EUROPEAN ASSESSMENT DOCUMENT

EAD 200033-00-0602

March 2016

NAILED SHEAR CONNECTOR

©2016

The reference title and language for this EAD is English. The applicable rules of copyright refer to the document elaborated in and published by EOTA.

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).

©EOTA 2016

Contents

©EOTA 2016

1 SCOPE OF THE EAD

1.1 Description of the construction product

The kit consists of a nailed shear connector and powder actuated fasteners.

The nailed shear connector is a mechanically attached shear connector for use in steel-to-concrete composite beams and in composite decks with profiled sheeting as an alternate to welded headed studs.

The nailed shear connector consists of an L-shape cold-formed cantilever metal connector made from steel sheeting with a minimum thickness of 2 mm. The cantilever metal part consists of a fastening leg and an anchorage leg. The fastening leg of the connector is fastened by 2 powder-actuated fasteners (cartridge fired pin)[1] made to the base material steel member, whereas the anchorage leg embeds in the concrete deck of the composite beam. The nailed shear connector can be used for composite beams with and without profiled composite decking. The length of the anchorage leg may vary in order to take the different thicknesses of the concrete slab as well as the different heights of composite deck into account. The fastening leg is pre-drilled or pre-punched at the locations where the powder-actuated fasteners are to be driven.

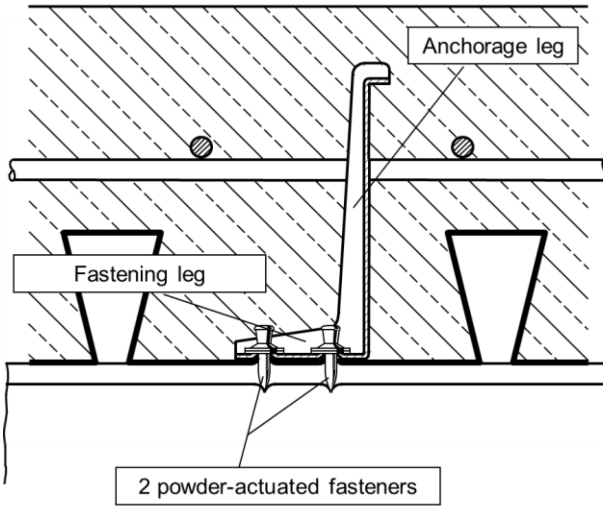


Figure 1: Nailed shear connector definitions

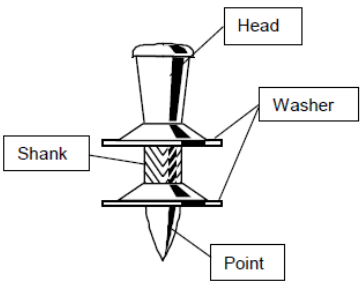


Figure 2: Powder-actuated fastener used for nailed shear connection

Powder-actuated fasteners used for nailed shear connectors are made of carbon steel and comprise of pins with minimum shank diameter of 4.5 mm which are normally assembled with one or two metal washers. The washers serve to guide the fastener while it is being driven into the base material. The washers also serve to improve the shear resistance. A special powder-actuated fastening tool is used in order to install the fastener. The driving force of the fastening tool is provided by the power load of the cartridge. The application limit of the powder-actuated fastening system depends on the strength and thickness of the

[1] Both terms (powder actuated fastener and cartridge fired pin) are commonly used

base material. The fastening tool (incl. cartridge) is an integral part of this assessment with regards to the capacity of the nailed shear connection and the application of the respective system.

The nailed shear connectors can be placed in one or more rows along the length of the composite beams. Aside of the use as shear connector for composite beams, nailed shear connectors may also be used for the end anchorage of composite decks, see Figure 3.

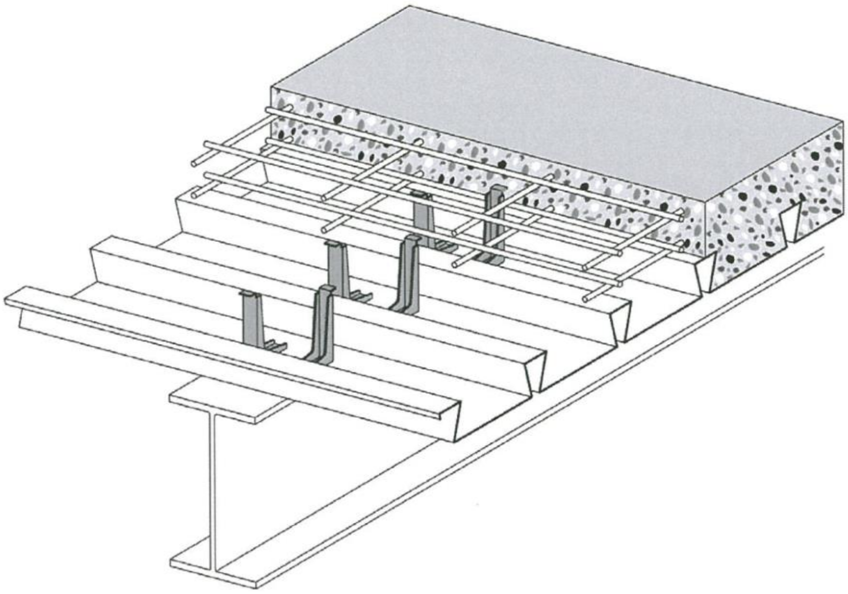


Figure 3: Nailed shear connector (here with 2 rows of shear connectors) for shear connection in composite constructions as well as end anchorage of composite deck.

The assessment of the load-bearing capacity of the fastener and the corresponding connections are part of this EAD. The fastening tool (incl. cartridge) is an integral part of this assessment with regards to its effect on the capacity of the connection.

The product is not covered by a harmonised European standard (hEN).

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 nailed shear connector is intended to be used as connection device between steel and concrete in composite beams and composite decks according to EN 1994-1-1. The nailed shear connector can either be used in new buildings or for the renovation of existing buildings with the aim to increase the bearing capacity of aged floor constructions.

©EOTA 2016

The range of concrete applied is normal weight concrete C20/25 – C50/60 or light weight concrete LC 20/22 – LC 50/55 (1750 kg/m² ≤ ρ < 2400 kg/m³) according to EN 206. Applicable steels for new construction are non-alloy structural steel at least S235 according to EN 10025-2. Structural steel for composite beams follow EN 1994-1-1 with reference made to EN 1993-1-1 and the material codes given there. Steel for profiled sheeting follows EN 1993-1-3 and the material codes given there.

