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**DEPARTMENT FOR STRUCTURES**
**Section for Metal, Timber and Polymer Structures**

**Notified test laboratory NB-CPR no. 1404**

Ljubljana, February 16th, 2016

# REPORT

# No. P 1258/15-630-1

# on control laboratory tests of plain shank nails produced by RETA d.o.o. according to EN 14592:2008+A1:2012

| | |
|---|---|
| **Orderer :** | RETA d.o.o., Zagrebačka ul. 37, HR - 47000 Karlovac |
| **Order/contract :** | Offer No. 1279/2015 from December 3rd, 2015 |

**Responsible investigator:**

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# 1. INTRODUCTION

This report contains the results of geometry measurements and mechanical tests of plain shank nails in accordance with provisions of the technical specification EN 14592:2008+A1:2012 (*Timber structures - Dowel-type fasteners - Requirements*). Control measurements of geometry and tests for defining mechanical characteristics were carried out at the Laboratory for Structures of Slovenian National Building and Civil Engineering Institute (ZAG Ljubljana), Dimičeva 12, 1000 Ljubljana, from January 18th to January 29th, 2016.

# 2. DESCRIPTION OF PLAIN SHANK NAILS

## 2.1 Definition of product

Tested plain shank nails were manufactured by RETA d.o.o., Zagrebačka ul. 37, HR - 47000 Karlovac. The following types of nails which shall be used in timber structures were tested - their geometry is presented in Figure 1:

- Plain shank nails with nominal diameters 2.2, 2.5, 2.8, 3.1, 3.4, 3.8, 4.2, 5.0, 6.0 in 7.0 mm. No corrosion protection is applied. Nails should be inserted manually and no predrilling is foreseen.

According to the material specification, provided by the client, the plain shank nails were produced from the following types of material: carbon steel FE 37+B (UNI EN ISO 16120) - diameters 2.2, 2.5, 2.8, 3.1, 3.4, 3.8 and 4.2 mm and C 9D 2 (EN 10016-2) - 5.0, 6.0 and 7.0 mm.

The nominal dimensions of plain shank nails are presented in Table 1.

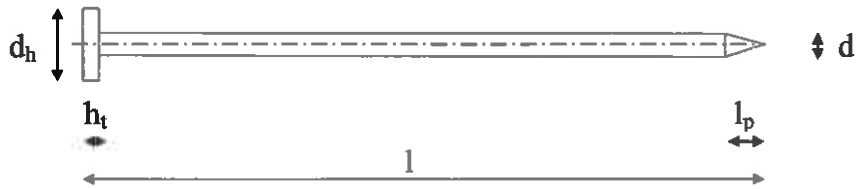


*Figure 1: Geometry of plain shank nails*

Table 1: Marking and grouping of plain shank nails

| Mark -ing | d[1] [mm] | $l_i$[2] [mm] | Characteristic yield moment | Characteristic withdrawal parameter | Char. head pull-through parameter | Characteristic tensile capacity |
|---|---|---|---|---|---|---|
| 2.2 | 2.2 | 40, 50 | x | x | x | x |
| 2.5 | 2.5 | 50, 60, 70 | x | x | x | x |
| 2.8 | 2.8 | 35, 39, 50, 60, 70, 80, 90 | x | x | x | x |
| 3.1 | 3.1 | 70, 80, 90 | x | x | x | x |
| 3.4 | 3.4 | 70, 80, 90 | x | x | x | x |
| 3.8 | 3.8 | 70, 80, 90, 100 | x | x | x | x |
| 4.2 | 4.2 | 100, 90, 120 | x | x | x | x |
| 5.0 | 5.0 | 140, 150 | x | x | x | x |
| 6.0 | 6.0 | 160, 180, 200, 210 | x | x | x | x |
| 7.0 | 7.0 | 210, 220, 230, 250, 280, 300 | x | x | x | x |

[1] declared nominal diameter
[2] informative lengths

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# 3. STANDARD REQUIREMENTS

Geometry and mechanical characteristics of nails were evaluated according to the harmonized European standard EN 14592:2008+A1:2012, Chapters 6.1.3 and 6.1.4. Initial type testing of mechanical characteristics was performed according to the requirements given in EN 14592:2008+A1:2012, Chapter 7.2 (Table 2).

## 3.1 Characteristic tensile strength of wire

Nails have to be produced from wire with minimum tensile strength of 600 N/mm$^2$ (according to EN 10218).

## 3.2 Geometry

Standard EN 14592:2008+A1:2012 defines the following criteria for geometry properties of the plain shank nails:

- The nominal diameter, d, of nail shall not be less than 1.9 mm and shall not be greater than 8.0 mm. The measured nominal diameter shall be within ± 2.5 % of the declared value. The minimum measurement should be taken as the nominal diameter. All other dimensions are calculated as average values.
- The area of nail head, $A_h$, shall not be less than $2.5d^2$, and the thickness of the head, $h_t$, shall not be less than 0.25d.
- The length (l) of the nail and the length of the point $l_p$ shall not be less than 0.5d and shall not be greater than 2.5d.
- All dimensions, excluding the nominal diameter, have to be within ± 5 % of the declared values.

Five specimens have to be sampled. Calibrated measuring device has to be capable of achieving an accuracy of ± 1 % of the measurement.

## 3.3 Mechanical strength and stiffness

The following mechanical characteristic have to be declared for the nails:

- Characteristic yield moment,
- Characteristic withdrawal parameter,
- Characteristic head pull through parameter,
- Characteristic tensile capacity.

At least ten specimens have to be tested for each diameter. Characteristic values have to be calculated according to EN 14358:2006 *(Timber structures – Calculation of characteristic 5-percentile values and acceptance criteria for a sample).*

### 3.3.1 Characteristic yield moment

Tests have to be performed according to EN 409:2009 *(Timber structures – Test methods – Determination of the yield moment of dowel type fasteners)*, where the bending angle α is limited to a maximum value of 45 degrees). The distances $l_1$ in $l_3$ are equal to 2d and the distance $l_2$ is

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equal to 3d. No cracks shall be observed at a bending angle α. Test should be performed in 10 ± 5 s.

Pass/fail criteria is used for description of cracks.

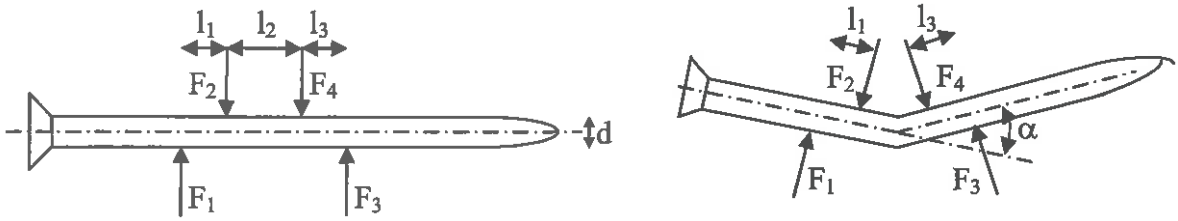


*Figure 2: Schematic representation of yield moment test*

### 3.3.2 Characteristic withdrawal parameter

Characteristic withdrawal parameter $f_{ax,k}$ is declared on specific timber density directly by testing in accordance with EN 1382:1999 *(Timber structures – Test methods – Withdrawal capacity of timber fasteners)*.

