Instytut Techniki Budowlanej
Group of Testing Laboratories
Accredited by the Polish Centre for Accreditation
Accreditation Certificate No. AB 023

AB 023

# TEST REPORT
# LZK00-02291/25/Z00NZK

| | |
|---|---|
| **Client:** | **Handan Tedun Fastener Group Co., Ltd**<br>**2303 Sunshine Building, Handan City, Hebei Province** |
| **Product name:**<br>**(as specified by the Client)** | Screw anchor |
| **Date of issue:** | 17.12.2025 |

Laboratorium Konstrukcji Budowlanych, Geotechniki i Betonu (LZK)
Katowice, ul Korfantego 191, m.wolyniak@itb.pl

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# 1. Information on the test

| | |
|---|---|
| **Other parties to the agreement:** | **Handan Tedun Fastener Group Co., Ltd 2303 Sunshine Building, Handan City, Hebei Province** |
| Test start date: | 08.09.2025 |
| Test completion date: | 17.11.2025 |

Test location:
In the laboratory LZK , in the following location : Katowice, ul Korfantego 191

# 2. Product

## 2.1. Information provided by the Client

| | |
|---|---|
| **Product:** | Screw anchor |
| **Declared range of application:** | Fastening of building structures |

# 3. Test item, sample

## 3.1. Information provided by the Client

| | |
|---|---|
| **Sample origin:** | **Handan Tedun Fastener Group Co., Ltd 2303 Sunshine Building, Handan City, Hebei Province** |

## 3.2. Information obtained based on visual inspection in the Laboratory

**Acceptance of the test item into the laboratory:**

| | |
|---|---|
| **Date:** | 08.09.2025 |
| **Acceptance protokol:** | LZK00-02291/25/Z00NZK |

**Condition of the test item:**

A sample was provided in a condition and quantity suitable for testing.

**Description of the test item:**

The Tedun screw anchors was determined in cracked concrete or non-cracked concrete, are designed to make anchorages in reinforced or non reinforced concrete, strength class C20/25 to C50/60. The anchors are made of carbon steel.

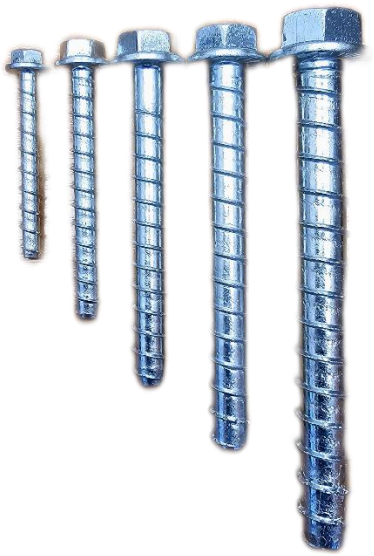

**Figure No 1: Screw anchor 6,8,10,12,16**

**Table No 1: Technical specification**

| Parameter | Symbol | Units | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|---|
| Drill bit diameter | $d_0$ | mm | 6 | 8 | 10 | 12 | 16 |
| Main load bearing section diamenter | d | mm | 5,5 | 7,5 | 9,6 | 11,3 | 15,05 |
| Nominal embedment depth | $h_{nom}$ | mm | 55 | 65 | 85 | 100 | 120 |
| Thread pitch | ht | mm | 6,0 | 6,0 | 6,6 | 8,2 | 9,5 |
| Tip chamfer | hs | mm | 1,5 | 2 | 1,5 | 1,5 | 2 |
| Clearance hole diameter in the fixture | $d_f$ | mm | 8 | 11 | 13 | 15 | 19 |
| Effective embedment depth | $h_{ef}$ | mm | 42 | 51 | 68 | 80 | 96 |
| Minimum hole depth | $h_{hole}$ | mm | 65 | 75 | 95 | 110 | 135 |
| Minimum thickness of member | $h_{min}$ | mm | 80 | 80 | 90 | 120 | 140 |

**Table No 2: Concrete base material**

| Type of concrete | $f_{cm,cube}$ | Class | Supplier | Test |
|---|---|---|---|---|
| [-] | [MP] [psi] | [-] | [-] | [-] |
| Normal weight concrete | 29,9 MPa | C20/25 | GORAZDZE BETON | A1,A3,F1,F3,F4,F6, F8,F9,F11,F12,V1 |
| | 67,4 MPa | C50/60 | GORAZDZE BETON | A2,A4,F2,N2 |

**Table No 3: Program of test**

| Purpose of test | | | Number of test | | | | |
|---|---|---|---|---|---|---|---|
| Test | Concrete | Crack | 6 | 8 | 10 | 12 | 16 |
| [-] | [-] | [mm] | | | | | |
| A1 | C20/25 | 0,0 | 5 | 5 | 5 | 5 | 5 |
| A2 | C50/60 | 0,0 | 5 | 5 | 5 | 5 | 5 |
| A3 | C20/25 | 0,3 | 5 | 5 | 5 | 5 | 5 |
| A4 | C50/60 | 0,3 | 5 | 5 | 5 | 5 | 5 |
| F1 | C20/25 | 0,5 | 5 | 5 | 5 | 5 | 5 |
| F2 | C50/60 | 0,5 | 5 | 5 | 5 | 5 | 5 |
| F3 | C20/25 | 01-0,3 | 5 | 5 | 5 | 5 | 5 |
| F4b | C20/25 | 0,0 | 5 | 5 | 5 | 5 | 5 |
| F6 | C20/25 | 0,0 | 10 | 10 | 10 | 10 | 10 |
| F8 | C20/25 | 0,0 | 15 | 15 | 15 | 15 | 15 |
| F9 | C20/25 | 0,3 | 5 | 5 | 5 | 5 | 5 |
| F11 | C20/25 | 0,0 | 5 | 5 | 5 | 5 | 5 |
| F12 | C20/25 | 0,0 | 5 | 5 | 5 | 5 | 5 |
| V1 | C20/25 | 0,0 | 5 | 5 | 5 | 5 | 5 |
| N1 | - | 0,0 | 5 | 5 | 5 | 5 | 5 |
| N2 | C50/60 | 0,0 | 5 | 5 | 5 | 5 | 5 |
| C1 | C20/25 | 0,5 | 5 | 5 | 5 | 5 | 5 |

# 4. Test results

## 4.1. Test: Tension test A1

### 4.1.1. Test method

The A1 test was carried out in compliance with EAD 330232-01-0601, table A1.

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.1.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample.

**Table No 4: Result of test A1**

| Serie [-] | A1 | A1 | A1 | A1 | A1 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 21,55 | 25,43 | 45,12 | 58,65 | 87,56 |
| | 22,45 | 28,45 | 43,21 | 59,12 | 86,34 |
| $F_{u,m,i}$ [kN] | 19,45 | 29,12 | 40,21 | 62,33 | 82,34 |
| | 20,20 | 30,23 | 44,54 | 61,22 | 85,34 |
| | 21,87 | 29,65 | 42,33 | 55,66 | 80,55 |
| $F_{u,m,t}$ [kN] | 21,10 | 28,58 | 43,08 | 59,40 | 84,43 |
| s | 1,24 | 1,88 | 1,94 | 2,58 | 2,90 |
| $cv_F$ | 5,88 | 6,57 | 4,51 | 4,34 | 3,44 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,55 | ±0,56 | ±0,57 | ±0,39 | ±0,50 |

**Table No 5: Evaluation of test A1**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ / $f_{u,test}$ | $f_{ck,cube}$ / $f_{uk}$ | $F_{u,m,20}$ / $F_{u,m,s}$ | $cv_F$ | Failure |
|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [%] | [-] |
| A1 | 6 | 42 | 5 | 0,0 | 21,10 | 32,6 | 25,0 | 18,48 | 5,88 | p.o. |
| A1 | 8 | 51 | 5 | 0,0 | 28,58 | 32,6 | 25,0 | 25,02 | 6,57 | p.o. |
| A1 | 10 | 68 | 5 | 0,0 | 43,08 | 32,6 | 25,0 | 37,73 | 4,51 | p.o. |
| A1 | 12 | 80 | 5 | 0,0 | 59,40 | 32,6 | 25,0 | 52,01 | 4,34 | p.o. |
| A1 | 16 | 96 | 5 | 0,0 | 84,43 | 32,6 | 25,0 | 73,93 | 3,44 | p.o. |

**Table No 6: Evaluation of characteristic value in test A1**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $N_{u,m,r}$ | $N_{u,m,r,min}$ | $N_{u,m}$/ | $N_{Rk,A1}$ | $N_{Rk,p,A1}$ | $N_{Rk,c}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | | $N_{u,m,r,min}$ | | | |
| [-] | [mm] | [mm] | [-] | [kN] | [kN] | [kN] | [-] | [kN] | [kN] | [kN] |
| A1 | 6 | 42 | 5 | 18,48 | 18,37 | 16,79 | 1,10 | 14,79 | 14,8 | 13,4 |
| A1 | 8 | 51 | 5 | 25,02 | 24,58 | 22,47 | 1,11 | 19,43 | 19,4 | 17,9 |
| A1 | 10 | 68 | 5 | 37,73 | 37,85 | 34,60 | 1,09 | 31,94 | 31,9 | 27,6 |
| A1 | 12 | 80 | 5 | 52,01 | 48,30 | 44,15 | 1,18 | 44,35 | 44,3 | 35,2 |
| A1 | 16 | 96 | 5 | 73,93 | 72,50 | 66,27 | 1,12 | 65,29 | 65,3 | 46,3 |

## 4.2. Test: Tension test A2

### 4.2.1. Test method

The A2 test was carried out in compliance with EAD 330232-01-0601, table A1.