Old steels which cannot be classified accordingly are still applicable provided these are made of unalloyed carbon steel with minimum yield strength of 170 N/mm².

The minimum concrete slab thickness is 50 mm. With regards to detailing of the shear connection and the concrete cover the provisions of EN 1994-1-1 section 6.6.5.2 apply.

The intended use comprises composite structures with static or quasi-static loading, see EN 1990 and EN 1991. Furthermore, the use of nailed shear connectors is allowed in structures subject to seismic loads under certain conditions defined herewith.

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 nailed shear connectors for the intended use of 50 years when installed in the works (provided that the nailed shear connectors 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[2].

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.

2 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 referred to above.

©EOTA 2016

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 1 shows how the performance of the nailed shear connector is assessed 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	Characteristic resistance in solid concrete decks, shear connector orientation parallel to beam axis	2.2.1	Level(P_{Rk} [kN]) Level(P_{Rd} [N/mm²])
2	Characteristic resistance in solid concrete decks, shear connector orientation perpendicular to beam axis	2.2.2	Level(P_{Rk} [kN]) Level(P_{Rd} [N/mm²])
3	Characteristic resistance in composite decks – decking ribs perpendicular to beam axis – shear connector orientation parallel or perpendicular to beam axis	2.2.3	Level(V_{Rk} [kN]) Level(V_{Rd} [kN])
4	Characteristic resistance in composite decks – decking ribs parallel to beam axis – shear connector orientation parallel or perpendicular to beam axis	2.2.4	Level(V_{Rk} [kN]) Level(V_{Rd} [kN])
5	Characteristic resistance of end anchorage of composite decks	2.2.5	Level(V_{Rk} [kN]) Level(V_{Rd} [kN])
6	Characteristic resistance for use in seismic areas under seismic actions according to EN 1998-1	2.2.6	Level(V_{Rk} [kN]) Level(V_{Rd} [kN])

©EOTA 2016

No	Essential characteristic	Assessment method	Type of expression of product performance *(level, class, description)*
7	Characteristic resistance in solid concrete decks in renovation application with old metallic iron or steel material with an actual yield strength less than 235 MPa	2.2.7	Level(V_{Rk} [kN]) Level(V_{Rd} [kN])
8	Application limit	2.2.8	Level(Pass/Fail)
Basic Works Requirement 2: Safety in case of fire			
9	Reaction to fire	2.2.9	Class (A1 if product meets requirements)
10	Resistance to fire	2.2.10	Level($V_{fi,Rk}$ [kN]) Level($V_{fi,Rd}$ [kN])

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

The design shall be in accordance with the general rules given in EN 1990. It should be shown that the value of the design shear action V_{Ed} does not exceed the value of the design shear resistance V_{Rd}:

$V_{Ed} \leq V_{Rd}$

with:

V_{Ed} … design shear action of nailed shear connector

V_{Rd} … design shear resistance of nailed shear connector

The forces shall be derived using appropriate combinations of actions for normal and accidental design situations as recommended in EN 1990.

The design resistance shall be calculated as follows:

$V_{Rd} = V_{Rk}/\gamma_V$

with:

V_{Rk} … characteristic shear resistance of nailed shear connector

γ_V …. partial safety factor for shear connection ($\gamma_V = 1.25$).

In case of a fire the design resistance shall be calculated as follows:

$V_{fi,Rd} = V_{fi,Rk}/\gamma_{M,fi,V}$

with:

$V_{fi,Rk}$ … characteristic shear resistance of nailed shear connector in case of a fire

$\gamma_{M,fi,V}$ …. partial safety factor for shear connection in fire design ($\gamma_{M,fi,V} = 1.0$)

Ideal plastic behavior of the nailed shear connection in the structure may only be assumed if sufficient ductility of the nailed shear connection is provided according to EN 1994-1-1, 6.6.1.1(4) and (5). Otherwise only elastic design is allowed, see EN 1994-1-1, 6.2.1.5 and no partial shear connection according EN 1994-1-1, 6.6.1.2 is possible.

©EOTA 2016

2.2.1 Characteristic resistance in solid concrete decks, shear connector orientation parallel to beam axis

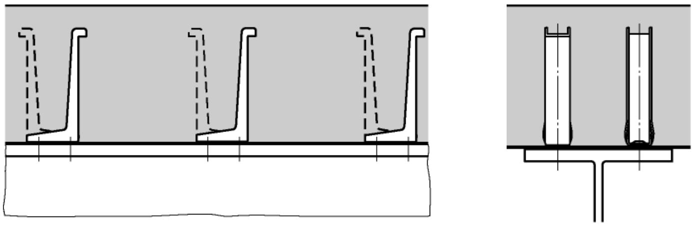


Figure 4: Nailed shear connector with solid concrete deck and orientation parallel to beam axis

The characteristic resistance of the nailed shear connector is either controlled by the shear connector resistance or by the shear resistance of the 2 powder-actuated fasteners. The design resistance of the nailed shear connector resistance is evaluated based on push tests according to EN 1994-1-1 and it is further limited by the pure shear design resistance of both shanks of the powder-actuated fasteners.

2.2.1.1 Resistance of the nailed shear connector

The characteristic shear resistances of the nailed shear connectors shall be tested by means of push tests according to EN 1994-1-1, Annex B.2. As the resistance of nailed shear connectors are not part of EN 1994-1-1 the design should be based on tests, carried out in a way that provides information on the properties of the nailed shear connection required for design. The variables to be investigated include the geometry and the mechanical properties of the concrete slab, the shear connectors and the reinforcement.