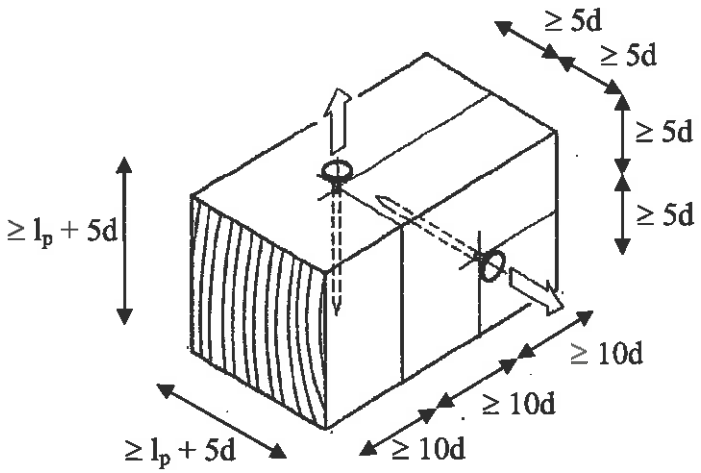


*Figure 3: Schematic representation of withdrawal test (EN 1382:1999)*

The nail axis should be perpendicular to the surface of timber element. Installation of nails should follow the manufacturer recommendations. Solid timber elements can be used; their geometry has to comply with dimensions as presented in Figure 3.

The penetration depth $l_p$ should be bigger than 12 d. Test should be performed in 90 ± 30 s.

As a result of testing, characteristic withdrawal parameter values ($f_{ax,k} = F_{max} / (d \cdot l_p)$) together with the characteristic timber density ($\rho_k$) have to be declared.

### 3.3.3 Characteristic head pull through parameter

Characteristic head pull through parameter $f_{ax,k}$ is declared by testing (Figure 4) in accordance with EN 1383:1999 *(Timber structures – Test methods – Withdrawal capacity of timber fasteners)* on one timber density: nails have to be pull through timber pieces.

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The nail axis should be perpendicular to the timber surface, knots and other imperfections should be avoided. The dimensions of timber elements are defined: the thickness (t) is less or equal to 7d and the width and length are equal to 4t.

The rate of loading shall be such that the time taken to reach $F_{max}$ is 300 ± 120 s.

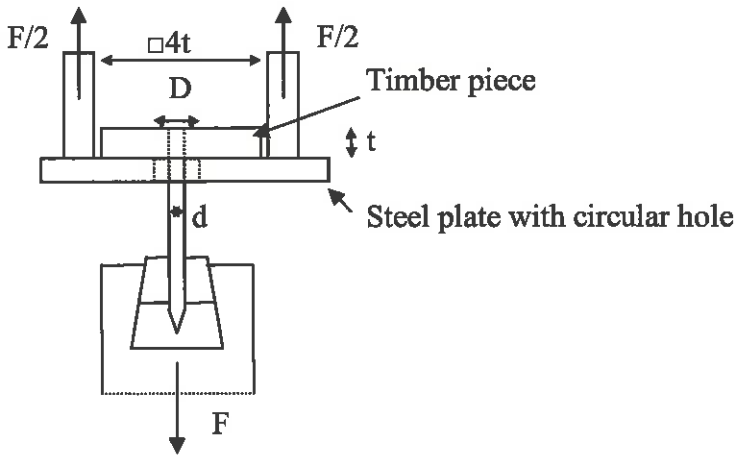


*Figure 4: Schematic representation of head pull through test (EN 1383:1999)*

Table 2: Dimensions of timber pieces and diameters of circular holes (diameter D)

| | d* [mm] | t ≤ 7d [mm] | D [mm], D ≥ 2t |
|---|---|---|---|
| Nails | 2.2 | 15.5 | 40 |
| | 2.5 | 17.5 | 40 |
| | 2.8 | 19.5 | 50 |
| | 3.1 | 21.5 | 50 |
| | 3.4 | 24 | 60 |
| | 3.8 | 26.5 | 60 |
| | 4.2 | 29.5 | 70 |
| | 5.0 | 35 | 80 |
| | 6.0 | 42 | 100 |
| | 7.0 | 49 | 110 |

* declared nominal diameter

The pull through parameter (f) is determined from equation: $f = F_{max} / d_h^2$. As a result of testing, characteristic head pull through parameter values ($f_{head,k}$) together with the characteristic timber density ($\rho_k$) shall be declared.

### 3.3.4 Characteristic tensile capacity

Characteristic tensile capacity $f_{tens,k}$ is declared by testing in accordance with EN 1383:1999, using a steel plate to replace the head side timber member shown in Figure 4 (also see Figure 4 in standard EN 1383:1999). The steel plate shall have sufficient thickness to introduce either a pull-off failure of the head, or a tensile failure of the nail and shall contain a pre-drilled hole for the nail which may not exceed the maximum outer diameter of the nail + 1 mm in diameter. The rate of loading shall be chosen so that the failure load (ultimate load) is reached within 10 ± 30 s.

As a result of testing, tensile capacity values ($f_{tens,k}$) for each diameter are declared.

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### 3.4 Corrosion protection

For nails where corrosion protection is required, the grade of parent material or thickness of coating material shall be declared in accordance with Annex A of EN 14592:2008+A1:2012.

## 4. SPECIMENS

Standard EN 14592:2008+A1:2012 in clause 7.1 allows grouping of products into families "where it is considered that the results for one or more characteristic from any one product within the family are representative for that same characteristics for all the products within that same family". Grouping of nails was performed in agreement with the client and is presented in Table 1.

Spruce structural timber corresponding to the strength class C24 (or GL 24) was used in the tests. Timber originated from Slovenia.

Specimens were delivered to ZAG laboratory on December 1st, 2015. The specimens were designated as:

- Characteristic tensile strength of wire:
  Z/2478/15 - Z/2487/15,
- Geometry:
  L15121/G/1 – L15121/G/50,
- Yield moment test:
  L15121/A/1 – L15121/A/100,
- Withdrawal parameter test:
  L15121/B/1 – L15121/B/100,
- Head pull through parameter test:
  L15121/C/1 – L15121/C/100,
- Tensile capacity test:
  L15121/D/1 – L15121/D/100.

## 5. MEASURING EQUIPMENT

Nails dimensions and dimensions of timber pieces (except length) were measured with the calliper gauges with accuracy ± 0.03 mm. The length of timber pieces (withdrawal parameter test, torsional resistance to insertion) was measured with the measuring tape (accuracy ± 1 mm).

The moisture content was measured according to SIST EN 13183-2:2003 *(Moisture content of a piece of sawn timber - Part 2: Estimation by electrical resistance method)*. GANN 4050 measuring instrument was used.

The masses and consequently the weights of timber pieces were measured with electronic laboratory balance KERN FKB A (accuracy ± 1 g).

The displacements were measured with a linear variable differential transformers (LVDTs) with accuracy ± 0.03 mm (displacements bigger than 50 mm with accuracy ± 0.1 mm).

Forces were measured with the load cells with the following measuring range/accuracy:

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- Yield moment test, withdrawal parameter test, head pull through parameter test, tensile capacity test: 50 kN ± 0.05 kN,

# 6. TEST RESULTS

## 6.1 Characteristic tensile strength of wire

The tensile strength tests of wire specimens were performed on 10th of December in the Laboratory for Metals, Corrosion and Anti-Corrosion Protection.