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.2.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample.

**Table No 7: Result of test A2**

| Serie [-] | A2 | A2 | A2 | A2 | A2 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 60 | 60 | 60 | 60 | 60 |
| $f_{c,t}$ [N/mm²] | 69,3 | 69,3 | 69,3 | 69,3 | 69,3 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 24,54 | 34,54 | 51,23 | 63,23 | 93,23 |
| | 25,66 | 33,45 | 54,32 | 69,22 | 96,54 |
| $F_{u,m,i}$ [kN] | 23,12 | 36,76 | 52,87 | 68,76 | 91,29 |
| | 26,77 | 32,45 | 51,22 | 65,87 | 97,67 |
| | 23,43 | 35,22 | 53,88 | 70,33 | 98,71 |
| $F_{u,m,t}$ [kN] | 24,70 | 34,48 | 52,70 | 67,48 | 95,49 |
| s | 1,53 | 1,65 | 1,45 | 2,89 | 3,12 |
| $cv_F$ | 6,19 | 4,79 | 2,75 | 4,28 | 3,27 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,56 | ±0,56 | ±0,58 | ±0,40 | ±0,51 |

**Table No 8: Evaluation of test A2**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ | $f_{ck,cube}$ | $F_{u,m,50}$ | $cv_F$ | Failure |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $f_{u,test}$ | $f_{uk}$ | $F_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [%] | [-] |
| A2 | 6 | 42 | 5 | 0,0 | 24,70 | 69,30 | 60,00 | 22,99 | 6,19 | p.o |
| A2 | 8 | 51 | 5 | 0,0 | 34,48 | 69,30 | 60,00 | 32,09 | 4,79 | p.o |
| A2 | 10 | 68 | 5 | 0,0 | 52,70 | 69,30 | 60,00 | 49,04 | 2,75 | p.o |
| A2 | 12 | 80 | 5 | 0,0 | 67,48 | 69,30 | 60,00 | 62,79 | 4,28 | p.o |
| A2 | 16 | 96 | 5 | 0,0 | 95,49 | 69,30 | 60,00 | 88,85 | 3,27 | p.o |

**Table No 9: Evaluation of characteristic value in test A2**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $cv_F$ | $N_{Rk,A2}$ |
|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [kN] | [%] | [kN] |
| A2 | 6 | 42 | 5 | 22,99 | 6,19 | 18,15 |
| A2 | 8 | 51 | 5 | 32,09 | 4,79 | 26,86 |
| A2 | 10 | 68 | 5 | 49,04 | 2,75 | 44,46 |
| A2 | 12 | 80 | 5 | 62,79 | 4,28 | 53,64 |
| A2 | 16 | 96 | 5 | 88,85 | 3,27 | 78,98 |

**Table No 10: Evaluation of n factor**

| Serie | Size | $h_{ef}$ | Temp. | $N_{u,m,50}$ | $f_{c,t,50}$ | Failure | $N_{u,m,20}$ | $f_{c,t,20}$ | n[1)] |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [ºC] | [N/mm²] | [N/mm²] | [-] | [N/mm²] | [N/mm²] | [-] |
| A1/A2 | 6 | 42 | 20 | 24,7 | 69,3 | c.c | 21,1 | 32,6 | 0,21 |
| A1/A2 | 8 | 51 | 20 | 34,5 | 69,3 | c.c | 28,6 | 32,6 | 0,25 |
| A1/A2 | 10 | 68 | 20 | 52,7 | 69,3 | c.c | 43,1 | 32,6 | 0,27 |
| A1/A2 | 12 | 80 | 20 | 67,5 | 69,3 | c.c | 59,4 | 32,6 | 0,17 |
| A1/A2 | 16 | 96 | 20 | 95,5 | 69,3 | c.c | 84,4 | 32,6 | 0,16 |
| 1) Equation $n = Log(N_{u,m,50}/N_{u,m,20}) / Log(f_{c,t,50}/f_{c,t,20})$ | | | | | | | | | |

**Table No 11: Evaluation of $\psi_c$ factor**

| Sizes | | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|
| n | | 0,21 | 0,25 | 0,27 | 0,17 | 0,16 |
| | C30/37 | 1,09 | 1,11 | 1,11 | 1,07 | 1,07 |
| | C40/50 | 1,16 | 1,19 | 1,20 | 1,12 | 1,12 |
| | C50/60 | 1,21 | 1,26 | 1,28 | 1,17 | 1,16 |

## 4.3. Test: Tension test A3

### 4.3.1. Test method

The A3 test was carried out in compliance with EAD 330232-01-0601, table A1.

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.3.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample.

**Table No 12: Result of test A3**

| Serie [-] | A3 | A3 | A3 | A3 | A3 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 15,82 | 19,43 | 32,45 | 40,54 | 73,23 |
| | 16,43 | 20,65 | 33,92 | 42,11 | 74,65 |
| $F_{u,m,i}$ [kN] | 16,56 | 21,32 | 35,00 | 46,98 | 71,22 |
| | 14,76 | 18,43 | 37,27 | 45,45 | 70,79 |
| | 15,43 | 20,55 | 36,92 | 49,22 | 72,65 |
| $F_{u,m,t}$ [kN] | 15,80 | 20,08 | 35,11 | 44,86 | 72,51 |
| s | 0,74 | 1,14 | 2,03 | 3,54 | 1,56 |
| $cv_F$ | 4,69 | 5,69 | 5,77 | 7,89 | 2,15 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,20 | ±0,55 | ±0,56 | ±0,57 | ±0,41 |

**Table No 13: Evaluation of test A3**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ | $f_{ck,cube}$ | $F_{u,m,20}$ | $cv_F$ | Failure |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $f_{u,test}$ | $f_{uk}$ | $F_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [%] | [-] |
| A3 | 6 | 42 | 5 | 0,3 | 15,80 | 32,6 | 25,0 | 13,84 | 4,69 | p.o. |
| A3 | 8 | 51 | 5 | 0,3 | 20,08 | 32,6 | 25,0 | 17,58 | 5,69 | p.o. |
| A3 | 10 | 68 | 5 | 0,3 | 35,11 | 32,6 | 25,0 | 30,75 | 5,77 | p.o. |
| A3 | 12 | 80 | 5 | 0,3 | 44,86 | 32,6 | 25,0 | 39,28 | 7,89 | p.o. |
| A3 | 12 | 41 | 5 | 0,3 | 72,51 | 32,6 | 25,0 | 63,50 | 2,15 | p.o. |

**Table No 14: Evaluation of characteristic value in test A3**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $N_{u,m,r}$ | $N_{u,m,r,min}$ | $N_{u,m}$/ | $N_{Rk,A3}$ | $N_{Rk,p,A3}$ | $N_{Rk,c}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | | $N_{u,m,r,min}$ | | | |
| [-] | [mm] | [mm] | [-] | [kN] | [kN] | [kN] | [-] | [kN] | [kN] | [kN] |
| A3 | 6 | 42 | 5 | 13,84 | 12,93 | 11,82 | 1,17 | 11,63 | 11,6 | 9,4 |
| A3 | 8 | 51 | 5 | 17,58 | 17,30 | 15,81 | 1,11 | 14,18 | 14,2 | 12,5 |
| A3 | 10 | 68 | 5 | 30,75 | 26,64 | 24,34 | 1,26 | 24,71 | 24,7 | 19,3 |
| A3 | 12 | 80 | 5 | 39,28 | 33,99 | 31,07 | 1,26 | 28,75 | 28,7 | 24,6 |
| A3 | 16 | 96 | 5 | 63,50 | 51,02 | 46,63 | 1,36 | 58,85 | 58,8 | 32,4 |

## 4.4. Test: Tension test A4

### 4.4.1. Test method

The A4 test was carried out in compliance with EAD 330232-01-0601, table A1.

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.4.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample.