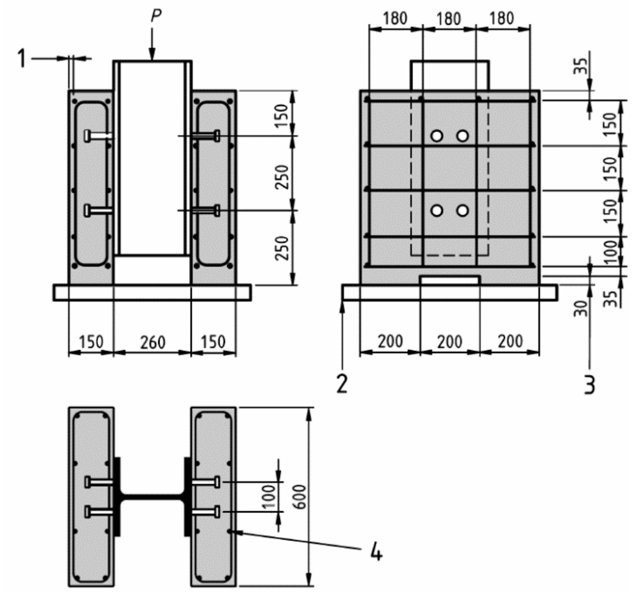


Figure 5: Standard push test specimen according to EN 1994-1-1

For standard push tests the dimensions of the test specimen, the steel section and the reinforcement should be as given in Figure 5. The recess in the concrete slabs is optional.

The determination of characteristic values of the resistance is derived from experimental tests which are evaluated statistically.

For the evaluation of the resistance in solid concrete decks at least 3 push tests shall be performed with the same type of specimens. By evaluating the influences of different parameters (e.g. size of shear connector, concrete strength…) for each parameter a series with at least further 3 push-out tests is necessary.

The statistical evaluation is performed according to EN 1990:2010-12, Annex D. Therefore, the fractile of 5% is determined.

©EOTA 2016

For small test series (limited number of push tests) the coefficient of variation is considered according to EN 1990, D.7.1 (5) to 0.1. Otherwise the coefficient of variation can be determined on the basis of the experimental tests.

If three tests on nominally identical specimens are carried out and the deviation of any individual test result from the mean value obtained from all tests does not exceed 10%, the nailed shear connector resistance may be determined simplified according to EN 1994-1-1, B 2.5. The characteristic resistance P_{Rk} should be taken as the minimum failure load (divided by the number of connectors) reduced by 10% (P_{Rk} = 0.9 * min $P_{u,test}$). If the deviation from the mean value exceeds 10%, at least three more tests of the same kind should be made. The test evaluation should then be carried out in accordance with EN 1990, Annex D.

The design value of the static shear connector resistance is the characteristic value divided by the recommended partial safety factor γ_V = 1.25.

The slip capacity of a shear connector specimen δ_u should be taken as the maximum slip, measured at the characteristic resistance as given by EN 1994-1-1, see Figure 6. The characteristic slip capacity δ_{uk} should be taken as the minimum test value of δ_u reduced by 10% or determined by statistical evaluation from all the test results. Shear connectors can be seen as ductile if the characteristic slip capacity δ_{uk} is larger than 6 mm.

The respective failure modes (steel failure, concrete failure etc.) as well as the material properties of the sheeting, the base material, concrete strength and the fastener shall be documented in the test report.

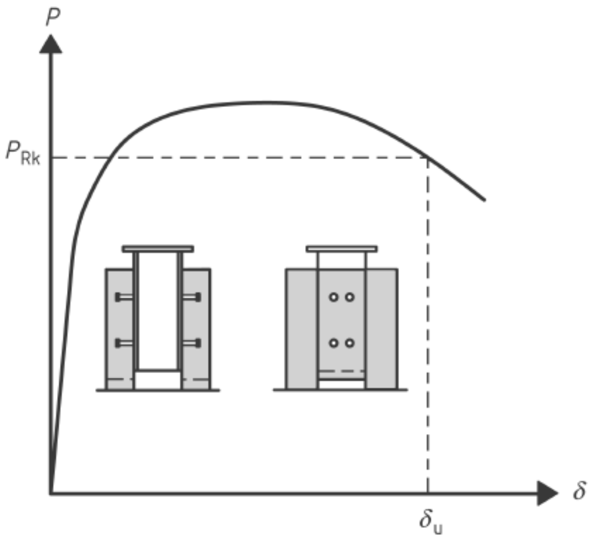


Figure 6: Determination of slip capacity δ_u according to EN 1994-1-1, Annex B.2

2.2.1.2 Shear resistance of powder-actuated fasteners

The characteristic shear resistance of the powder-actuated fastener shall be determined by means of at least 10 single layer shear tests. Unalloyed carbon steel is to be used for the fixed sheeting with the thickness t_I as well as the base material with the thickness t_{II}. The thickness t_I of the fastened steel sheet should be at least 3.0 mm. The strength of the sheet shall be selected such, that no slotting in the fixed sheet occurs and that pure shear fracture of the fastener controls the ultimate resistance. The tensile strength as well as the thickness of the material of the component with the thickness t_{II} is optional as long as failure of the base material is excluded.

The test load shall be increased until shear failure of the fastener occurs.

The load-deformation curves and the respective failure modes as well as the material properties of the sheeting, the base material/steel member and the fastener used for the tests shall be documented in the test report. Furthermore the failure loads shall be given in the test report. The material properties should be documented by means of inspection documents 3.1 according to EN 10204. The core hardness – measured in HRC-Rockwell hardness according to EN ISO 6508-1 – of the fastener has to be determined and documented in the test report (at least 10 fastener samples). The material properties of the fastener have to correspond to the material specifications given by the manufacturer.

©EOTA 2016

An example for the test setup of a single layer shear test is shown in Annex 1.

The test results shall be multiplied by the following correction factor α:

$$\alpha = (R_{m,min}/R_m)$$

with:

$R_{m,min}$ .. minimum tensile strength of powder-actuated fastener according to product specification. If the minimum specification is given as core hardness (e.g. HRC Rockwell hardness) the minimum strength can be converted from the hardness according to EN ISO 18265.

R_m … actual tensile strength of tested powder-actuated fastener. The actual strength can be converted from the measured core hardness values according to EN ISO 18265. The average hardness value of the 10 tested samples can be used for the conversion.

The corrected test results shall be evaluated statistically according to EN 1990 (determination of 5% fractile with a confidence level 75%). The corrected and statistically evaluated test results (5% fractiles) are the characteristic values of resistance.

The design value of the static shear resistance of the powder-actuated fastener is the characteristic value divided by the recommended partial safety factor γ_M = 1.25.

