$C_w$	Smooth or square twist nails	2,0	1,0
	Threaded nail	1,0	0,8
	Screws	0,8	0,6
$C_s$	Smooth or square twist nails, threaded nails or screws	0,5	0,3

$c_p$  = is the power to the density modification term in the modification expressions in clause 4, either  $c_w$  or  $c_s$ ;  
 $COV_R$  = Coefficient of variation of the load-carrying capacity considering full variation of the wood density;  
 $COV_\delta$  = Coefficient of variation of the measured or the modified load-carrying capacity;  
 $COV_\rho$  = Coefficient of variation of the measured wood density;  
 $\rho$  = actual density of the timber member in which the failure took place, in kilograms per cubic metre;  
 $\rho_{mean}$  = mean density of the timber grade to which the test results shall be applied, in kilograms per cubic metre;  
 $F_t$  = actual tensile capacity of the fastener in Newtons;  
 $F_{t,k}$  = characteristic tensile capacity of the fastener in Newtons;  
 $f_t$  = actual tensile strength of the three-dimensional nailing plate material, in Newtons per square millimetre;  
 $f_{t,k}$  = characteristic tensile strength of the three-dimensional nailing plate material, in Newtons per square millimetre;  
 $t_{ef}$  = actual thickness of the three-dimensional nailing plate, reduced by the thickness of the coating, in millimetres;  
 $t_{ef,k}$  = nominal thickness (reduced by the thickness of the coating) of the three-dimensional nailing plate, in millimetres;  
 $d$  = actual diameter of fastener  
 $d_d$  = declared diameter of fastener  
 $M_y$  = actual fastener yield moment tested in accordance with EN 409;  
 $M_{y,k}$  = declared characteristic fastener yield moment;  
 $M_{y,k,NP}$  = characteristic yield moment of the nailing plate cross section, in Newton mm per mm;  
 $M_{y,NP}$  = actual yield moment of the nailing plate cross section, in Newton mm per mm;

*Note: The value of  $f_{t,k}$  is the value given as  $R_m$  in EN 10088-2 (for stainless steels) or in EN 10147 (for hot-dip zinc-coated structural steel).*



- 1 Support at centre of bearing.
- 2 Support with excentricity.
- 3 Support with rotation restraint.

Figure 1 – End grain to side grain

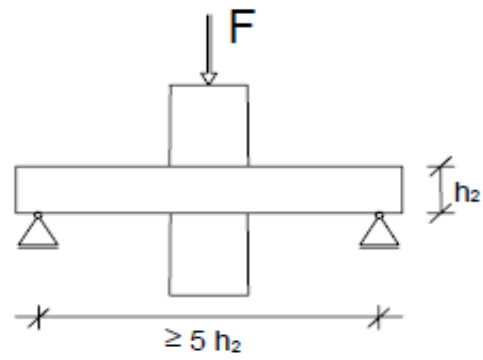
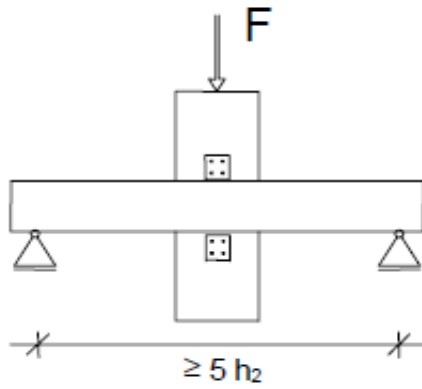
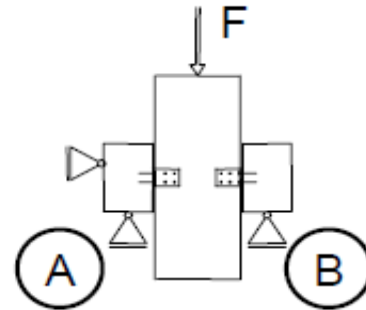
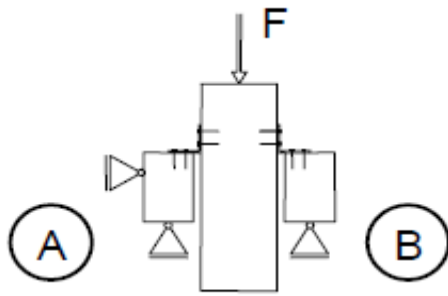
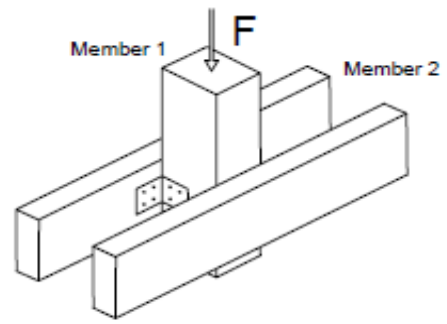
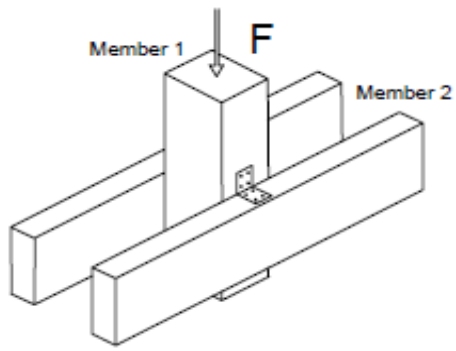