**Table No 15: Result of test A4**

| Serie [-] | A4 | A4 | A4 | A4 | A4 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 60 | 60 | 60 | 60 | 60 |
| $f_{c,t}$ [N/mm²] | 69,3 | 69,3 | 69,3 | 69,3 | 69,3 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 17,83 | 23,43 | 37,65 | 49,65 | 80,93 |
| | 19,21 | 22,65 | 38,98 | 50,32 | 81,22 |
| $F_{u,m,i}$ [kN] | 17,43 | 21,76 | 40,65 | 51,23 | 79,65 |
| | 15,98 | 24,65 | 38,92 | 52,33 | 75,23 |
| | 19,43 | 23,21 | 39,12 | 48,99 | 76,93 |
| $F_{u,m,t}$ [kN] | 17,98 | 23,14 | 39,06 | 50,50 | 78,79 |
| s | 1,41 | 1,06 | 1,07 | 1,31 | 2,62 |
| $cv_F$ | 7,84 | 4,59 | 2,73 | 2,60 | 3,32 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,21 | ±0,56 | ±0,57 | ±0,58 | ±0,49 |

**Table No 16: Evaluation of test A4**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ | $f_{ck,cube}$ | $F_{u,m,50}$ | $cv_F$ | Failure |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $f_{u,test}$ | $f_{uk}$ | $F_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [%] | [-] |
| A4 | 6 | 42 | 5 | 0,3 | 17,98 | 69,30 | 60,00 | 16,73 | 7,84 | p.o. |
| A4 | 8 | 51 | 5 | 0,3 | 23,14 | 69,30 | 60,00 | 21,53 | 4,59 | p.o. |
| A4 | 10 | 68 | 5 | 0,3 | 39,06 | 69,30 | 60,00 | 36,35 | 2,73 | p.o. |
| A4 | 12 | 80 | 5 | 0,3 | 50,50 | 69,30 | 60,00 | 46,99 | 2,60 | p.o. |
| A4 | 16 | 96 | 5 | 0,3 | 78,79 | 69,30 | 60,00 | 73,31 | 3,32 | p.o. |

**Table No 17: Evaluation of characteristic value in test A4**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $cv_F$ | $N_{Rk,A4}$ |
|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [kN] | [%] | [kN] |
| A4 | 6 | 42 | 5 | 16,73 | 7,84 | 12,27 |
| A4 | 8 | 51 | 5 | 21,53 | 4,59 | 18,17 |
| A4 | 10 | 68 | 5 | 36,35 | 2,73 | 32,98 |
| A4 | 12 | 80 | 5 | 46,99 | 2,60 | 42,83 |
| A4 | 16 | 96 | 5 | 73,31 | 3,32 | 65,04 |

**Table No 18: Evaluation of n factor**

| Serie | Size | $h_{ef}$ | Temp. | $N_{u,m,50}$ | $f_{c,t,50}$ | Failure | $N_{u,m,20}$ | $f_{c,t,20}$ | n[1)] |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [ºC] | [N/mm²] | [N/mm²] | [-] | [N/mm²] | [N/mm²] | [-] |
| A3/A4 | 6 | 42 | 20 | 17,98 | 69,3 | c.c | 15,80 | 32,6 | 0,17 |
| A3/A4 | 8 | 51 | 20 | 23,14 | 69,3 | c.c | 20,08 | 32,6 | 0,19 |
| A3/A4 | 10 | 68 | 20 | 39,06 | 69,3 | c.c | 35,11 | 32,6 | 0,14 |
| A3/A4 | 12 | 80 | 20 | 50,50 | 69,3 | c.c | 44,86 | 32,6 | 0,16 |
| A3/A4 | 16 | 96 | 20 | 78,79 | 69,3 | c.c | 72,51 | 32,6 | 0,11 |
| 1) Equation $n = Log(N_{u,m,50}/N_{u,m,20}) / Log(f_{c,t,50}/f_{c,t,20})$ | | | | | | | | | |

**Table No 19: Evaluation of $\psi_c$ factor**

| Sizes | | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|
| n | | 0,17 | 0,19 | 0,14 | 0,16 | 0,11 |
| | C30 | 1,07 | 1,08 | 1,06 | 1,07 | 1,05 |
| | C40 | 1,13 | 1,14 | 1,10 | 1,12 | 1,08 |
| | C50 | 1,17 | 1,19 | 1,14 | 1,15 | 1,11 |

## 4.5. Test: Tension test F1

### 4.5.1. Test method

The F1 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.5.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 20: Result of test F1**

| Serie [-] | F1 | F1 | F1 | F1 | F1 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 13,14 | 16,56 | 29,54 | 41,22 | 62,34 |
| | 12,43 | 18,23 | 28,59 | 39,43 | 64,12 |
| $F_{u,m,i}$ [kN] | 13,22 | 17,18 | 31,22 | 38,12 | 65,36 |
| | 14,56 | 19,43 | 30,56 | 35,67 | 61,22 |
| | 11,87 | 15,67 | 28,34 | 45,43 | 61,89 |
| $F_{u,m,t}$ [kN] | 13,04 | 17,41 | 29,65 | 39,97 | 62,99 |
| s | 1,01 | 1,46 | 1,24 | 3,66 | 1,71 |
| $cv_F$ | 7,76 | 8,40 | 4,18 | 9,16 | 2,71 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,20 | ±0,20 | ±0,56 | ±0,57 | ±0,40 |

**Table No 21: Evaluation of test F1**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ / $f_{u,test}$ | $f_{ck,cube}$ / $f_{uk}$ | $F_{u,m,20}$ / $F_{u,m,s}$ | Failure |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [-] |
| F1 | 6 | 42 | 5 | 0,5 | 13,04 | 32,6 | 25,0 | 11,42 | p.o |
| F1 | 8 | 51 | 5 | 0,5 | 17,41 | 32,6 | 25,0 | 15,25 | p.o |
| F1 | 10 | 68 | 5 | 0,5 | 29,65 | 32,6 | 25,0 | 25,96 | p.o |
| F1 | 12 | 80 | 5 | 0,5 | 39,97 | 32,6 | 25,0 | 35,01 | p.o |
| F1 | 16 | 96 | 5 | 0,5 | 62,99 | 32,6 | 25,0 | 55,16 | p.o |

**Table No 22: Evaluation of characteristic value in test F1**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $cv_F$ | $N_{Rk,F1}$ |
|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [kN] | [%] | [kN] |
| F1 | 6 | 42 | 5 | 11,42 | 7,76 | 8,41 |
| F1 | 8 | 51 | 5 | 15,25 | 8,40 | 10,90 |
| F1 | 10 | 68 | 5 | 25,96 | 4,18 | 22,27 |
| F1 | 12 | 80 | 5 | 35,01 | 9,16 | 24,11 |
| F1 | 16 | 96 | 5 | 55,16 | 2,71 | 50,07 |

**Table No 23: Evaluation of factor α**

| Serie | Size | $h_{ef}$ | n | $N_{u,m,F1}$ | $N_{Rk,F1}$ | $cv_F$ | $N_{u,m,A3}$ | $N_{Rk,A3}$ | $cv_F$ | α | rqd.α | α/ rqdα |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [kN] | [kN] | [%] | [kN] | [kN] | [%] | [-] | [-] | [-] |
| F1 | 6 | 42 | 5 | 11,42 | 8,41 | 7,76 | 13,84 | 11,63 | 4,69 | 0,83 | 0,8 | 1,03 |
| F1 | 8 | 51 | 5 | 15,25 | 10,90 | 8,40 | 17,58 | 14,18 | 5,69 | 0,87 | 0,8 | 1,08 |
| F1 | 10 | 68 | 5 | 25,96 | 22,27 | 4,18 | 30,75 | 24,71 | 5,77 | 0,84 | 0,8 | 1,06 |
| F1 | 12 | 80 | 5 | 35,01 | 24,11 | 9,16 | 39,28 | 28,75 | 7,89 | 0,89 | 0,8 | 1,11 |
| F1 | 16 | 96 | 5 | 55,16 | 50,07 | 2,71 | 63,50 | 58,85 | 2,15 | 0,87 | 0,8 | 1,09 |

## 4.6. Test: Tension test F2

### 4.6.1. Test method

The F2 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

## 4.6.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 24: Result of test F2**

| Serie [-] | F2 | F2 | F2 | F2 | F2 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 60 | 60 | 60 | 60 | 60 |
| $f_{c,t}$ [N/mm²] | 69,3 | 69,3 | 69,3 | 69,3 | 69,3 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 15,45 | 19,19 | 34,56 | 42,35 | 73,23 |
| | 14,23 | 20,54 | 32,11 | 40,56 | 70,76 |
| $F_{u,m,i}$ [kN] | 13,56 | 18,65 | 31,45 | 45,98 | 69,45 |
| | 15,87 | 18,56 | 32,89 | 40,45 | 73,12 |
| | 16,16 | 19,03 | 30,98 | 41,76 | 68,45 |
| $F_{u,m,t}$ [kN] | 15,05 | 19,19 | 32,40 | 42,22 | 71,00 |
| s | 1,11 | 0,80 | 1,41 | 2,25 | 2,15 |
| $cv_F$ | 7,39 | 4,15 | 4,34 | 5,33 | 3,02 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,20 | ±0,21 | ±0,56 | ±0,57 | ±0,40 |

**Table No 25: Evaluation of test F2**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ | $f_{ck,cube}$ | $F_{u,m,50}$ | Failure |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $f_{u,test}$ | $f_{uk}$ | $F_{u,m,s}$ | |
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [-] |
| F2 | 6 | 42 | 5 | 0,5 | 15,05 | 69,3 | 60 | 14,01 | p.o. |
| F2 | 8 | 51 | 5 | 0,5 | 19,19 | 69,3 | 60 | 17,86 | p.o. |
| F2 | 10 | 68 | 5 | 0,5 | 32,40 | 69,3 | 60 | 30,15 | p.o. |
| F2 | 12 | 80 | 5 | 0,5 | 42,22 | 69,3 | 60 | 39,29 | p.o. |
| F2 | 16 | 96 | 5 | 0,5 | 71,00 | 69,3 | 60 | 66,07 | p.o. |