2.2.2 Characteristic resistance in solid concrete decks, shear connector orientation perpendicular to beam axis

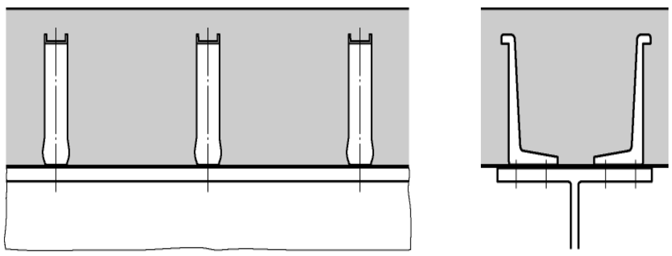


Figure 7: Nailed shear connector with solid concrete deck and orientation perpendicular to beam axis

For the *Characteristic resistance in solid concrete decks, shear connector orientation perpendicular to beam axis* the same preferences and assessment methods apply and shall be used as described in section 2.2.1.1 and 2.2.1.2.

2.2.3 Characteristic resistance in composite decks - decking ribs perpendicular to beam axis - shear connector orientation parallel or perpendicular to beam axis

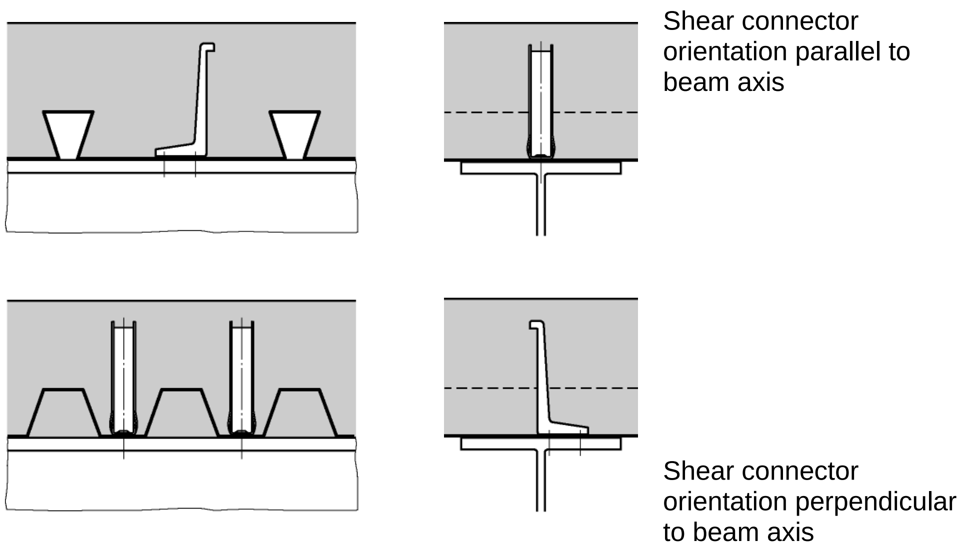


Figure 8: Nailed shear connector with composite decking perpendicular to beam

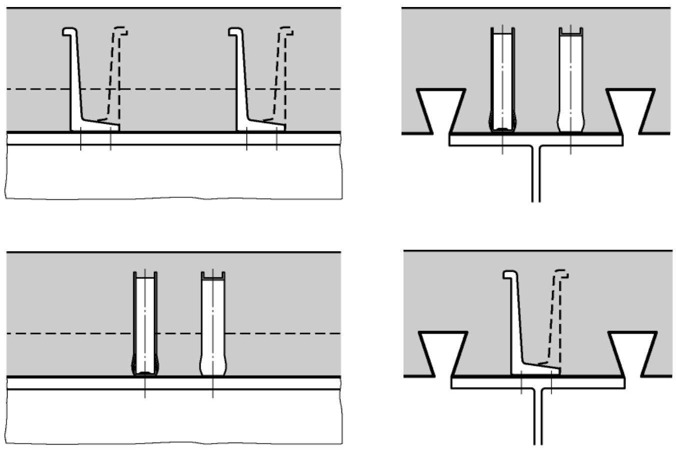
In general push tests using decking ribs need to be performed according to the given information in chapter 2.2.1.

The following additional parameters need to be taken into consideration (see Figure 8):

- Shape and dimensions of the decking rib
- Position of the nailed shear connector inside the rib
- Relation between the height of the shear connector and the height of the decking rib (embedment depth)
- The series of push tests using decking ribs can be evaluated according to chapter 2.2.1.
- If series with at least three tests on nominally identical specimens are carried out and the deviation of any individual test result from the mean value obtained from all tests does not exceed 10%, the shear connector resistance may be determined simplified according to EN 1994-1-1, B 2.5. The characteristic resistance P_{Rk} should be taken as the minimum failure load (divided by the number of connectors) reduced by 10% ($P_{Rk} = 0.9 * \min P_{u,test}$). If the deviation from the mean value exceeds 10%, at least three more tests of the same kind should be made. The test evaluation should then be carried out in accordance with EN 1990, Annex D, see also chapter 2.2.1.
- If more parameters are investigated for a special kind of composite decking, it is also possible to derive an analytical relationship. The result of this relation may be presented either as a reduction factor k_t that is applied to the bearing capacity of a comparable solid slab or as a complete new equation that describes the bearing capacity depending on the investigated parameters.
- The design value of the static shear connector resistance is the characteristic value divided by the recommended partial safety factor $\gamma_V = 1.25$. As for solid concrete decks the design resistance of the nailed shear connector must not exceed the design shear resistance of the 2 powder-actuated fasteners according to section 2.2.1.2.

©EOTA 2016

2.2.4 Characteristic resistance in composite decks - decking ribs parallel to beam axis - shear connector orientation parallel or perpendicular to beam axis



Shear connector orientation parallel to beam axis

Shear connector orientation perpendicular to beam axis

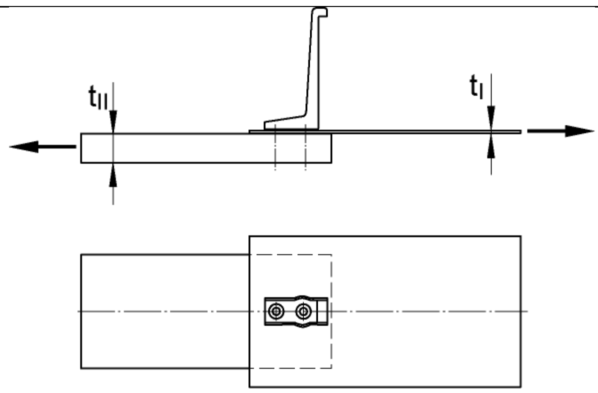
Figure 9: Nailed shear connector with composite decking parallel to beam

For the *Characteristic resistance in composite decks - decking ribs parallel to beam axis - shear connector orientation parallel or perpendicular to beam axis* the same preferences and assessment methods apply and shall be used as described in section 2.2.3.