*Figure 5: Tensile tests of wire specimens*

Tests were performed according to the requirements of EN ISO 6892-1:2012. The results of tensile tests are presented in Table 3. Detailed test results can be found in Annex A.

Table 3: Tensile test results

| Group of specimens | Nails (diameter) | $R_{m\_average}$ [MPa] | $R_{m\_k}$ [MPa] |
|---|---|---|---|
| Z/2478/15 | 2.2 | 884 | 875 |
| Z/2479/15 | 2.5 | 835 | 818 |
| Z/2480/15 | 2.8 | 841 | 835 |
| Z/2481/15 | 3.1 | 751 | 732 |
| Z/2482/15 | 3.4 | 795 | 793 |
| Z/2483/15 | 3.8 | 800 | 784 |
| Z/2484/15 | 4.2 | 755 | 687 |
| Z/2485/15 | 5.0 | 738 | 728 |
| Z/2486/15 | 6.0 | 711 | 707 |
| Z/2487/15 | 7.0 | 638 | 632 |

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## 6.2 Geometry

The geometry of five nails for each diameter was checked. The average values of results are presented in Table 4.

The following dimensions were checked:

- d – nominal diameter,
- l – overall nail length,
- $h_t$ – thickness of nail head,
- $d_h$ – nail head diameter,
- $l_p$ – length of the point.

All measured dimensions satisfy the criteria given by the standard EN 14592:2008+A1:2012 (see also Chapter 3.1).

- All other standard requirements regarding the geometry of nails are fulfilled.

Table 4: Dimensions of nails

| Group of specimens | $l_{nom}$ [mm] | $l_{meas}$ [mm] | $(l_{meas}/l_{nom})-1$ [%] | $d_{nom}$ [mm] | $d_{meas}$* [mm] | $(d_{meas}/d_{nom})-1$ [%] | $h_{t,nom}$ [mm] | $h_{t,meas}$ [mm] | $(h_{t,meas}/h_{t,nom})-1$ [%] | $d_{h,nom}$ [mm] | $d_{h,meas}$* [mm] | $(d_{h,meas}/d_{h,nom})-1$ [%] | $l_p$ [mm] | $l_{p,meas}$ [mm] | $(l_{p,meas}/l_{p,nom})-1$ [%] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L15121/G/1-5 | 50.0 | 48.76 | -2.48 | 2.20 | 2.20 | 0.00 | 0.90 | 0.90 | 0.22 | 4.60 | 4.61 | 0.17 | 4.50 | 4.53 | 0.71 |
| L15121/G/5-10 | 60.0 | 58.51 | -2.49 | 2.50 | 2.50 | -0.08 | 0.80 | 0.81 | 1.00 | 6.20 | 6.25 | 0.81 | 4.80 | 4.73 | -1.42 |
| L15121/G/11-15 | 60.0 | 58.52 | -2.47 | 2.80 | 2.81 | 0.21 | 1.10 | 1.10 | 0.18 | 7.10 | 7.17 | 1.02 | 5.00 | 5.13 | 2.68 |
| L15121/G/16-20 | 70.0 | 68.42 | -2.26 | 3.10 | 3.10 | 0.06 | 1.20 | 1.21 | 0.67 | 7.10 | 7.13 | 0.48 | 5.30 | 5.23 | -1.36 |
| L15121/G/21-25 | 80.0 | 78.00 | -2.50 | 3.40 | 3.41 | 0.35 | 1.45 | 1.47 | 1.66 | 7.10 | 7.14 | 0.54 | 6.50 | 6.58 | 1.23 |
| L15121/G/26-30 | 100.0 | 98.54 | -1.46 | 3.80 | 3.80 | 0.11 | 1.90 | 1.90 | 0.21 | 8.10 | 8.08 | -0.25 | 6.70 | 6.71 | 0.12 |
| L15121/G/31-35 | 100.0 | 97.67 | -2.33 | 4.20 | 4.20 | 0.10 | 2.20 | 2.21 | 0.36 | 8.30 | 8.32 | 0.19 | 7.00 | 7.09 | 1.29 |
| L15121/G/36-40 | 140.0 | 137.84 | -1.54 | 5.00 | 5.01 | 0.16 | 2.00 | 2.02 | 0.90 | 9.80 | 9.63 | -1.73 | 8.70 | 8.60 | -1.13 |
| L15121/G/41-45 | 180.0 | 179.78 | -0.12 | 6.00 | 6.01 | 0.20 | 2.70 | 2.73 | 1.04 | 12.00 | 11.84 | -1.30 | 10.50 | 10.62 | 1.10 |
| L15121/G/46-50 | 210.0 | 207.43 | -1.23 | 7.00 | 7.01 | 0.11 | 2.90 | 2.87 | -1.17 | 13.00 | 12.88 | -0.91 | 12.50 | 12.52 | 0.18 |

* minimal measured value, other values are the average values

l ... overall nail length

d ... nominal diameter

$h_t$ ... thickness of nail head

$d_h$ ... nail head diameter

$l_p$ ... length of the point

## 6.3 Characteristic yield moment

Testing equipment, position of specimen and position of measuring equipment at yield moment test are presented in Figure 6.

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*Figure 6: Yield moment test*

Test results are presented in Table 5. Detailed results can be found in the Annex A.

Table 5: Characteristic yield moment

| Nails | Group of specimens | $M_{y,average}$ [Nm] | $M_{y,k}$ [Nm] |
|---|---|---|---|
| 2.2 | L14074/A/1-10 | 1.52 | **1.44** |
| 2.5 | L14074/A/11-20 | 2.07 | **1.88** |
| 2.8 | L14074/A/21-30 | 2.96 | **2.43** |
| 3.1 | L14074/A/31-40 | 3.91 | **3.73** |
| 3.4 | L14074/A/41-50 | 4.97 | **4.75** |
| 3.8 | L14074/A/51-60 | 7.03 | **6.84** |
| 4.2 | L14074/A/61-70 | 8.40 | **8.22** |
| 5.0 | L14074/A/71-80 | 15.46 | **14.71** |
| 6.0 | L14074/A/81-90 | 24.70 | **23.45** |
| 7.0 | L14074/A/141-140 | 38.38 | **36.81** |

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## 6.4 Characteristic withdrawal parameter

*Figure 7: Withdrawal parameter test*

Testing equipment and position of specimen at withdrawal parameter test are presented in Figure 7.

Test results are presented in Table 6. One piece of timber was used for each test group. Penetration depth $l_p$ used for calculation of withdrawal parameter was measured. Detailed test results can be found in the Annex A.

All nails were pulled out of timber as defined in testing procedure.