**Table No 26: Evaluation of characteristic value in test F2**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $cv_F$ | $N_{Rk,F2}$ |
|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [kN] | [%] | [kN] |
| F2 | 6 | 42 | 5 | 14,01 | 7,39 | 10,49 |
| F2 | 8 | 51 | 5 | 17,86 | 4,15 | 15,34 |
| F2 | 10 | 68 | 5 | 30,15 | 4,34 | 25,70 |
| F2 | 12 | 80 | 5 | 39,29 | 5,33 | 32,17 |
| F2 | 16 | 96 | 5 | 66,07 | 3,02 | 59,28 |

**Table No 27: Evaluation of factor α**

| Serie | Size | $h_{ef}$ | n | $N_{u,m,F2}$ | $N_{Rk,F2}$ | $cv_F$ | $N_{u,m,A4}$ | $N_{Rk,A4}$ | $cv_F$ | α | rqd.α | α/ rqdα |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [kN] | [kN] | [%] | [kN] | [kN] | [%] | [-] | [-] | [-] |
| F2 | 6 | 42 | 5 | 14,01 | 10,49 | 7,39 | 16,73 | 12,27 | 7,84 | 0,84 | 0,8 | 1,05 |
| F2 | 8 | 51 | 5 | 17,86 | 15,34 | 4,15 | 21,53 | 18,17 | 4,59 | 0,83 | 0,8 | 1,04 |
| F2 | 10 | 68 | 5 | 30,15 | 25,70 | 4,34 | 36,35 | 32,98 | 2,73 | 0,83 | 0,8 | 1,04 |
| F2 | 12 | 80 | 5 | 39,29 | 32,17 | 5,33 | 46,99 | 42,83 | 2,60 | 0,84 | 0,8 | 1,04 |
| F2 | 16 | 96 | 5 | 66,07 | 59,28 | 3,02 | 73,31 | 65,04 | 3,32 | 0,90 | 0,8 | 1,13 |

## 4.7. Test: Tension test F3

### 4.7.1. Test method

The F3 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.7.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 28: Result of test F3**

| Serie [-] | F3 | F3 | F3 | F3 | F3 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 10,45 | 17,54 | 28,98 | 36,76 | 65,67 |
| | 11,32 | 16,56 | 29,78 | 32,11 | 58,97 |
| $F_{u,m,i}$ [kN] | 12,98 | 15,16 | 33,21 | 39,45 | 60,23 |
| | 9,56 | 18,65 | 25,98 | 35,87 | 57,86 |
| | 10,87 | 13,54 | 30,65 | 40,65 | 62,32 |
| $F_{u,m,t}$ [kN] | 11,04 | 16,29 | 29,72 | 36,97 | 61,01 |
| s | 1,27 | 2,00 | 2,63 | 3,34 | 3,09 |
| $cv_F$ | 11,47 | 12,29 | 8,84 | 9,03 | 5,06 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,20 | ±0,20 | ±0,56 | ±0,57 | ±0,39 |

**Table No 29: Evaluation of test F3**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ | $f_{ck,cube}$ | $F_{u,m,20}$ | Failure |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $f_{u,test}$ | $f_{uk}$ | $F_{u,m,s}$ | |
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [-] |
| F3 | 6 | 42 | 5 | 0,1-0,3 | 11,0 | 32,6 | 25 | 9,7 | p.o |
| F3 | 8 | 51 | 5 | 0,1-0,3 | 16,3 | 32,6 | 25 | 14,3 | p.o |
| F3 | 10 | 68 | 5 | 0,1-0,3 | 29,7 | 32,6 | 25 | 26,0 | p.o |
| F3 | 12 | 80 | 5 | 0,1-0,3 | 37,0 | 32,6 | 25 | 32,4 | p.o |
| F3 | 16 | 96 | 5 | 0,1-0,3 | 61,0 | 32,6 | 25 | 53,4 | p.o |

**Table No 30: Evaluation of characteristic value in test F3**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $cv_F$ | $N_{Rk,F3}$ |
|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [kN] | [%] | [kN] |
| F3 | 6 | 42 | 5 | 9,7 | 11 | 5,9 |
| F3 | 8 | 51 | 5 | 14,3 | 12 | 8,3 |
| F3 | 10 | 68 | 5 | 26,0 | 9 | 18,2 |
| F3 | 12 | 80 | 5 | 32,4 | 9 | 22,4 |
| F3 | 16 | 96 | 5 | 53,4 | 5 | 44,2 |

**Table No 31: Evaluation of factor α**

| Serie | Size | $h_{ef}$ | n | $N_{u,m,F3}$ | $N_{Rk,F3}$ | $cv_F$ | $N_{u,m,A3}$ | $N_{Rk,A3}$ | $cv_F$ | α | rqd.α | α/ rqdα | $\delta_{100}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [kN] | [kN] | [%] | [kN] | [kN] | [%] | [-] | [-] | [-] | [mm] |
| F3 | 6 | 42 | 5 | 9,66 | 5,90 | 11,47 | 13,84 | 11,63 | 4,69 | 0,70 | 0,9 | 0,78 | <3 |
| F3 | 8 | 51 | 5 | 14,27 | 8,30 | 12,29 | 17,58 | 14,18 | 5,69 | 0,81 | 0,9 | 0,90 | <3 |
| F3 | 10 | 68 | 5 | 26,03 | 18,21 | 8,84 | 30,75 | 24,71 | 5,77 | 0,85 | 0,9 | 0,94 | <3 |
| F3 | 12 | 80 | 5 | 32,37 | 22,43 | 9,03 | 39,28 | 28,75 | 7,89 | 0,82 | 0,9 | 0,92 | <3 |
| F3 | 16 | 96 | 5 | 53,43 | 44,24 | 5,06 | 63,50 | 58,85 | 2,15 | 0,84 | 0,9 | 0,93 | <3 |

## 4.8. Test: Tension test F4

### 4.8.1. Test method

The F4 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.8.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 32: Result of test F4**

| Serie [-] | F4 | F4 | F4 | F4 | F4 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 23,12 | 28,99 | 48,56 | 62,34 | 93,24 |
| | 22,54 | 29,32 | 46,92 | 60,67 | 89,43 |
| $F_{u,m,i}$ [kN] | 23,87 | 30,23 | 46,47 | 65,23 | 83,23 |
| | 22,34 | 31,22 | 45,48 | 59,67 | 85,67 |
| | 24,32 | 32,11 | 48,28 | 58,23 | 86,25 |
| $F_{u,m,t}$ [kN] | 23,24 | 29,29 | 47,14 | 61,23 | 87,56 |
| s | 0,85 | 1,30 | 1,28 | 2,69 | 3,87 |
| $cv_F$ | 3,65 | 4,44 | 2,72 | 4,40 | 4,42 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,56 | ±0,56 | ±0,58 | ±0,39 | ±0,50 |

**Table No 33: Evaluation of test F4**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ / $f_{u,test}$ | $f_{ck,cube}$ / $f_{uk}$ | $F_{u,m,20}$ / $F_{u,m,s}$ | $cv_F$ | Failure |
|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [%] | [-] |
| F4b | 6 | 42,0 | 5 | 0,0 | 23,24 | 32,6 | 25 | 20,35 | 3,65 | p.o. |
| F4b | 8 | 51,0 | 5 | 0,0 | 29,29 | 32,6 | 25 | 25,65 | 4,44 | p.o. |
| F4b | 10 | 68,0 | 5 | 0,0 | 47,14 | 32,6 | 25 | 41,28 | 2,72 | p.o. |
| F4b | 12 | 80,0 | 5 | 0,0 | 61,23 | 32,6 | 25 | 53,62 | 4,40 | p.o. |
| F4b | 16 | 96,0 | 5 | 0,0 | 87,56 | 32,6 | 25 | 76,68 | 4,42 | p.o. |

**Table No 34: Evaluation of characteristic value in test F4**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ / $N_{u,m,s}$ | $cv_F$ | $N_{Rk,F4}$ |
|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [kN] | [%] | [kN] |
| F4b | 6 | 42 | 5 | 20,35 | 3,65 | 17,82 |
| F4b | 8 | 51 | 5 | 25,65 | 4,44 | 21,77 |
| F4b | 10 | 68 | 5 | 41,28 | 2,72 | 37,47 |
| F4b | 12 | 80 | 5 | 53,62 | 4,40 | 45,60 |
| F4b | 16 | 96 | 5 | 76,68 | 4,42 | 65,17 |

**Table No 35: Evaluation of factor α**

| Serie | Size | $h_{ef}$ | n | $N_{u,m,F4b}$ | $N_{Rk,F4b}$ | $cv_F$ | $N_{u,m,A1}$ | $N_{Rk,A1}$ | $cv_F$ | α | rqd.α | α/ rqdα |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [kN] | [kN] | [%] | [kN] | [kN] | [%] | [-] | [-] | [-] |
| F4b | 6 | 42 | 5 | 20,35 | 17,82 | 3,65 | 18,48 | 14,79 | 6,19 | 1,101 | 1 | >1 |
| F4b | 8 | 51 | 5 | 25,65 | 21,77 | 4,44 | 25,02 | 19,43 | 4,79 | 1,025 | 1 | >1 |
| F4b | 10 | 68 | 5 | 41,28 | 37,47 | 2,72 | 37,73 | 31,94 | 2,75 | 1,094 | 1 | >1 |
| F4b | 12 | 80 | 5 | 53,62 | 45,60 | 4,40 | 52,01 | 44,35 | 4,28 | 1,031 | 1 | >1 |
| F4b | 16 | 96 | 5 | 76,68 | 65,17 | 4,42 | 73,93 | 65,29 | 3,27 | 1,037 | 1 | >1 |