2.2.5 Characteristic resistance of end anchorage of composite decks

The characteristic resistance of the end anchorage of composite decking shall be determined by means of single layer shear tests for each relevant deck thickness. As a minimum tests with the minimum and maximum thickness of the composite deck have to be performed.

The sheeting is fixed together with the nailed shear connector. Tests have to be performed with shear connector orientation parallel as well as perpendicular to the sheeting. Figure 10 shows examples of lap shear test samples. An example for the test setup is further shown in Annex 2. The width of the sheeting has to be selected such, that fracture of the fixed sheeting does not control the ultimate resistance. At least 10 samples have to be tested per test series.



Nailed shear connector parallel to composite decking

©EOTA 2016

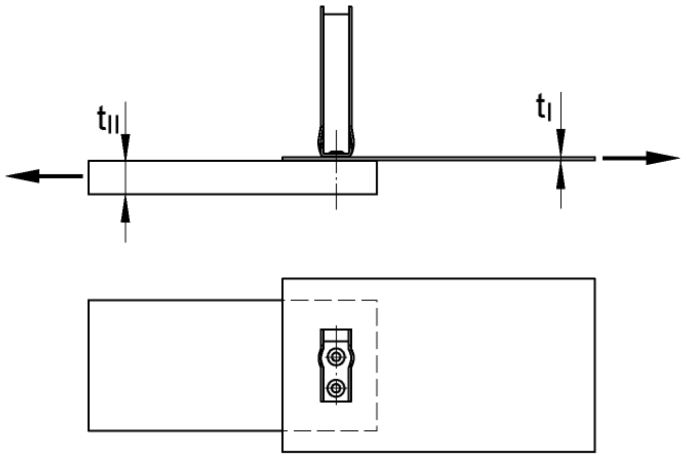
	Nailed shear connector perpendicular to composite decking

Figure 10: Example of lap shear test sample

The test load shall be increased until local bearing deformation (hole elongation) of the sheeting develops. Shear fracture of the fastener is not acceptable as failure mode.

The load-deformation curves and the respective failure modes as well as the material properties of the sheeting, the base material and the fastener used for the tests shall be documented in the test report. Furthermore the failure loads shall be given in the test report. The material properties should be documented by means of inspection documents 3.1 according to EN 10204.

The tensile strength of the fixed sheeting should be at the lower limit according to the relevant product standard (e.g. EN 10346). The tensile strength as well as the thickness of the base material is optional as long as failure of the base material is excluded.

The test results shall be multiplied by the following correction factor α:

$$\alpha = (R_{m,min}/R_m)\cdot (t_{I,min}/t_I)$$

with:

$R_{m,min}$ .. minimum tensile strength of composite decking according to the relevant product standard

R_m … tensile strength of the used sheeting t_I used for the tests

$t_{I,min}$ … minimum thickness (without coating) of the composite decking according to the relevant product standard

t_I … thickness of the sheeting used for the tests (without coating)

The corrected test results of the lap shear tests shall be evaluated statistically according to EN 1990 (determination of 5% fractiles with a confidence level 75%). The corrected and statistically evaluated test results (5% fractiles) are the characteristic values of the end anchorage resistance of the nailed shear connector.

The design value of the end anchorage resistance is the characteristic value of the end anchorage resistance divided by the recommended partial safety factor γ_V = 1.25. The design value for end anchorage of composite decking is limited by the design resistance of the shear connector when used in combination with steel decking parallel to the beam.

2.2.6 Characteristic resistance for use in seismic areas under seismic actions according to EN 1998-1

Provided the nailed shear connector performs ductile according to section 2.2.1.1 the nailed shear connector may be used for composite beams used as secondary seismic members in dissipative as well as non-dissipative structures.

2.2.7 Characteristic resistance in solid concrete decks in renovation application with old construction steel with an actual yield strength less than 235 MPa

Old construction steel which is not covered by current material standards might have yield and ultimate strength below the minimum specified values of S235 according to EN 10025. There are 2 options for the determination of the corresponding characteristic resistance of nailed shear connectors:

Option A:
Performance of push tests using original material from renovation jobsites in order to determine the characteristic resistance directly. The assessment of the tests shall be done in accordance with the assessment described in section 2.2.1.1 and 2.2.1.2 and/or section 2.2.3

Option B.
Performance of single layer lap shear tests to develop a strength dependent reduction factor $\alpha_{BM,red}$. This reduction factor takes the influence of reduced base material strength into account. The lap shear tests shall be executed as described in section 2.2.1.2. An example for the test setup is shown in Annex 1. At least 10 samples have to be tested per test series.

Test condition:

- Base material thickness: The test results are applicable for base material thickness equal and greater than the tested thickness. In case the minimum base material thickness is selected for the tests, the test results are valid within the entire application range.
- Tests have to be executed with minimum 3 different base material strength R_m.
    - Test 1: R_{m1} = 300 – 400 N/mm²
    - Test 2: R_{m2} = 400 – 500 N/mm²
    - Test 3: R_{m3} = 500 – 600 N/mm²
- The actual difference between the strength of Test 1 and Test 2 should be at least 80 N/mm². The difference between the actual strength of Test 2 and Test 3 should be at least 80 N/mm².
- The minimum thickness of the fixed sheeting has to correspond with the maximum wall thickness of the nailed shear connector. The strength of the sheet should be selected such that little slotting (< 2 mm) deformation occurs and that the ultimate strength of the shear test is controlled by the base metal (local bearing deformation combined with subsequent pull-out of the fastener from the base material).

The dependency of the lap shear strength on the base material strength has to be described by means of a linear regression analysis. The corresponding expression is used to extrapolate to lap shear strength for base materials with strength less than 360 N/mm².