Table 6: Characteristic withdrawal parameter

| Group of specimens | Nails (marking) | Nominal diameter [mm] | Average penetration depth $l_p$ [mm] | $\rho^*$ [kg/m$^3$] | $F_{ax,average}$ [kN] | Average withdrawal parameter $f_{ax,average}$ [N/mm$^2$] | **Characteristic withdrawal parameter $f_{ax,k}$ [N/mm$^2$]** |
|---|---|---|---|---|---|---|---|
| L15121/B/1-10 | 2.2x50 | 2.2 | 28.90 | 516 | 0.283 | 4.38 | **3.35** |
| L15121/B/11-20 | 2.5x60 | 2.5 | 36.70 | 575 | 0.666 | 7.18 | **5.38** |
| L15121/B/21-30 | 2.8x60 | 2.8 | 38.90 | 495 | 0.443 | 4.65 | **2.39** |
| L15121/B/31-40 | 3.1x70 | 3.1 | 40.10 | 543 | 0.957 | 7.49 | **5.06** |
| L15121/B/41-50 | 3.4x80 | 3.4 | 47.60 | 514 | 0.541 | 3.33 | **2.21** |
| L15121/B/51-60 | 3.8x100 | 3.8 | 63.20 | 433 | 1.040 | 4.44 | **2.41** |
| L15121/B/61-70 | 4.2x100 | 4.2 | 70.00 | 456 | 1.181 | 4.74 | **2.40** |
| L15121/B/71-80 | 5.0x140 | 5.0 | 88.10 | 509 | 3.405 | 7.28 | **6.23** |
| L15121/B/81-90 | 6.0x180 | 6.0 | 120.00 | 500 | 4.455 | 6.38 | **4.03** |
| L15121/B/91-100 | 7.0x210 | 7.0 | 154.90 | 443 | 5.404 | 5.54 | **3.88** |

* Average density or density of single piece.

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## 6.5 Characteristic head pull through parameter

*Figure 8: Head pull through test*

Table 7: Average and characteristic head pull through parameters

| Group of specimens | Nails (marking) | $h_{average}$ * [mm] | $\rho_{average}$ [kg/m$^3$] | $\rho_k$ [kg/m$^3$] | $f_{head,average}$ [N/mm$^2$] | $f_{head,k}$ [N/mm$^2$] |
|---|---|---|---|---|---|---|
| L15121/C/1-10 | 2.2x50 | 15.6 | 464 | 428 | 42.25 | **33.22** |
| L15121/C/11-20 | 2.5x60 | 17.5 | 453 | 411 | 36.03 | **28.32** |
| L15121/C/21-30 | 2.8x60 | 19.5 | 467 | 409 | 36.30 | **30.10** |
| L15121/C/31-40 | 3.1x70 | 21.6 | 472 | 425 | 34.86 | **29.02** |
| L15121/C/41-50 | 3.4x80 | 23.9 | 450 | 431 | 30.67 | **22.06** |
| L15121/C/51-60 | 3.8x100 | 26.0 | 505 | 394 | 34.29 | **21.96** |
| L15121/C/61-70 | 4.2x100 | 29.6 | 505 | 443 | 36.36 | **25.46** |
| L15121/C/71-80 | 5.0x140 | 35.0 | 476 | 373 | 36.55 | **31.72** |
| L15121/C/81-90 | 6.0x180 | 42.1 | 478 | 369 | 33.77 | **30.62** |
| L15121/C/91-100 | 7.0x210 | 48.96 | 458 | 428 | 26.26 | **20.42** |

* Average measured height of timber pieces ($h_{average} \leq 7d$).

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Testing equipment, position of timber and specimen at head pull through parameter test are presented in Figure 8. Test results are presented in Table 7. The nominal head diameter was used when calculating head pull through parameters. Design thickness of timber pieces was in all cases approximately seven times diameter (7d).

Detailed results can be found in the Annex A.

In all test cases the nails were pulled through timber piece.

### 6.6 Characteristic tensile capacity

Specimens after tensile capacity tests are presented in Figure 9. Test results are presented in Table 8.

Detailed test results are presented in the Annex A.

Table 8: Average and characteristic tensile capacity

| Group of specimens | Nails (marking) | $f_{tens,average}$ [kN] | $f_{tens,k}$ [kN] | $f_{tens,average}$ [kN/ mm$^2$] | $f_{tens,k}$ [kN/mm$^2$] |
|---|---|---|---|---|---|
| L15121/D/1-10 | 2.2x50 | 2.25 | **1.89** | 1.18 | **1.13** |
| L15121/D/11-20 | 2.5x60 | 3.06 | **2.77** | 0.65 | **0.62** |
| L15121/D/21-30 | 2.8x60 | 4.10 | **3.72** | 0.49 | **0.48** |
| L15121/D/31-40 | 3.1x70 | 4.73 | **3.95** | 0.49 | **0.48** |
| L15121/D/41-50 | 3.4x80 | 5.61 | **4.58** | 0.49 | **0.48** |
| L15121/D/51-60 | 3.8x100 | 8.47 | **7.43** | 0.38 | **0.37** |
| L15121/D/61-70 | 4.2x100 | 10.27 | **10.07** | 0.36 | **0.35** |
| L15121/D/71-80 | 5.0x140 | 13.44 | **11.91** | 0.26 | **0.25** |
| L15121/D/81-90 | 6.0x180 | 18.77 | **17.71** | 0.17 | **0.17** |
| L15121/D/91-100 | 7.0x210 | 24.88 | **23.97** | 0.15 | **0.14** |

*Figure 9: Tensile capacity test – test specimens*

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## 7. Conclusions

The purpose of presented testing was to evaluate the geometry and mechanical performance of plain shank nails with the requirements defined in EN 14592:2008+A1:2012. On the basis of the measurements of geometry and on the basis of laboratory tests (yield moment test, withdrawal parameter test, head pull-through parameter test and tensile capacity test), the following conclusions can be made:

- The values of characteristic tensile strength of wire vary in the range of 632 MPa to 875 MPa.
- The dimensions of specimens comply with the requirements of EN 14592:2008+A1:2012.
- The values of characteristic yield moment $M_{y,k}$ vary in the range of 1.44 Nm to 36.81 Nm.
- The values of characteristic withdrawal parameter $f_{ax,k}$ vary in the range of 2.21 N/mm$^2$ to 6.23 N/mm$^2$.
- The values of characteristic head pull through parameter $f_{head,k}$ vary in the range of 20.42 N/mm$^2$ to 33.22 N/mm$^2$. Timber pieces with thickness approximately 7d were used in all test cases.
- The values of characteristic tensile capacity $f_{tens,k}$ vary in the range of 1.89 kN to 23.97 kN.

An overview of test results is given in Table 9.

Table 9: Summary of test results

| $d_{nom}$ [1] [mm] | $l_{nom}$ [1] [mm] | $M_{y,k}$ [Nm] | $f_{ax,k}$ [2] [N/mm$^2$] | $f_{head,k}$ [3] [N/mm$^2$] | $f_{tens,k}$ [kN] |
|---|---|---|---|---|---|
| 2.2x50 | 40-50 | 1.44 | 3.35 ($\rho$ = 516 kg/m$^3$) | 33.22 ($\rho_k$ = 428 kg/m$^3$) | 1.89 |
| 2.5x60 | 50-70 | 1.88 | 5.38 ($\rho$ = 575 kg/m$^3$) | 28.32 ($\rho_k$ = 411 kg/m$^3$) | 2.77 |
| 2.8x60 | 35-90 | 2.43 | 2.39 ($\rho$ = 495 kg/m$^3$) | 30.10 ($\rho_k$ = 409 kg/m$^3$) | 3.72 |
| 3.1x70 | 70-90 | 3.73 | 5.06 ($\rho$ = 543 kg/m$^3$) | 29.02 ($\rho_k$ = 425 kg/m$^3$) | 3.95 |
| 3.4x80 | 70-90 | 4.75 | 2.21 ($\rho$ = 514 kg/m$^3$) | 22.06 ($\rho_k$ = 431 kg/m$^3$) | 4.58 |
| 3.8x100 | 70-100 | 6.84 | 2.41 ($\rho$ = 433 kg/m$^3$) | 21.96 ($\rho_k$ = 394 kg/m$^3$) | 7.43 |
| 4.2x100 | 100-120 | 8.22 | 2.40 ($\rho$ = 456 kg/m$^3$) | 25.46 ($\rho_k$ = 443 kg/m$^3$) | 10.07 |
| 5.0x140 | 140-150 | 14.71 | 6.23 ($\rho$ = 509 kg/m$^3$) | 31.72 ($\rho_k$ = 373 kg/m$^3$) | 11.91 |
| 6.0x180 | 160-210 | 23.45 | 4.03 ($\rho$ = 500 kg/m$^3$) | 30.62 ($\rho_k$ = 369 kg/m$^3$) | 17.71 |
| 7.0x210 | 210-300 | 36.81 | 3.88 ($\rho$ = 443 kg/m$^3$) | 20.42 ($\rho_k$ = 428 kg/m$^3$) | 23.97 |

[1] Diameter / length defined by manufacturer.