## 4.9. Test: Tension test F9

### 4.9.1. Test method

The F9 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.9.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 36: Result of test F9**

| Serie [-] | F9 | F9 | F9 | F9 | F9 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 14,00 | 17,56 | 28,32 | 39,54 | 67,87 |
| | 15,04 | 19,23 | 30,43 | 37,65 | 69,21 |
| $F_{u,m,i}$ [kN] | 16,32 | 19,23 | 28,99 | 42,12 | 65,43 |
| | 12,12 | 16,76 | 26,78 | 41,23 | 62,66 |
| | 13,76 | 18,56 | 29,12 | 42,11 | 60,64 |
| $F_{u,m,t}$ [kN] | 14,25 | 18,27 | 28,73 | 40,53 | 65,16 |
| s | 1,56 | 1,09 | 1,33 | 1,92 | 3,55 |
| $cv_F$ | 10,96 | 5,94 | 4,63 | 4,74 | 5,45 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOK145n | ±0,20 | ±0,21 | ±0,56 | ±0,57 | ±0,40 |

**Table No 37: Evaluation of test F9**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ | $f_{ck,cube}$ | $F_{u,m,50}$ | Failure |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $f_{u,test}$ | $f_{uk}$ | $F_{u,m,s}$ | |
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [-] |
| F9 | 6 | 42 | 5 | 0,3 | 14,25 | 32,6 | 25 | 12,48 | p.o. |
| F9 | 8 | 51 | 5 | 0,3 | 18,27 | 32,6 | 25 | 16,00 | p.o. |
| F9 | 10 | 68 | 5 | 0,3 | 28,73 | 32,6 | 25 | 25,16 | p.o. |
| F9 | 12 | 80 | 5 | 0,3 | 40,53 | 32,6 | 25 | 35,49 | p.o. |
| F9 | 16 | 96 | 5 | 0,3 | 65,16 | 32,6 | 25 | 57,06 | p.o. |

**Table No 38: Evaluation of characteristic value in test F9**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $cv_F$ | $N_{Rk,F9}$ |
|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [kN] | [%] | [kN] |
| F9 | 6 | 42 | 5 | 12,48 | 11 | 7,83 |
| F9 | 8 | 51 | 5 | 16,00 | 6 | 12,77 |
| F9 | 10 | 68 | 5 | 25,16 | 5 | 21,20 |
| F9 | 12 | 80 | 5 | 35,49 | 5 | 29,77 |
| F9 | 16 | 96 | 5 | 57,06 | 5 | 46,48 |

**Table No 39: Evaluation of factor α**

| Serie | Size | $h_{ef}$ | n | $N_{u,m,F9}$ | $N_{Rk,F9}$ | $cv_F$ | $N_{u,m,A3}$ | $N_{Rk,A3}$ | $cv_F$ | α | rqd.α | α/ rqdα | $\gamma_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [kN] | [kN] | [%] | [kN] | [kN] | [%] | [-] | [-] | [-] | [-] |
| F9 | 6 | 42 | 5 | 12,48 | 7,83 | 10,96 | 13,84 | 11,63 | 4,69 | 0,90 | 0,8 | 1,0 | 1,2 |
| F9 | 8 | 51 | 5 | 16,00 | 12,77 | 5,94 | 17,58 | 14,18 | 5,69 | 0,91 | 0,8 | 1,0 | 1,2 |
| F9 | 10 | 68 | 5 | 25,16 | 21,20 | 4,63 | 30,75 | 24,71 | 5,77 | 0,82 | 0,8 | 1,0 | 1,2 |
| F9 | 12 | 80 | 5 | 35,49 | 29,77 | 4,74 | 39,28 | 28,75 | 7,89 | 0,90 | 0,8 | 1,0 | 1,2 |
| F9 | 16 | 96 | 5 | 57,06 | 46,48 | 5,45 | 63,50 | 58,85 | 2,15 | 0,90 | 0,8 | 1,0 | 1,2 |

## 4.10. Test: Test F11

### 4.10.1. Test method

The F11 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.10.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 40: Result of test F11**

| Serie [-] | F11 | F11 | F11 | F11 | F11 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 33 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $c_{min}$ [mm] | 35 | 35 | 40 | 50 | 60 |
| $s_{min}$ [mm] | 35 | 35 | 40 | 50 | 60 |
| $h_{min}$ [mm] | 80 | 80 | 90 | 120 | 140 |
| $T_{inst}$ [Nm] | 10 | 20 | 30 | 50 | 50 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| $T_{u,m,i}$ [Nm] | 58 | 84 | 132 | 200 | 226 |
| | 56 | 85 | 132 | 196 | 228 |
| | 57 | 87 | 122 | 198 | 230 |
| | 58 | 82 | 134 | 197 | 234 |
| | 59 | 83 | 135 | 189 | 237 |
| $T_{u,m,t}$ [Nm] | 58 | 84 | 131 | 196 | 231 |
| s | 1 | 2 | 5 | 4 | 4 |
| $cv_F$ | 2 | 2 | 4 | 2 | 2 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOKK-151 | ±3 | ±3 | ±4 | ±4 | ±5 |

**Table No 41: Evaluation of test F11**

| Serie | Size | $h_{ef}$ | k | rqd.$T_{inst}$ | n | $T_{u,m,t}$ | $f_{uk}$ | $f_{u,test}$ | $T_{5\%}$ | rqd.$T_{inst,test}$ | $T_{5\%}$/rqd.$T_{inst,test}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [Nm] | [-] | [Nm] | [N/mm²] | [N/mm²] | [Nm] | [Nm] | [-] |
| F11 | 6 | 42 | 2,1 | 10 | 5 | 58 | 25 | 32,6 | 54 | 24 | 2,2 |
| F11 | 8 | 51 | 2,1 | 20 | 5 | 84 | 25 | 32,6 | 78 | 48 | 1,6 |
| F11 | 10 | 68 | 2,1 | 30 | 5 | 131 | 25 | 32,6 | 113 | 72 | 1,6 |
| F11 | 12 | 80 | 2,1 | 50 | 5 | 196 | 25 | 32,6 | 182 | 120 | 1,5 |
| F11 | 16 | 96 | 2,1 | 80 | 5 | 231 | 25 | 32,6 | 224 | 192 | 1,2 |

## 4.11. Test: Tension test F12

### 4.11.1. Test method

The F12 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.11.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 42: Result of test F12**

| Serie [-] | F12 | F12 | F12 | F12 | F12 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $c_{cr,sp}$ | 63 | 76,5 | 102 | 120 | 144 |
| $s_{cr,sp}$ | 126 | 153 | 204 | 240 | 288 |
| $h_{min}$ [mm] | 80 | 80 | 90 | 120 | 140 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 20,32 | 25,67 | 39,54 | 56,45 | 82,32 |
| | 18,34 | 26,54 | 41,22 | 55,12 | 80,78 |
| $F_{u,m,i}$ [kN] | 19,66 | 24,12 | 43,76 | 60,60 | 81,44 |
| | 18,98 | 27,43 | 39,76 | 57,58 | 81,77 |
| | - | - | - | - | - |
| $F_{u,m,t}$ [kN] | 19,33 | 25,94 | 41,07 | 57,44 | 81,58 |
| s | 0,85 | 1,41 | 1,94 | 2,34 | 0,64 |
| $cv_F$ | 4,42 | 5,44 | 4,73 | 4,07 | 0,79 |
| n | 4 | 4 | 4 | 4 | 4 |
| U-LOK145n | ±0,21 | ±0,56 | ±0,57 | ±0,59 | ±0,50 |

**Table No 43: Evaluation of test F12**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ | $f_{ck,cube}$ | $F_{u,m,20}$ | Failure |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $f_{u,test}$ | $f_{uk}$ | $F_{u,m,s}$ | |
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [-] |
| F12 | 6 | 42 | 4 | 0,0 | 19,3 | 32,6 | 25 | 16,9 | sp |
| F12 | 8 | 51 | 4 | 0,0 | 25,9 | 32,6 | 25 | 22,7 | sp |
| F12 | 10 | 68 | 4 | 0,0 | 41,1 | 32,6 | 25 | 36,0 | sp |
| F12 | 12 | 80 | 4 | 0,0 | 57,4 | 32,6 | 25 | 50,3 | sp |
| F12 | 16 | 96 | 4 | 0,0 | 81,6 | 32,6 | 25 | 71,4 | sp |

The statistical test was carried out acc. to one-sides F-test with level of significance a=0,05 and two-sides t-test or t-Welch with level of significance a=0,05 for independent data from test A1 and test F12.

H0 (Null Hypothesis) is the hypothesis assuming that results of tests F12 do not differ from results of tests A1.