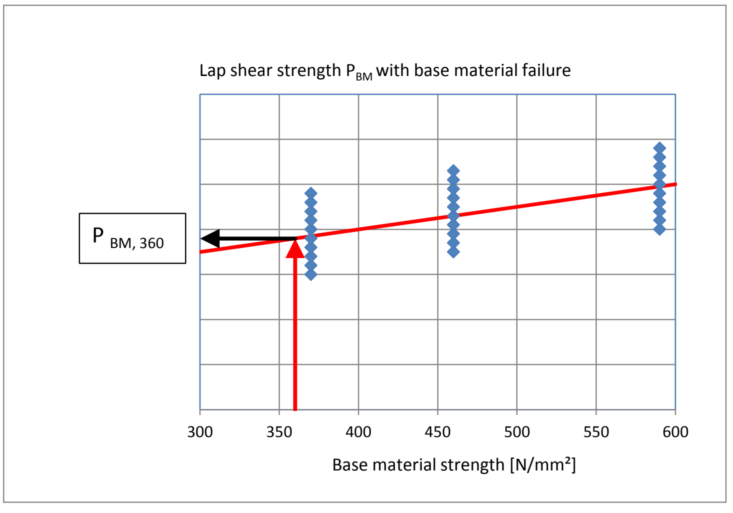


Figure 11: Concept of extrapolation to base material strength less than 360 N/mm²

©EOTA 2016

The reduction factor α_{BM} for the lap shear strength for base material with strength less than 360 N/mm² is calculated as follows:

$\alpha_{BM,red} = P_{BM,red} / P_{BM,360}$

with:

$P_{BM,red}$ ..... Lap shear strength for base material strength less than 360 N/mm² applying the established linear regression function

$P_{BM,360}$ ..... Lap shear strength for base material strength of 360 N/mm² applying the established linear regression function

The design resistance of the nailed shear connector for base material strength less than 360 N/mm² is calculated as follows:

$P_{Rd,red} = \alpha_{BM,red} \cdot P_{Rd}$

with:

$P_{Rd,red}$ …. Design resistance of nailed shear connector for base material strength less than 360 N/mm²

P_{Rd} …. Design resistance of the nailed shear connector for steel grade S235

$\alpha_{BM,red}$ …. Reduction factor to consider base material strength less than 360 N/mm²

2.2.8 Application limit

The application limits, such as minimum and maximum penetration depth, maximum strength of base material depending on the corresponding thickness t_{II}, type of fastening tool and cartridge as well as maximum stand-off of fastener head shall be determined by the manufacturer. The application limits concerning the maximum strength of the base material depending on the corresponding thickness t_{II} (example see Figure 12) shall be checked by tension pullout tests of the powder-actuated fastener as follows:

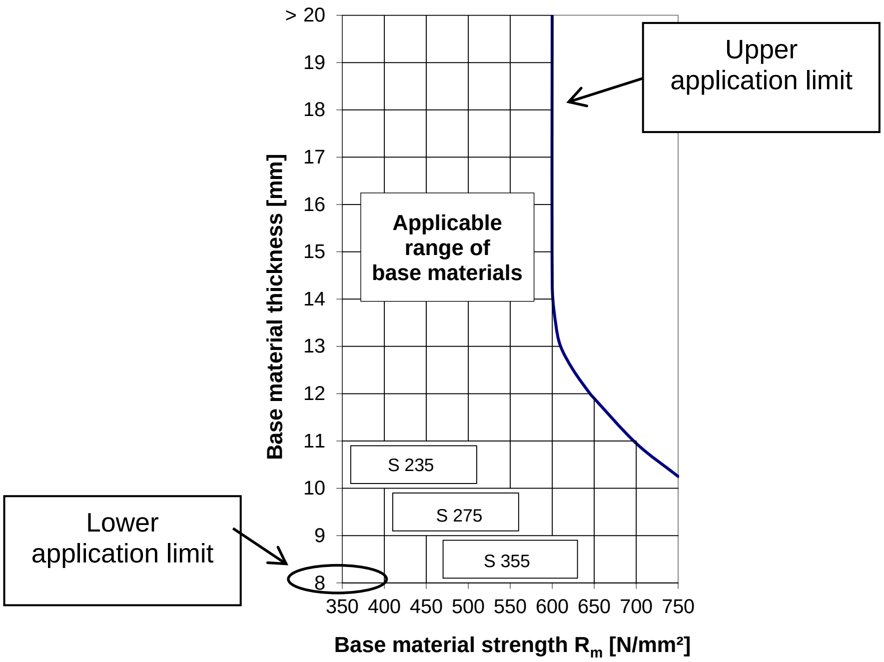


Figure 12: Example of application limit diagram

Tests have to be executed at the lower application limit

- For minimum base material thickness $t_{II} \geq 8$ mm, flat steel plates can be used as test samples.
- For minimum base material thickness 6 mm $\leq t_{II} < 8$ mm, the tests need to be executed on the top flange of steel sections (e.g. European I-beams) in order to consider the potential effect of

©EOTA 2016

deformation of thin flanges caused by the driving process. The shear connector positioning on the top flange of the beam has to be according to the manufacturer´s recommendation.

- The tensile strength of base material should be at the lower limit of grade S235 according to EN 10025.
- A shear connector type with the maximum wall thickness shall be used.
- To simulate the presence of metal deck, an intermediate sheet between the shear connector and the base material shall be used. The thickness of the sheeting should be 1 mm.
- At least 10 shear connectors have to be fastened.

Tests have to be executed at the upper application limit as follows:

- Maximum base material thickness t_{II} (≥ 20 mm)
- The tensile strength of the base material shall be at the upper application limit.
- A shear connector model with the minimum wall thickness shall be used.
- No intermediate sheet between shear connector and base material shall be used.
- At least 10 shear connectors have to be fastened.

The application limit tests are necessary in combination with all types of fastening tools to be approved for setting the powder-actuated fastener.

(Remark: The right setting of the powder actuated fastener is essential for a correct load-bearing connection.)

The test results shall be evaluated statistically (determination of 5% fractiles) according to EN 1990. A separate evaluation for the first and the second driven fastener is required.

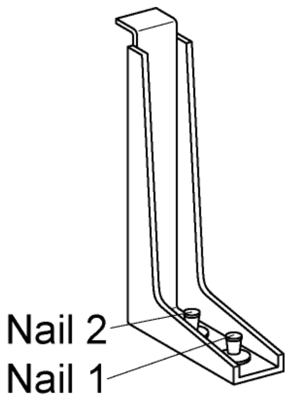


Figure 13: Nailed shear connector showing example of first and second nail

Criteria:

- Feasibility of correct installation:
- The nail head stand-off needs to be within the specified tolerance range.
- No fastener shear fractures occur during the installation.
- No excessive deformation of thin walled beam flanges develops.
- Characteristic pull-out resistance ≥ 8.8 kN

No correction of the test data is required for the calculation of the characteristic pull-out resistance. The test results of the pull-out values shall be evaluated statistically according to EN 1990 (determination of 5%

fractiles with a confidence level 75%). The characteristic pull-out resistances shall be calculated separately for the first and the secondly driven powder-actuated fastener, respectively.