Figure 2 – Symmetrical side grain to side grain

Figure 3 – Symmetrical side grain to side grain

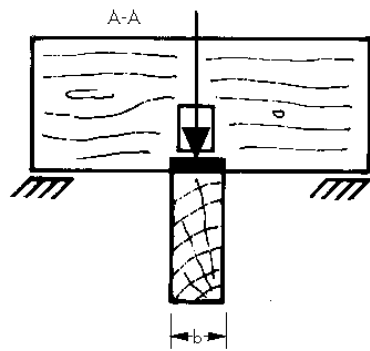
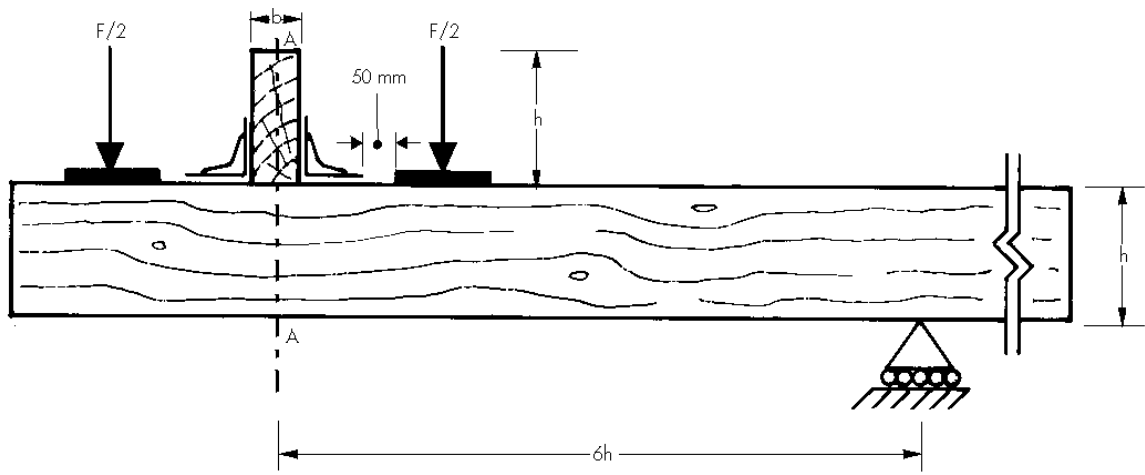


Figure 4 – Side grain to side grain

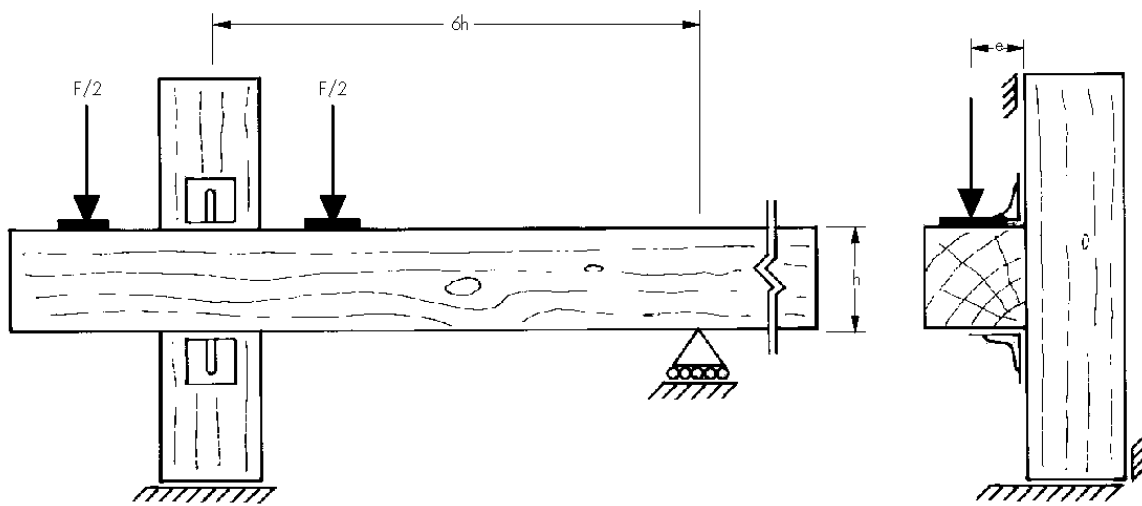


Figure 5 – Side grain to side grain. Force towards the angle brackets



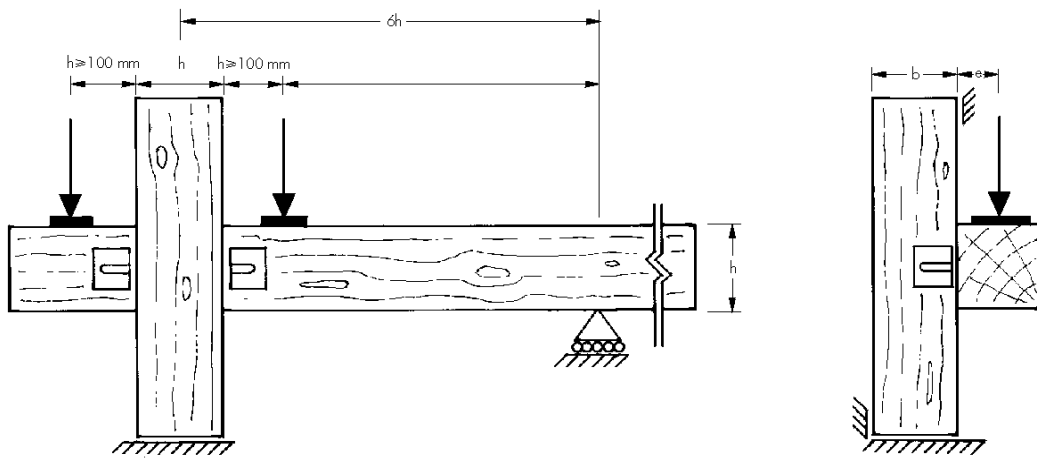


Figure 6 – Side grain to side grain. Shear force in the angle brackets