[2] Single piece of timber (or average).

[3] Thickness of timber pieces equal to 7d.

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**Therefore it can be concluded that geometry and mechanical characteristics of tested plain shank nails meet the initial type testing requirements defined in EN 14592:2008+A1:2012.**

Prepared by:

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# ANNEX A:

# DETAILED TEST RESULTS

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Table A2: Characteristic tensile strength of wire – detailed test results (1/2)

| Specimen | $R_{m,i}$ [MPa] | Specimen | $R_{m,i}$ [MPa] | Specimen | $R_{m,i}$ [MPa] |
|---|---|---|---|---|---|
| Z/2478/15-1 | 884 | Z/2479/15-1 | 831 | Z/2480/15-1 | 844 |
| Z/2478/15-2 | 888 | Z/2479/15-2 | 840 | Z/2480/15-2 | 843 |
| Z/2478/15-3 | 883 | Z/2479/15-3 | 826 | Z/2480/15-3 | 839 |
| Z/2478/15-4 | 878 | Z/2479/15-4 | 843 | Z/2480/15-4 | 840 |
| Z/2478/15-5 | 885 | Z/2479/15-5 | 834 | Z/2480/15-5 | 839 |
| $R_{m,average}$ [MPa] | **884** | $R_{m,average}$ [MPa] | **835** | $R_{m,average}$ [MPa] | **841** |
| $R_{m,k}$ [MPa] | **875** | $R_{m,k}$ [MPa] | **818** | $R_{m,k}$ [MPa] | **835** |

| Specimen | $R_{m,i}$ [MPa] | Specimen | $R_{m,i}$ [MPa] | Specimen | $R_{m,i}$ [MPa] |
|---|---|---|---|---|---|
| Z/2481/15-1 | 743 | Z/2482/15-1 | 796 | Z/2483/15-1 | 803 |
| Z/2481/15-2 | 765 | Z/2482/15-2 | 794 | Z/2483/15-2 | 789 |
| Z/2481/15-3 | 750 | Z/2482/15-3 | 795 | Z/2483/15-3 | 805 |
| Z/2481/15-4 | 749 | Z/2482/15-4 | 794 | Z/2483/15-4 | 798 |
| Z/2481/15-5 | 750 | Z/2482/15-5 | 795 | Z/2483/15-5 | 804 |
| $R_{m,average}$ [MPa] | **751** | $R_{m,average}$ [MPa] | **795** | $R_{m,average}$ [MPa] | **800** |
| $R_{m,k}$ [MPa] | **732** | $R_{m,k}$ [MPa] | **793** | $R_{m,k}$ [MPa] | **784** |

| Specimen | $R_{m,i}$ [MPa] | Specimen | $R_{m,i}$ [MPa] | Specimen | $R_{m,i}$ [MPa] |
|---|---|---|---|---|---|
| Z/2484/15-1 | 724 | Z/2485/15-1 | 739 | Z/2486/15-1 | 710 |
| Z/2484/15-2 | 748 | Z/2485/15-2 | 732 | Z/2486/15-2 | 709 |
| Z/2484/15-3 | 753 | Z/2485/15-3 | 740 | Z/2486/15-3 | 712 |
| Z/2484/15-4 | 747 | Z/2485/15-4 | 742 | Z/2486/15-4 | 710 |
| Z/2484/15-5 | 804 | Z/2485/15-5 | 736 | Z/2486/15-5 | 712 |
| $R_{m,average}$ [MPa] | **755** | $R_{m,average}$ [MPa] | **738** | $R_{m,average}$ [MPa] | **711** |
| $R_{m,k}$ [MPa] | **687** | $R_{m,k}$ [MPa] | **728** | $R_{m,k}$ [MPa] | **707** |

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The results of the tests refer only to the tested specimens. This report may only be reproduced as a whole.

Table A2: Characteristic tensile strength of wire – detailed test results (2/2)

| Specimen | $R_{m,i}$ [MPa] |
|---|---|
| Z/2487/15-1 | 635 |
| Z/2487/15-2 | 641 |
| Z/2487/15-3 | 639 |
| Z/2487/15-4 | 638 |
| Z/2487/15-5 | 636 |
| $R_{m,average}$ [MPa] | **638** |
| $R_{m,k}$ [MPa] | **632** |

Table A2: Characteristic yield moment – detailed test results (1/3)

| Specimen | $M_{y,i}$ [Nm] | Specimen | $M_{y,i}$ [Nm] | Specimen | $M_{y,i}$ [Nm] |
|---|---|---|---|---|---|
| L15121/A/1 | 1.52 | L15121/A/11 | 2.04 | L15121/A/21 | 2.73 |
| L15121/A/2 | 1.45 | L15121/A/12 | 2.00 | L15121/A/22 | 3.34 |
| L15121/A/3 | 1.53 | L15121/A/13 | 2.12 | L15121/A/23 | 2.64 |
| L15121/A/4 | 1.51 | L15121/A/14 | 2.10 | L15121/A/24 | 2.76 |
| L15121/A/5 | 1.54 | L15121/A/15 | 2.11 | L15121/A/25 | 3.30 |
| L15121/A/6 | 1.59 | L15121/A/16 | 1.99 | L15121/A/26 | 3.32 |
| L15121/A/7 | 1.53 | L15121/A/17 | 2.23 | L15121/A/27 | 2.82 |
| L15121/A/8 | 1.51 | L15121/A/18 | 2.12 | L15121/A/28 | 2.75 |
| L15121/A/9 | 1.46 | L15121/A/19 | 1.89 | L15121/A/29 | 2.82 |
| L15121/A/10 | 1.54 | L15121/A/20 | 2.11 | L15121/A/30 | 3.15 |
| $M_{y,average}$ [Nm] | **1.52** | $M_{y,average}$ [Nm] | **2.07** | $M_{y,average}$ [Nm] | **2.96** |
| $M_{y,k}$ [Nm] | **1.44** | $M_{y,k}$ [Nm] | **1.88** | $M_{y,k}$ [Nm] | **2.43** |