Comment on the pullout criteria:

Powder-actuated fasteners used for shear-connectors typically were or are also covered by European Technical Approvals for general use of fastening thin walled steel members to steel (e.g. ETA-04/0063). The value stated above corresponds with the characteristic resistance of the powder-actuated fastener given in the stated ETA.

2.2.9 Reaction to fire

The powder-actuated fastener and the cold formed shear connector are considered to satisfy the requirements to performance class A1 of the characteristic reaction to fire, in accordance with the provisions of EC decision 96/603/EC (as amended) without the need for testing on the basis of conformity with the specification of the product detailed in that Decision and its intended end use application being covered by the Decision. The products shall be classified according to EN 13501-1.

2.2.10 Resistance to fire

Nailed shear connectors used for fire design should be designed according to EN 1994-1-2. For the special case of nailed shear connectors a new temperature dependent reduction factor $k_{u,\Theta,PAF}$ needs to be determined addressing the temperature dependent shear strength of the powder-actuated fasteners. The minimum temperature dependent reduction factor $k_{u,\Theta,NSC}$ (considering steel failure $k_{u,\Theta}$, concrete failure $k_{c,\Theta}$ and powder-actuated fastener shear failure $k_{u,\Theta,PAF}$) has to be used in the composite beam design in case of fire.

For the evaluation of the temperature dependent reduction factor $k_{u,\Theta,PAF}$ single shear tests at elevated temperatures are to be performed with the powder-actuated fasteners. Those tests can be performed with powder-actuated fasteners representative for the powder-actuated fasteners used for the nailed shear connectors. Representative fasteners need to have the same diameter, the same metallurgical composition and same core hardness as the powder-actuated fasteners used for the nailed shear connectors. However, representative fastener are accepted to be longer than the used powder-actuated fasteners for the nailed shear connectors in order to facilitate pure shear loading in the test engine.

Test condition:

- Tests have to be executed at room temperature, subsequently followed with tests at elevated temperature in the following temperature steps: 100 °C, 200 °C, 300 °C, 400 °C, 500 °C, 600 °C etc.
- Minimum 5 tests per shear test series have to be executed.
- The test procedure needs to ensure that the target temperature is achieved uniformly within the entire fastener, e.g. with heating of the oven with the first nail of a test series up to the target temperature of the series and holding the target temperature at least 45 minutes before execution of the first test. For subsequent shear tests of the same series a holding period of 30 minutes is sufficient. After the holding temperature has passed, the shear test is executed at a constant maximum test speed of 1 mm/min.

Provided the scatter of the test series is in the same magnitude, the temperature dependent reduction factor $k_{u,\Theta,PAF}$ is evaluated for the powder-actuated fastener per each tested temperature level as follows:

$k_{u,\Theta,PAF} = V_{u,\Theta,mean} / V_{u,RT,mean}$

with:

$V_{u,\Theta,mean}$ ..... Mean single shear resistance of powder-actuated fasteners at elevated temperature

$V_{u,RT,mean}$ ... Mean single shear resistance of powder-actuated fasteners at room temperature

©EOTA 2016

The characteristic resistance of the nailed shear connector at elevated temperature is calculated as follows:

$P_{fi,Rk} = k_{u,\Theta,NSC} \cdot P_{Rk}$

with:

- $P_{fi,Rk}$ …. Characteristic resistance of nailed shear connector at elevated temperature
- P_{Rk} …. Characteristic resistance of the nailed shear connector at room temperature
- $k_{u,\Theta,NSC}$ …. Minimum temperature dependent reduction factor (minimum of $k_{u,\Theta}$, $k_{c,\Theta}$ and $k_{u,\Theta,PAF}$)

The design resistance of the nailed shear connector at elevated temperature is calculated as follows:

$P_{fi,Rd} = \cdot P_{fi,Rk} / \gamma_{M,fi,V}$

with:

- $P_{fi,Rd}$ …. Design resistance of the nailed shear connector at elevated temperature
- $P_{fi,Rk}$ …. Characteristic resistance of nailed shear connector at elevated temperature
- $\gamma_{M,fi,V}$ …. Partial safety factor for fire design (=1.0)

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 1998/214/EC, amended by 2001/596/EC

The system is: **2+**

3.2 Tasks of the manufacturer

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

©EOTA 2016

Table 2 Control plan for the manufacturer; cornerstones

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method *(refer to 2.2 or 3.4)*	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]					
Shear Connectors					
1	Dimensions and tolerances	Measuring or visual check	Acc. to Control plan	Acc. to Control plan	Every manufacturing batch or 1000 shear connectors
2	Check of initial materials	Inspection document 3.1. acc. to EN 10204-2004 (to be furnished by the supplier)	Comparison with manufacturer's specifications		
3	Geometry, dimensions and shape	Check of dimensions and tolerances			
4	Zinc plating (where relevant)	x-ray measurement			
Powder actuated fasteners					
6	Dimensions and tolerances	Measuring or visual check	Acc. to Control plan	Acc. to Control plan	Every manufacturing batch or 100000 fasteners
7	Mechanical properties e.g. tensile strength, hardness, ductility, hydrogen embrittlement	E.g. tensile test, hardness test acc. to Brinell or Vickers	Comparison with manufacturer's specifications		
8	Check of initial materials	Inspection document 3.1. acc. to EN 10204-2004 (to be furnished by the supplier)			
9	Geometry and dimensions	Check of dimensions and tolerances			
10	Tensile strength (f_{uk})	Conversion of hardness values according to EN ISO 18265			
11	Core hardness and Surface hardness (at specified functioning relevant points of the product) (where relevant)	Tests according to: EN ISO 6507 or EN ISO 6508			

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method *(refer to 2.2 or 3.4)*	Criteria, if any	Minimum number of samples	Minimum frequency of control
12	Zinc plating (where relevant)	x-ray measurement	Comparison with manufacturer's specifications	Acc. to Control plan	Every manufacturing batch or 100000 fasteners
13	Manufacture's mark	Check of manufacture's mark	According to the requirements stated in the ETA		

3.3 Tasks of the notified body

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

Table 3 Control plan for the notified body; cornerstones

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method *(refer to 2.2 or 3.4)*	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control *(for systems 1+, 1 and 2+ only)*					
1	Ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the shear connector and of the fastener	-	Laid down in control plan	-	When starting the production or a new production line
Continuous surveillance, assessment and evaluation of factory production control *(for systems 1+, 1 and 2+ only)*					
2	Verifying that the system of factory production control and the specified automated manufacturing process are maintained taking account of the control plan.	-	Laid down in control plan	10	Once per year

©EOTA 2016

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.