**Table No 44: Evaluation of test F12 and A1, statistical test F**

| Serie | Size | $n_{F12}$-1 | $n_{A1}$-1 | $s_{F12}$ | $s_{A1}$ | F (test F) | f Critical one-tail | p-value (test F) | Null Hypothesis ($H_0$:T) |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [-] | [-] | [kN | [kN] | [-] | [-] | [-] | [-] |
| F12/A1 | 6 | 3 | 4 | 0,85 | 1,24 | 2,10 | 4,19 | 0,24 | Accepted |
| F12/A1 | 8 | 3 | 4 | 1,41 | 1,88 | 1,77 | 4,19 | 0,29 | Accepted |
| F12/A1 | 10 | 3 | 4 | 1,94 | 1,94 | 1,00 | 4,19 | 0,48 | Accepted |
| F12/A1 | 12 | 3 | 4 | 2,34 | 2,58 | 1,22 | 4,19 | 0,41 | Accepted |
| F12/A1 | 16 | 3 | 4 | 0,64 | 2,90 | 20,33 | 4,19 | 0,01 | Not Accepted |

**Table No 45: Evaluation of test F12 and A1, statistical test t**

| Serie | Size | $n_{F12}$-1 | $n_{A1}$-1 | $s_{F12}$ | $s_{A1}$ | $N_{u,m,F12}$ | $N_{u,m,A1}$ | T (t-test) | T (t-Welch) | t Critical two-tail | p-value (t-test) | Null Hypothesis ($H_0$:T) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [-] | [-] | [kN | [kN] | [kN] | [kN] | [-] | [-] | [-] | [-] | [-] |
| F12/A1 | 6 | 3 | 4 | 0,85 | 1,24 | 16,9 | 18,5 | 2,13 | - | 2,36 | 0,07 | Accepted |
| F12/A1 | 8 | 3 | 4 | 1,41 | 1,88 | 22,7 | 25,0 | 2,03 | - | 2,36 | 0,08 | Accepted |
| F12/A1 | 10 | 3 | 4 | 1,94 | 1,94 | 36,0 | 37,7 | 1,35 | - | 2,36 | 0,22 | Accepted |
| F12/A1 | 12 | 3 | 4 | 2,34 | 2,58 | 50,3 | 52,0 | 1,03 | - | 2,36 | 0,34 | Accepted |
| F12/A1 | 12 | 3 | 4 | 0,64 | 2,90 | 71,4 | 73,9 | - | 0,57 | 2,57 | 0,59 | Accepted |

## 4.12. Test: Shear test V1

### 4.12.1. Test method

The V1 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.12.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample.

**Table No 46: Result of test V1**

| Serie [-] | V1 | V1 | V1 | V1 | V1 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 14,23 | 23,23 | 35,65 | 45,67 | 81,22 |
| | 13,45 | 22,65 | 35,98 | 45,87 | 81,65 |
| $F_{u,m,i}$ [kN] | 12.11 | 25,66 | 35,23 | 46,23 | 81,56 |
| | 12,87 | 24,34 | 35,86 | 46,98 | 82.44 |
| | 14,76 | 23,77 | 36,54 | 46,98 | 82,90 |
| $F_{u,m,t}$ [kN] | 13,83 | 23,93 | 35,85 | 46,35 | 81,83 |
| s | 0,83 | 1,15 | 0,48 | 0,61 | 0,74 |
| $cv_F$ | 6,04 | 4,82 | 1,34 | 1,32 | 0,90 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOKK-31g | ±0,06 | ±0,11 | ±0,14 | ±0,16 | ±0,26 |

**Table No 47: Evaluation of test V1**

| Serie | Size | $h_{ef}$ | $V_{u,m}$ | $f_{u,test}$ | $f_{uk}$ | $V_{u,m,20}/V_{um,s}$ | $cv_F$ | $V_{Rk}$ | $A_s$ | $f_{uk}$ | $V_{Rk,s}$ | $V_{Rk}/V_{Rk,s}$ | $V_{Rk,s,ETA}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [%] | [kN] | [mm²] | [N/mm²] | [kN] | [-] | [kN] |
| V1 | 6 | 42 | 13,83 | 885 | 800 | 12,50 | 6,04 | 9,93 | 24,6 | 800 | 9,8 | 1,01 | 9,84 |
| V1 | 8 | 51 | 23,93 | 878 | 800 | 21,80 | 4,82 | 18,23 | 44,2 | 800 | 17,7 | 1,03 | 17,68 |
| V1 | 10 | 68 | 35,85 | 906 | 800 | 31,66 | 1,34 | 30,22 | 72,4 | 800 | 29,0 | 1,04 | 28,96 |
| V1 | 12 | 80 | 46,35 | 857 | 800 | 43,26 | 1,32 | 41,32 | 99,4 | 800 | 39,8 | 1,04 | 39,76 |
| V1 | 16 | 96 | 81,83 | 893 | 800 | 73,31 | 0,90 | 71,07 | 177,7 | 800 | 71,1 | 1,00 | 71,07 |

## 4.13. Test: Tension test N1

### 4.13.1. Test method

The N1 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.13.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 48: Result of test N1**

| Serie [-] | N1 | N1 | N1 | N1 | N1 |
|---|---|---|---|---|---|
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| | 21 | 38 | 65 | 85 | 158 |
| | 22 | 39 | 66 | 86 | 160 |
| $F_{u,m,i}$ [kN] | 21 | 39 | 66 | 86 | 159 |
| | 22 | 38 | 65 | 84 | 159 |
| | 23 | 40 | 66 | 85 | 158 |
| $F_{u,m,t}$ [kN] | 21,80 | 38,80 | 65,60 | 85,20 | 158,80 |
| s | 0,84 | 0,84 | 0,55 | 0,84 | 0,84 |
| $cv_F$ | 3,84 | 2,16 | 0,83 | 0,98 | 0,53 |
| U-LOKK033 | ±1 | ±1 | ±1 | ±1 | ±2 |

**Table No 49: Evaluation of test N1**

| Serie | Size | $F_{u,m,t}$ | $A_{s,bolt}$ | $f_{u,test}$ | $f_{uk}$ | $N_{Rk,s,ETA}$ |
|---|---|---|---|---|---|---|
| [-] | [mm] | [kN] | [mm²] | [N/mm²] | [N/mm²] | [kN] |
| N1 | 5,6 | 21,8 | 24,6 | 885 | 800 | 19,7 |
| N1 | 7,5 | 38,8 | 44,2 | 878 | 800 | 35,3 |
| N1 | 9,6 | 65,6 | 72,4 | 906 | 800 | 57,9 |
| N1 | 11,3 | 85,2 | 99,4 | 857 | 800 | 79,5 |
| N1 | 15,1 | 158,8 | 177,9 | 893 | 800 | 142,3 |

## 4.14. Test: Torque test (F6)

### 4.14.1. Test method

The test was carried out in compliance with instructions in EAD 330232-01-0601:2019, table A.1, test F6.

Concrete base material in F6 test was normal weight non-cracked concrete C20/25.

The F6 test was performed at normal temperature.

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

### 4.14.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample.

**Table No 50: Result of test F6**

| Serie [-] | F6 | F6 | F6 | F6 | F6 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $T_{inst}$ [Nm] | 10 | 20 | 30 | 50 | 50 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| $T_{u,m,i}$ [Nm] | 50 | 87 | 124 | 198 | 230 |
| | 54 | 88 | 125 | 202 | 234 |
| | 54 | 84 | 126 | 200 | 234 |
| | 56 | 86 | 130 | 202 | 230 |
| | 55 | 89 | 128 | 196 | 228 |
| | 55 | 82 | 122 | 196 | 226 |
| | 54 | 84 | 122 | 195 | 228 |
| | 43 | 82 | 128 | 200 | 235 |
| | 42 | 88 | 129 | 200 | 238 |
| | 52 | 82 | 130 | 202 | 236 |
| $T_{u,m,t}$ [Nm] | 52 | 85 | 126 | 199 | 232 |
| s | 5 | 3 | 3 | 3 | 4 |
| $cv_F$ | 10 | 3 | 2 | 1 | 2 |
| n | 10 | 10 | 10 | 10 | 10 |
| U-LOKK-151 | ±3 | ±3 | ±4 | ±4 | ±5 |

**Table No 51: Evaluation of test F6**

| Serie | Size | $h_{ef}$ | k | rqd.$T_{inst}$ | n | $T_{u,m,t}$ | $f_{uk}$ | $f_{u,test}$ | $T_{5\%}$ | rqd.$T_{inst,test}$ | $T_{5\%}$/rqd.$T_{inst,test}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [Nm] | [-] | [Nm] | [N/mm²] | [N/mm²] | [Nm] | [Nm] | [-] |
| F6 | 6 | 42 | 2,1 | 10 | 10 | 52 | 25 | 32,6 | 39 | 24 | 1,6 |
| F6 | 8 | 51 | 2,1 | 20 | 10 | 85 | 25 | 32,6 | 78 | 48 | 1,6 |
| F6 | 10 | 68 | 2,1 | 30 | 10 | 126 | 25 | 32,6 | 119 | 72 | 1,6 |
| F6 | 12 | 80 | 2,1 | 50 | 10 | 199 | 25 | 32,6 | 192 | 120 | 1,6 |
| F6 | 16 | 96 | 2,1 | 80 | 10 | 232 | 25 | 32,6 | 228 | 192 | 1,2 |

## 4.15. Test: Torque test (F8)

### 4.15.1. Test method

The F8 test was carried out for all types heads concrete screw in compliance with EAD 330232-01-0601:2019, table A.1, test F8. Concrete base material in F8 test - normal weight non-cracked concrete C50/60

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

## 4.15.2. Results

Every tests have been performed with impact screw driver BOSCH GDS 18 E. After installation of concrete screws impact screw driver switched cut off after 5 sec.