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Table A1: Characteristic yield moment – detailed test results (2/3)

| Specimen | $M_{y,i}$ [Nm] | Specimen | $M_{y,i}$ [Nm] | Specimen | $M_{y,i}$ [Nm] |
|---|---|---|---|---|---|
| L15121/A/31 | 4.01 | L15121/A/41 | 4.95 | L15121/A/51 | 6.97 |
| L15121/A/32 | 3.92 | L15121/A/42 | 5.06 | L15121/A/52 | 6.89 |
| L15121/A/33 | 3.80 | L15121/A/43 | 4.74 | L15121/A/53 | 7.05 |
| L15121/A/34 | 3.89 | L15121/A/44 | 5.10 | L15121/A/54 | 7.07 |
| L15121/A/35 | 3.95 | L15121/A/45 | 4.98 | L15121/A/55 | 7.15 |
| L15121/A/36 | 4.03 | L15121/A/46 | 4.89 | L15121/A/56 | 7.09 |
| L15121/A/37 | 3.98 | L15121/A/47 | 4.92 | L15121/A/57 | 6.91 |
| L15121/A/38 | 3.94 | L15121/A/48 | 5.08 | L15121/A/58 | 7.11 |
| L15121/A/39 | 3.86 | L15121/A/49 | 5.04 | L15121/A/59 | 6.95 |
| L15121/A/40 | 3.75 | L15121/A/50 | 4.98 | L15121/A/60 | 7.08 |
| $M_{y,average}$ [Nm] | **3.91** | $M_{y,average}$ [Nm] | **4.97** | $M_{y,average}$ [Nm] | **7.03** |
| $M_{y,k}$ [Nm] | **3.73** | $M_{y,k}$ [Nm] | **4.75** | $M_{y,k}$ [Nm] | **6.84** |

| Specimen | $M_{y,i}$ [Nm] | Specimen | $M_{y,i}$ [Nm] | Specimen | $M_{y,i}$ [Nm] |
|---|---|---|---|---|---|
| L15121/A/61 | 8.40 | L15121/A/71 | 16.09 | L15121/A/81 | 23.79 |
| L15121/A/62 | 8.32 | L15121/A/72 | 14.88 | L15121/A/82 | 25.97 |
| L15121/A/63 | 8.54 | L15121/A/73 | 15.36 | L15121/A/83 | 24.58 |
| L15121/A/64 | 8.28 | L15121/A/74 | 15.52 | L15121/A/84 | 24.38 |
| L15121/A/65 | 8.45 | L15121/A/75 | 15.26 | L15121/A/85 | 25.11 |
| L15121/A/66 | 8.43 | L15121/A/76 | 15.41 | L15121/A/86 | 24.83 |
| L15121/A/67 | 8.52 | L15121/A/77 | 15.47 | L15121/A/87 | 24.61 |
| L15121/A/68 | 8.38 | L15121/A/78 | 16.05 | L15121/A/88 | 24.43 |
| L15121/A/69 | 8.40 | L15121/A/79 | 15.42 | L15121/A/89 | 25.21 |
| L15121/A/70 | 8.31 | L15121/A/80 | 15.16 | L15121/A/90 | 24.14 |
| $M_{y,average}$ [Nm] | **8.40** | $M_{y,average}$ [Nm] | **15.46** | $M_{y,average}$ [Nm] | **24.70** |
| $M_{y,k}$ [Nm] | **8.22** | $M_{y,k}$ [Nm] | **14.71** | $M_{y,k}$ [Nm] | **23.45** |

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The results of the tests refer only to the tested specimens. This report may only be reproduced as a whole.

Table A1: Characteristic yield moment – detailed test results (3/3)

| Specimen | $M_{y,i}$ [Nm] |
|---|---|
| L15121/A/91 | 39.50 |
| L15121/A/92 | 37.91 |
| L15121/A/93 | 39.98 |
| L15121/A/94 | 37.81 |
| L15121/A/95 | 38.32 |
| L15121/A/96 | 38.11 |
| L15121/A/97 | 38.10 |
| L15121/A/98 | 37.51 |
| L15121/A/99 | 38.40 |
| L15121/A/100 | 38.19 |
| $M_{y,average}$ [Nm] | **38.38** |
| $M_{y,k}$ [Nm] | **36.81** |

Table A2: Characteristic withdrawal parameter (1/3)

| Specimen | $f_{ax,i}$ [N/mm$^2$] | Specimen | $f_{ax,i}$ [N/mm$^2$] | Specimen | $f_{ax,i}$ [N/mm$^2$] |
|---|---|---|---|---|---|
| L15121/B/1 | 5.24 | L15121/B/11 | 7.98 | L15121/B/21 | 3.88 |
| L15121/B/2 | 5.11 | L15121/B/12 | 7.89 | L15121/B/22 | 3.68 |
| L15121/B/3 | 4.80 | L15121/B/13 | 5.86 | L15121/B/23 | 4.41 |
| L15121/B/4 | 4.51 | L15121/B/14 | 7.72 | L15121/B/24 | 6.02 |
| L15121/B/5 | 4.51 | L15121/B/15 | 8.32 | L15121/B/25 | 4.50 |
| L15121/B/6 | 4.19 | L15121/B/16 | 5.57 | L15121/B/26 | 4.75 |
| L15121/B/7 | 3.75 | L15121/B/17 | 6.94 | L15121/B/27 | 7.08 |
| L15121/B/8 | 3.86 | L15121/B/18 | 6.84 | L15121/B/28 | 2.35 |
| L15121/B/9 | 3.75 | L15121/B/19 | 6.97 | L15121/B/29 | 4.51 |
| L15121/B/10 | 4.05 | L15121/B/20 | 7.67 | L15121/B/30 | 5.36 |
| $f_{ax,average}$ [N/mm$^2$] | **4.38** | $f_{ax,average}$ [N/mm$^2$] | **7.18** | $f_{ax,average}$ [N/mm$^2$] | **4.65** |
| $f_{ax,k}$ [N/mm$^2$] | **3.35** | $f_{ax,k}$ [N/mm$^2$] | **5.38** | $f_{ax,k}$ [N/mm$^2$] | **2.39** |

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Table A2: Characteristic withdrawal parameter (2/3)

| Specimen | $f_{ax,i}$ [N/mm$^2$] | Specimen | $f_{ax,i}$ [N/mm$^2$] | Specimen | $f_{ax,i}$ [N/mm$^2$] |
|---|---|---|---|---|---|
| L15121/B/31 | 9.79 | L15121/B/41 | 4.29 | L15121/B/51 | 4.18 |
| L15121/B/32 | 8.56 | L15121/B/42 | 3.70 | L15121/B/52 | 3.64 |
| L15121/B/33 | 9.25 | L15121/B/43 | 3.95 | L15121/B/53 | 3.89 |
| L15121/B/34 | 7.24 | L15121/B/44 | 3.14 | L15121/B/54 | 3.41 |
| L15121/B/35 | 6.41 | L15121/B/45 | 2.77 | L15121/B/55 | 2.49 |
| L15121/B/36 | 5.74 | L15121/B/46 | 2.37 | L15121/B/56 | 5.53 |
| L15121/B/37 | 8.02 | L15121/B/47 | 3.33 | L15121/B/57 | 5.31 |
| L15121/B/38 | 6.13 | L15121/B/48 | 2.98 | L15121/B/58 | 6.48 |
| L15121/B/39 | 6.61 | L15121/B/49 | 3.91 | L15121/B/59 | 4.53 |
| L15121/B/40 | 7.17 | L15121/B/50 | 2.84 | L15121/B/60 | 4.90 |
| $f_{ax,average}$ [N/mm$^2$] | **7.49** | $f_{ax,average}$ [N/mm$^2$] | **3.33** | $f_{ax,average}$ [N/mm$^2$] | **4.44** |
| $f_{ax,k}$ [N/mm$^2$] | **5.06** | $f_{ax,k}$ [N/mm$^2$] | **2.21** | $f_{ax,k}$ [N/mm$^2$] | **2.41** |