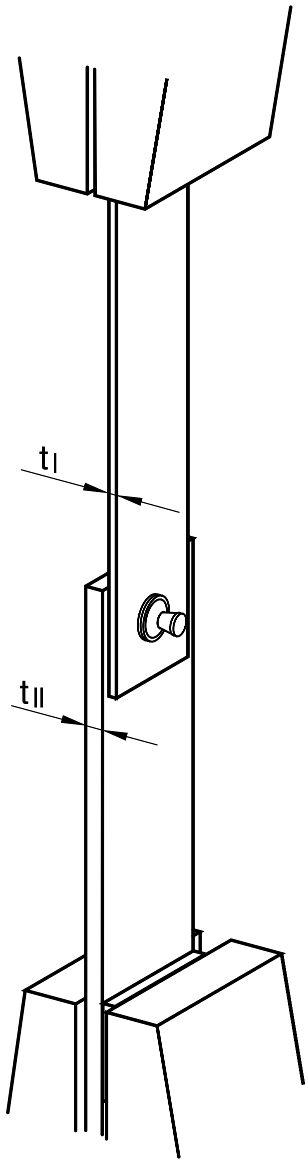
EN 206:2013	Concrete - Specification, performance, production and conformity
EN 1990:2002 + A1:2005 + A1:2005/AC:2010	Eurocode: Basis of structural design
EN 1991 (several parts)	Eurocode 1: Actions on structures
EN 1993-1-1:2005 + AC2009 + A1:2014	Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings
EN 1993-1-3:2006 + AC:2009	Eurocode 3: Design of steel structures - Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting
EN 1994-1-1:2004 + AC:2008 + A1:2014	Eurocode 4: Design of composite steel and concrete structures - Part 1-1: General rules and rules for buildings
EN 1994-1-2:2005 + AC:2008 + A1:2014	Eurocode 4: Design of composite steel and concrete structures - Part 1-2: General rules - Structural fire design
EN 1998-1:2004 + AC:2009	Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings
EN 10025-2:2004	Hot rolled products of structural steels – Part 2: Technical delivery conditions for non-alloy structural steels;
EN 10346:2009	Continuously hot-dip zinc coated strip and sheet of structural steels – Technical delivery conditions
EN 10204:2004	Metallic products – Types of inspection documents
EN 13501-1:2007+A1:2009	Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests
EN ISO 6507-1:2005	Metallic materials - Vickers hardness test – Part 1: Test method
EN ISO 6508-1:2015	Metallic materials – Rockwell hardness test – Part 1: Test method

©EOTA 2016

ANNEXES

©EOTA 2016

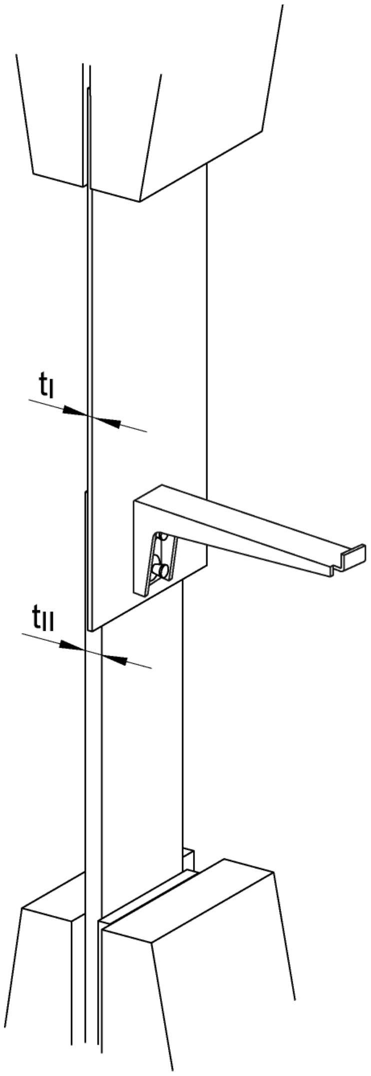
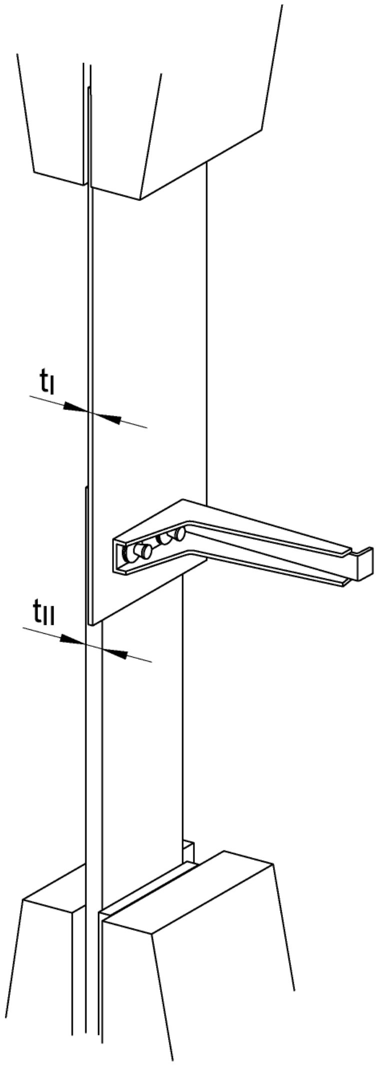
ANNEX 1: TEST SET UP FOR SINGLE LAYER SHEAR TEST



Remark: Clamping of the specimen in the test equipment has to be done in such a way, that the axis of the load is lying in the interface between the sheeting (t_I) and the base material (t_{II})

©EOTA 2016

ANNEX 2: TEST SET UP FOR LAP SHEAR TEST

	
Orientation of nailed shear connector parallel with sheeting	Orientation of nailed shear connector perpendicular with sheeting

<u>Remark</u>: Clamping of the specimen in the test equipment has to be done in such a way, that the axis of the load is lying in the interface between the sheeting (t_I) and the base material (t_{II}).

©EOTA 2016