Conclusion: no failure of concrete screw or anchorage occurred.

No drill bit failure was observed.

## 4.16. Test: Tension test F10

## 4.16.1. Test method

The F10 test was carried out in compliance with EAD 330232-01-0601, table A1

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

## 4.16.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample

**Table No 52: Result of test F10**

| Serie [-] | F10 | F10 | F10 | F10 | F10 |
|---|---|---|---|---|---|
| $f_{ck,cube}$ [N/mm²] | 25 | 25 | 25 | 25 | 25 |
| $f_{c,t}$ [N/mm²] | 32,6 | 32,6 | 32,6 | 32,6 | 32,6 |
| $f_{uk}$ [N/mm²] | 800 | 800 | 800 | 800 | 800 |
| $f_{u,test}$ [N/mm²] | 885 | 878 | 906 | 857 | 893 |
| Size [mm] | 6 | 8 | 10 | 12 | 16 |
| $h_{ef}$ [mm] | 42 | 51 | 68 | 80 | 96 |
| | 13,43 | 16,57 | 25,76 | 40,65 | 64,56 |
| | 15,65 | 17,92 | 27,98 | 41,12 | 65,98 |
| $F_{u,m,i}$ [kN] | 13,23 | 18,17 | 30,43 | 38,98 | 63,22 |
| | 11,21 | 15,43 | 27,12 | 36,56 | 64,36 |
| | 11,06 | 16,87 | 29,45 | 40,98 | 62,82 |
| $F_{u,m,t}$ [kN] | 12,92 | 16,99 | 28,15 | 39,66 | 64,19 |
| s | 1,88 | 1,10 | 1,85 | 1,93 | 1,24 |
| $cv_F$ | 14,58 | 6,50 | 6,57 | 4,87 | 1,94 |
| n | 5 | 5 | 5 | 5 | 5 |
| U-LOKK-145n | ±0,20 | ±0,20 | ±0,56 | ±0,57 | ±0,40 |

**Table No 53: Evaluation of test F10**

| Serie | Size | $h_{ef}$ | n | crack | $F_{u,m,t}$ | $f_{c,t}$ | $f_{ck,cube}$ | $F_{u,m,50}$ | Failure |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $f_{u,test}$ | $f_{uk}$ | $F_{u,m,s}$ | |
| [-] | [mm] | [mm] | [-] | [mm] | [kN] | [N/mm²] | [N/mm²] | [kN] | [-] |
| F10 | 6 | 42 | 5 | 0,3 | 12,92 | 32,6 | 25 | 11,31 | p.o |
| F10 | 8 | 51 | 5 | 0,3 | 16,99 | 32,6 | 25 | 14,88 | p.o |
| F10 | 10 | 68 | 5 | 0,3 | 28,15 | 32,6 | 25 | 24,65 | p.o |
| F10 | 12 | 80 | 5 | 0,3 | 39,66 | 32,6 | 25 | 34,73 | p.o |
| F10 | 16 | 96 | 5 | 0,3 | 64,19 | 32,6 | 25 | 56,21 | p.o |

**Table No 54: Evaluation of characteristic value in test F10**

| Serie | Size | $h_{ef}$ | n | $N_{u,m}$ | $cv_F$ | $N_{Rk,F9}$ |
|---|---|---|---|---|---|---|
| | | | | $N_{u,m,s}$ | | |
| [-] | [mm] | [mm] | [-] | [kN] | [%] | [kN] |
| F10 | 6 | 42 | 5 | 11,31 | 14,58 | 5,70 |
| F10 | 8 | 51 | 5 | 14,88 | 6,50 | 11,59 |
| F10 | 10 | 68 | 5 | 24,65 | 6,57 | 19,14 |
| F10 | 12 | 80 | 5 | 34,73 | 4,87 | 28,98 |
| F10 | 16 | 96 | 5 | 56,21 | 1,94 | 52,51 |

**Table No 55: Evaluation of factor α**

| Serie | Size | $h_{ef}$ | n | $N_{u,m,F10}$ | $N_{Rk,F10}$ | $cv_F$ | $N_{u,m,A3}$ | $N_{Rk,A3}$ | $cv_F$ | α | rqd.α | α/ rqdα | $\gamma_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [mm] | [mm] | [-] | [kN] | [kN] | [%] | [kN] | [kN] | [%] | [-] | [-] | [-] | [-] |
| F10 | 6 | 42 | 5 | 11,31 | 5,70 | 14,58 | 13,84 | 11,63 | 4,69 | 0,82 | 0,8 | >1 | 1,2 |
| F10 | 8 | 51 | 5 | 14,88 | 11,59 | 6,50 | 17,58 | 14,18 | 5,69 | 0,85 | 0,8 | >1 | 1,2 |
| F10 | 10 | 68 | 5 | 24,65 | 19,14 | 6,57 | 30,75 | 24,71 | 5,77 | 0,802 | 0,8 | >1 | 1,2 |
| F10 | 12 | 80 | 5 | 34,73 | 28,98 | 4,87 | 39,28 | 28,75 | 7,89 | 0,88 | 0,8 | >1 | 1,2 |
| F10 | 16 | 96 | 5 | 56,21 | 52,51 | 1,94 | 63,50 | 58,85 | 2,15 | 0,89 | 0,8 | >1 | 1,2 |

## 4.17. Test: Tension test C1

### 4.17.1. Test method

The C1.1 and C1.2 test was carried out in compliance with EAD 330232-01-0601.

The program of the tests is given in the table below:

**Table No : Test program**

| Code | Description | Concrete | Δw [mm] |
|---|---|---|---|
| C1.1 | Functioning under pulsation tension load | C20/25 | 0.5 |
| C1.2 | Functioning under alternating shear load | C20/25 | 0.5 |

#### Tests under pulsating tension load (test series C1.1)

The maximum tension load to be applied in the seismic tension test series C1.1 is calculated according to the following equation ([2], equation C.1):

$$N_{C1} = 0{,}5 \cdot N_{u,m} \cdot \left(\frac{f_{c,C1.1}}{f_{c,3}}\right)^{m}$$

where:

- $N_{u,m}$: mean ultimate tensile load of the tests in concrete on test series A3.
- $f_{c,C1.1}$: mean compressive strength of concrete used for the test series C1.1 at the time of testing.
- $f_{c,3}$: mean compressive strength of concrete used for the “Basic tension tests" at the time of testing.
- m: normalization exponent.

### Tests under alternating shear load cycling (test series C1.2)

These tests are intended to evaluate the performance of the fasterners under simulated seismic shear loading, including the effects of concrete cracking.

The maximum shear load to be applied in the seismic shear test series C1.2 is calculated according to the following equation ([2], equation C.5):

$$V_{C1} = 0{,}5 \cdot V_{u,m} \cdot \left(\frac{f_{u,C1.2}}{f_{u,5}}\right)$$

where:

- $V_{u,m}$: mean ultimate shear load of the tests in concrete.
- $f_{u,C1.2}$: mean ultimate tensile strength of steel fastener element used in the test series C1.1.
- $f_{u,5}$: mean ultimate tensile strength of steel fastener elements used in tests for “characteristic resistance to steel failure under shear load” in uncracked concrete C20/25.

The test implementation, environmental conditions and accuracy of the measuring devices used are in accordance with the requirements of the above-mentioned standard.

The C.1.1 and C.1.2 test was carried out for THE concrete screw in compliance with EAD 330232-01-0601:2019, table A.1, test C.1.1 and C.1.2

Concrete base material in C.1.1 and C.1.2.test - normal weight non-cracked concrete C20/25

## 4.17.2. Results

Uncertainty of the measurement is for a confidence level of 95 % and uncertainty factor 2. Uncertainty has been estimated on the basis of available data, including: data on the accuracy of the measurement system. The uncertainty value refers to the individual test results. The value of uncertainty can not be assigned directly to the characteristics of a given product, because the laboratory does not have knowledge about the variability of product population, but only about the tested sample.