| Specimen | $f_{ax,i}$ [N/mm$^2$] | Specimen | $f_{ax,i}$ [N/mm$^2$] | Specimen | $f_{ax,i}$ [N/mm$^2$] |
|---|---|---|---|---|---|
| L15121/B/61 | 3.77 | L15121/B/71 | 8.23 | L15121/B/81 | 6.95 |
| L15121/B/62 | 5.30 | L15121/B/72 | 6.98 | L15121/B/82 | 8.83 |
| L15121/B/63 | 7.64 | L15121/B/73 | 7.85 | L15121/B/83 | 6.06 |
| L15121/B/64 | 4.01 | L15121/B/74 | 8.05 | L15121/B/84 | 5.04 |
| L15121/B/65 | 3.36 | L15121/B/75 | 6.72 | L15121/B/85 | 4.02 |
| L15121/B/66 | 4.14 | L15121/B/76 | 7.00 | L15121/B/86 | 6.20 |
| L15121/B/67 | 5.46 | L15121/B/77 | 6.92 | L15121/B/87 | 6.22 |
| L15121/B/68 | 6.90 | L15121/B/78 | 6.93 | L15121/B/88 | 6.68 |
| L15121/B/69 | 3.17 | L15121/B/79 | 7.07 | L15121/B/89 | 6.72 |
| L15121/B/70 | 3.63 | L15121/B/80 | 7.05 | L15121/B/90 | 7.06 |
| $f_{ax,average}$ [N/mm$^2$] | **4.74** | $f_{ax,average}$ [N/mm$^2$] | **7.28** | $f_{ax,average}$ [N/mm$^2$] | **6.38** |
| $f_{ax,k}$ [N/mm$^2$] | **2.40** | $f_{ax,k}$ [N/mm$^2$] | **6.23** | $f_{ax,k}$ [N/mm$^2$] | **4.03** |

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Table A2: Characteristic withdrawal parameter (3/3)

| Specimen | $f_{ax,i}$ [N/mm²] |
|---|---|
| L15121/B/91 | 4.03 |
| L15121/B/92 | 5.11 |
| L15121/B/93 | 4.70 |
| L15121/B/94 | 5.05 |
| L15121/B/95 | 5.35 |
| L15121/B/96 | 5.78 |
| L15121/B/97 | 6.21 |
| L15121/B/98 | 6.61 |
| L15121/B/99 | 6.94 |
| L15121/B/100 | 5.60 |
| $f_{ax,average}$ [N/mm²] | **5.54** |
| $f_{ax,k}$ [N/mm²] | **3.88** |

Table A3: Characteristic head pull through parameter – detailed test results (1/3)

| Specimen | $f_{head,i}$ [N/mm²] | Specimen | $f_{head,i}$ [N/mm²] | Specimen | $f_{head,i}$ [N/mm²] |
|---|---|---|---|---|---|
| L15121/C/1 | 34.70 | L15121/C/11 | 36.83 | L15121/C/21 | 34.23 |
| L15121/C/2 | 34.98 | L15121/C/12 | 31.98 | L15121/C/22 | 31.65 |
| L15121/C/3 | 40.74 | L15121/C/13 | 40.18 | L15121/C/23 | 41.87 |
| L15121/C/4 | 43.19 | L15121/C/14 | 36.77 | L15121/C/24 | 38.78 |
| L15121/C/5 | 47.55 | L15121/C/15 | 35.73 | L15121/C/25 | 40.02 |
| L15121/C/6 | 42.01 | L15121/C/16 | 39.82 | L15121/C/26 | 35.93 |
| L15121/C/7 | 42.92 | L15121/C/17 | 29.81 | L15121/C/27 | 34.36 |
| L15121/C/8 | 46.73 | L15121/C/18 | 39.59 | L15121/C/28 | 36.75 |
| L15121/C/9 | 42.51 | L15121/C/19 | 30.71 | L15121/C/29 | 36.41 |
| L15121/C/10 | 47.21 | L15121/C/20 | 38.92 | L15121/C/30 | 32.98 |
| $f_{head,average}$ [N/mm²] | **42.25** | $f_{head,average}$ [N/mm²] | **36.03** | $f_{head,average}$ [N/mm²] | **36.30** |
| $f_{head,k}$ [N/mm²] | **33.22** | $f_{head,k}$ [N/mm²] | **28.32** | $f_{head,k}$ [N/mm²] | **30.10** |

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Table A3: Characteristic head pull through parameter – detailed test results (2/3)

| Specimen | $f_{head,i}$ [N/mm$^2$] | Specimen | $f_{head,i}$ [N/mm$^2$] | Specimen | $f_{head,i}$ [N/mm$^2$] |
|---|---|---|---|---|---|
| L15121/C/31 | 34.99 | L15121/C/41 | 27.13 | L15121/C/51 | 34.57 |
| L15121/C/32 | 32.92 | L15121/C/42 | 24.10 | L15121/C/52 | 32.50 |
| L15121/C/33 | 32.35 | L15121/C/43 | 39.14 | L15121/C/53 | 23.05 |
| L15121/C/34 | 35.95 | L15121/C/44 | 25.41 | L15121/C/54 | 31.27 |
| L15121/C/35 | 29.75 | L15121/C/45 | 31.67 | L15121/C/55 | 24.69 |
| L15121/C/36 | 37.42 | L15121/C/46 | 30.25 | L15121/C/56 | 41.79 |
| L15121/C/37 | 33.33 | L15121/C/47 | 31.56 | L15121/C/57 | 39.44 |
| L15121/C/38 | 36.20 | L15121/C/48 | 30.62 | L15121/C/58 | 38.90 |
| L15121/C/39 | 40.55 | L15121/C/49 | 37.24 | L15121/C/59 | 38.97 |
| L15121/C/40 | 35.16 | L15121/C/50 | 29.59 | L15121/C/60 | 37.69 |
| $f_{head,average}$ [N/mm$^2$] | **34.86** | $f_{head,average}$ [N/mm$^2$] | **30.67** | $f_{head,average}$ [N/mm$^2$] | **34.29** |
| $f_{head,k}$ [N/mm$^2$] | **29.02** | $f_{head,k}$ [N/mm$^2$] | **22.06** | $f_{head,k}$ [N/mm$^2$] | **21.96** |

| Specimen | $f_{head,i}$ [N/mm$^2$] | Specimen | $f_{head,i}$ [N/mm$^2$] | Specimen | $f_{head,i}$ [N/mm$^2$] |
|---|---|---|---|---|---|
| L15121/C/61 | 36.24 | L15121/C/71 | 39.16 | L15121/C/81 | 35.02 |
| L15121/C/62 | 26.58 | L15121/C/72 | 38.90 | L15121/C/82 | 35.03 |
| L15121/C/63 | 32.66 | L15121/C/73 | 37.15 | L15121/C/83 | 34.71 |
| L15121/C/64 | 31.32 | L15121/C/74 | 37.75 | L15121/C/84 | 32.08 |
| L15121/C/65 | 31.98 | L15121/C/75 | 36.24 | L15121/C/85 | 31.60 |
| L15121/C/66 | 39.87 | L15121/C/76 | 31.76 | L15121/C/86 | 33.87 |
| L15121/C/67 | 45.73 | L15121/C/77 | 36.02 | L15121/C/87 | 32.36 |
| L15121/C/68 | 36.44 | L15121/C/78 | 33.37 | L15121/C/88 | 35.58 |
| L15121/C/69 | 42.04 | L15121/C/79 | 37.95 | L15121/C/89 | 35.29 |
| L15121/C/70 | 40.75 | L15121/C/80 | 37.20 | L15121/C/90 | 32.19 |
| $f_{head,average}$ [N/mm$^2$] | **36.36** | $f_{head,average}$ [N/mm$^2$] | **36.55** | $f_{head,average}$ [N/mm$^2$] | **33.77** |
| $f_{head,k}$ [N/mm$^2$] | **25.46** | $f_{head,k}$ [N/mm$^2$] | **31.72** | $f_{head,k}$ [N/mm$^2$] | **30.62** |

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Table A3: Characteristic head pull through parameter – detailed test results (3/3)

| Specimen | $f_{head,i}$ [N/mm$^2$] |
|---|---|
| L15121/C/91 | 24.75 |
| L15121/C/92 | 21.61 |
| L15121/C/93 | 22.06 |
| L15121/C/94 | 26.71 |
| L15121/C/95 | 26.37 |
| L15121/C/96 | / |
| L15121/C/97 | 26.83 |
| L15121/C/98 | 32.03 |
| L15121/C/99 | 30.25 |
| L15121/C/100 | 25.74 |
| $f_{head,average}$ [N/mm$^2$] | **26.26** |
| $f_{head,k}$ [N/mm$^2$] | **20.42** |

Table A4: Characteristic tensile capacity – detailed test results (1/3)

| Specimen | $f_{tens,i}$ [kN] | Specimen | $f_{tens,i}$ [kN] | Specimen | $f_{tens,i}$ [kN] |
|---|---|---|---|---|---|
| L15121/D/1 | 2.29 | L15121/D/11 | 3.03 | L15121/D/21 | 4.39 |
| L15121/D/2 | 2.46 | L15121/D/12 | 3.16 | L15121/D/22 | 4.09 |
| L15121/D/3 | 2.43 | L15121/D/13 | 3.14 | L15121/D/23 | 4.13 |
| L15121/D/4 | 2.38 | L15121/D/14 | 3.25 | L15121/D/24 | 4.00 |
| L15121/D/5 | 2.03 | L15121/D/15 | 2.90 | L15121/D/25 | 4.11 |
| L15121/D/6 | 2.40 | L15121/D/16 | 2.94 | L15121/D/26 | 4.13 |
| L15121/D/7 | 2.18 | L15121/D/17 | 3.22 | L15121/D/27 | 4.17 |
| L15121/D/8 | 1.94 | L15121/D/18 | 2.92 | L15121/D/28 | 4.23 |
| L15121/D/9 | 2.20 | L15121/D/19 | 3.21 | L15121/D/29 | 4.09 |
| L15121/D/10 | 2.15 | L15121/D/20 | 2.87 | L15121/D/30 | 3.67 |
| $f_{tens,average}$ [kN] | **2.25** | $f_{tens,average}$ [kN] | **3.06** | $f_{tens,average}$ [kN] | **4.10** |
| $f_{tens,k}$ [kN] | **1.89** | $f_{tens,k}$ [kN] | **2.77** | $f_{tens,k}$ [kN] | **3.72** |

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Table A4: Characteristic tensile capacity – detailed test results (2/3)

| Specimen | $f_{tens,i}$ [kN] | Specimen | $f_{tens,i}$ [kN] | Specimen | $f_{tens,i}$ [kN] |
|---|---|---|---|---|---|
| L15121/D/31 | 4.12 | L15121/D/41 | 6.30 | L15121/D/51 | 8.30 |
| L15121/D/32 | 4.25 | L15121/D/42 | 4.73 | L15121/D/52 | 8.89 |
| L15121/D/33 | 4.51 | L15121/D/43 | 5.67 | L15121/D/53 | 7.76 |
| L15121/D/34 | 4.93 | L15121/D/44 | 6.21 | L15121/D/54 | 8.12 |
| L15121/D/35 | 5.28 | L15121/D/45 | 5.58 | L15121/D/55 | 8.60 |
| L15121/D/36 | 4.66 | L15121/D/46 | 5.73 | L15121/D/56 | 8.17 |
| L15121/D/37 | 4.77 | L15121/D/47 | 5.38 | L15121/D/57 | 8.63 |
| L15121/D/38 | 4.50 | L15121/D/48 | 6.17 | L15121/D/58 | 7.83 |
| L15121/D/39 | 5.17 | L15121/D/49 | 5.01 | L15121/D/59 | 9.19 |
| L15121/D/40 | 5.11 | L15121/D/50 | 5.30 | L15121/D/60 | 9.22 |
| $f_{tens,average}$ [kN] | **4.73** | $f_{tens,average}$ [kN] | **5.61** | $f_{tens,average}$ [kN] | **8.47** |
| $f_{tens,k}$ [kN] | **3.95** | $f_{tens,k}$ [kN] | **4.58** | $f_{tens,k}$ [kN] | **7.43** |

| Specimen | $f_{tens,i}$ [kN] | Specimen | $f_{tens,i}$ [kN] | Specimen | $f_{tens,i}$ [kN] |
|---|---|---|---|---|---|
| L15121/D/61 | 10.40 | L15121/D/71 | 13.06 | L15121/D/81 | 19.79 |
| L15121/D/62 | 10.27 | L15121/D/72 | 13.17 | L15121/D/82 | 19.09 |
| L15121/D/63 | 10.26 | L15121/D/73 | 11.79 | L15121/D/83 | 18.99 |
| L15121/D/64 | 10.39 | L15121/D/74 | 13.91 | L15121/D/84 | 18.83 |
| L15121/D/65 | 10.34 | L15121/D/75 | 13.89 | L15121/D/85 | 19.25 |
| L15121/D/66 | 10.26 | L15121/D/76 | 14.14 | L15121/D/86 | 18.33 |
| L15121/D/67 | 10.13 | L15121/D/77 | 13.92 | L15121/D/87 | 18.12 |
| L15121/D/68 | 10.12 | L15121/D/78 | 13.46 | L15121/D/88 | 18.38 |
| L15121/D/69 | 10.29 | L15121/D/79 | 14.19 | L15121/D/89 | 18.36 |
| L15121/D/70 | 10.22 | L15121/D/80 | 12.90 | L15121/D/90 | 18.53 |
| $f_{tens,average}$ [kN] | **10.27** | $f_{tens,average}$ [kN] | **13.44** | $f_{tens,average}$ [kN] | **18.77** |
| $f_{tens,k}$ [kN] | **10.07** | $f_{tens,k}$ [kN] | **11.91** | $f_{tens,k}$ [kN] | **17.71** |

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Table A4: Characteristic tensile capacity – detailed test results (3/3)

| Specimen | $f_{tens,i}$ [kN] |
|---|---|
| L15121/D/91 | 25.41 |
| L15121/D/92 | 25.17 |
| L15121/D/93 | 25.31 |
| L15121/D/94 | 25.13 |
| L15121/D/95 | 24.01 |
| L15121/D/96 | 24.78 |
| L15121/D/97 | 25.14 |
| L15121/D/98 | 24.52 |
| L15121/D/99 | 24.71 |
| L15121/D/100 | 24.59 |
| $f_{tens,average}$ [kN] | **24.88** |
| $f_{tens,k}$ [kN] | **23.97** |

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