**Table No 56: Results of C1.1. test**

| Serie | Anchor | $h_{nom}$ | $N_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.1 | 6 | 55 | 7,9 | | - | - | - | - | - | | - |
| | | | 4 | 14,56 | 12,12 | 11,04 | 10,12 | 10,95 | 11,8 | 1,7 | 14,6 |

**Table No 57: Seismic tension loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,C1.1}$ | $f_{c,A3}$ | $F_{u,test,A3}$ | $N_{C1}$ | $N_{C1,red}$ | $N_{C1,red}$ / $N_{C1}$ ($\alpha_{N,C1}$) |
|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [N/mm²] | [kN] | [kN] | [kN] | [-] |
| C.1.1 | 6 | 55 | 32,6 | 32,6 | 15,8 | 7,9 | 4 | 0,5 |

**Table No 58: Seismic tension test results**

| Serie | Anchor | $h_{nom}$ | Failure | $N_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.1) | 160% $N_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.1 | 6 | 55 | concrete | 11,8 | 15 | 6,4 | 1 |

**Table No 59: Results of C1.2. test**

| Serie | Anchor | $h_{nom}$ | $V_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.2 | 6 | 55 | 6,92 | - | | | | | - | - | - |
| | | | 3,5 | 12,54 | 12,76 | 13,09 | 12,88 | 12,43 | 12,7 | 0,3 | 2 |

**Table No 60: Seismic shear loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,test,i}$ | $f_{u,C1.2}$ | $f_{u,5}$ | $V_{u,m}$ | $V_{C1}$ | $V_{C1,red}$ | $V_{C1,red}$/$V_{C1}$ ($\alpha_{C1.2}$) |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [MPa] | [MPa] | [kN] | [kN] | [kN] | [-] |
| C.1.2 | 6 | 55 | 32,6 | 885 | 885 | 13,83 | 6,92 | 3,5 | 0,51 |

**Table No 61: Seismic shear test results**

| Serie | Anchor | $h_{nom}$ | Failure | $V_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.2) | 160% $V_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.2 | 6 | 55 | steel | 12,7 | 2 | 5,6 | 1 |

**Table No 62: Results of C1.1. test**

| Serie | Anchor | $h_{nom}$ | $N_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| | | | 10,0 | | - | - | - | - | - | | - |
| C.1.1 | 8 | 65 | 8 | 18,32 | 19,18 | 17,45 | 20,21 | 16,44 | 18,3 | 1,5 | 8 |

**Table No 63: Seismic tension loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,C1.1}$ | $f_{c,A3}$ | $F_{u,test,A3}$ | $N_{C1}$ | $N_{C1,red}$ | $N_{C1,red}$ / $N_{C1}$ ($\alpha_{N,C1}$) |
|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [N/mm²] | [kN] | [kN] | [kN] | [-] |
| C.1.1 | 8 | 65 | 32,6 | 32,6 | 20,08 | 10,0 | 8 | 0,8 |

**Table No 64: Seismic tension test results**

| Serie | Anchor | $h_{nom}$ | Failure | $N_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.1) | 160% $N_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.1 | 8 | 65 | concrete | 18,3 | 8 | 12,8 | 1 |

**Table No 65: Results of C1.2. test**

| Serie | Anchor | $h_{nom}$ | $V_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.2 | 8 | 65 | 11,97 | - | | | | | - | - | - |
| | | | 9 | 22,54 | 22,76 | 23,87 | 23,26 | 22,21 | 22,9 | 0,7 | 3 |

**Table No 66: Seismic shear loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,test,i}$ | $f_{u,C1.2}$ | $f_{u,5}$ | $V_{u,m}$ | $V_{C1}$ | $V_{C1,red}$ | $V_{C1,red}$/$V_{C1}$ ($\alpha_{C1.2}$) |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [MPa] | [MPa] | [kN] | [kN] | [kN] | [-] |
| C.1.2 | 8 | 65 | 32,6 | 878 | 878 | 23,93 | 11,97 | 9 | 0,75 |

**Table No 67: Seismic shear test results**

| Serie | Anchor | $h_{nom}$ | Failure | $V_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.2) | 160% $V_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.2 | 8 | 65 | steel | 22,9 | 3 | 14,4 | 1 |

**Table No 68: Results of C1.1. test**

| Serie | Anchor | $h_{nom}$ | $N_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.1 | 10 | 85 | 17,6 | - | - | - | - | - | - | | - |
| | | | 12 | 34,21 | 32,65 | 28,43 | 29,56 | 25,87 | 30,1 | 3,3 | 11 |

**Table No 69: Seismic tension loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,C1.1}$ | $f_{c,A3}$ | $F_{u,test,A3}$ | $N_{C1}$ | $N_{C1,red}$ | $N_{C1,red}$ / $N_{C1}$ ($\alpha_{N,C1}$) |
|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [N/mm²] | [kN] | [kN] | [kN] | [-] |
| C.1.1 | 10 | 85 | 32,6 | 32,6 | 35,11 | 17,6 | 12 | 0,7 |

**Table No 70: Seismic tension test results**

| Serie | Anchor | $h_{nom}$ | Failure | $N_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.1) | 160% $N_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.1 | 10 | 85 | concrete | 30,1 | 11 | 19,2 | 1 |

**Table No 71: Results of C1.2. test**

| Serie | Anchor | $h_{nom}$ | $V_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.2 | 10 | 85 | 17,93 | - | | | | | - | - | - |
| | | | 14 | 34,65 | 33,43 | 33,12 | 34,87 | 33,04 | 33,8 | 0,9 | 3 |

**Table No 72: Seismic shear loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,test,i}$ | $f_{u,C1.2}$ | $f_{u,5}$ | $V_{u,m}$ | $V_{C1}$ | $V_{C1,red}$ | $V_{C1,red}$/$V_{C1}$ ($\alpha_{C1.2}$) |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [MPa] | [MPa] | [kN] | [kN] | [kN] | [-] |
| C.1.2 | 10 | 85 | 32,6 | 906 | 906 | 35,85 | 17,93 | 14 | 0,78 |

**Table No 73: Seismic shear test results**

| Serie | Anchor | $h_{nom}$ | Failure | $V_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.2) | 160% $V_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.2 | 10 | 85 | steel | 33,8 | 3 | 22,4 | 1 |

**Table No 74: Results of C1.1. test**

| Serie | Anchor | $h_{nom}$ | $N_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.1 | 12 | 100 | 22,4 | - | - | - | - | - | - | | - |
| | | | 18 | 42,11 | 40,77 | 44,76 | 38,12 | 34,76 | 40,1 | 3,8 | 10 |

**Table No 75: Seismic tension loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,C1.1}$ | $f_{c,A3}$ | $F_{u,test,A3}$ | $N_{C1}$ | $N_{C1,red}$ | $N_{C1,red}$ / $N_{C1}$ ($\alpha_{N,C1}$) |
|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [N/mm²] | [kN] | [kN] | [kN] | [-] |
| C.1.1 | 12 | 100 | 32,6 | 32,6 | 44,86 | 22,4 | 18 | 0,8 |

**Table No 76: Seismic tension test results**

| Serie | Anchor | $h_{nom}$ | Failure | $N_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.1) | 160% $N_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.1 | 12 | 100 | concrete | 40,1 | 10 | 28,8 | 1 |

**Table No 77: Results of C1.2. test**

| Serie | Anchor | $h_{nom}$ | $V_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.2 | 12 | 100 | 23,18 | - | | | | | - | - | - |
| | | | 19 | 45,34 | 44,23 | 42,98 | 42,39 | 44,33 | 43,9 | 1,2 | 3 |

**Table No 78: Seismic shear loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,test,i}$ | $f_{u,C1.2}$ | $f_{u,5}$ | $V_{u,m}$ | $V_{C1}$ | $V_{C1,red}$ | $V_{C1,red}$/$V_{C1}$ ($\alpha_{C1.2}$) |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [MPa] | [MPa] | [kN] | [kN] | [kN] | [-] |
| C.1.2 | 12 | 100 | 32,6 | 857 | 857 | 46,35 | 23,18 | 19 | 0,82 |

**Table No 79: Seismic shear test results**

| Serie | Anchor | $h_{nom}$ | Failure | $V_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.2) | 160% $V_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.2 | 12 | 100 | steel | 43,9 | 3 | 30,4 | 1 |

**Table No 80: Results of C1.1. test**

| Serie | Anchor | $h_{nom}$ | $N_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.1 | 16 | 120 | 36,3 | - | - | - | - | - | - | | - |
| | | | 30 | 67,87 | 63,45 | 70,99 | 65,12 | 64,29 | 66,3 | 3,1 | 5 |

**Table No 81: Seismic tension loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,C1.1}$ | $f_{c,A3}$ | $F_{u,test,A3}$ | $N_{C1}$ | $N_{C1,red}$ | $N_{C1,red}$ / $N_{C1}$ ($\alpha_{N,C1}$) |
|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [N/mm²] | [kN] | [kN] | [kN] | [-] |
| C.1.1 | 16 | 120 | 32,6 | 32,6 | 72,51 | 36,3 | 30 | 0,8 |

**Table No 82: Seismic tension test results**

| Serie | Anchor | $h_{nom}$ | Failure | $N_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.1) | 160% $N_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.1 | 16 | 120 | concrete | 66,3 | 5 | 48 | 1 |

**Table No 83: Results of C1.2. test**

| Serie | Anchor | $h_{nom}$ | $V_{C1}$ | Ultimate load | | | | | Mean value | s | $C_{oV}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [kN] | [kN] | | | | | [kN] | [kN] | [%] |
| C.1.2 | 16 | 120 | 40,92 | - | | | | | - | - | - |
| | | | 30 | 80,54 | 80,24 | 79,02 | 79,72 | 81,15 | 80,1 | 0,8 | 1 |

**Table No 84: Seismic shear loads calculated**

| Serie | Anchor | $h_{nom}$ | $f_{c,test,i}$ | $f_{u,C1.2}$ | $f_{u,5}$ | $V_{u,m}$ | $V_{C1}$ | $V_{C1,red}$ | $V_{C1,red}$/$V_{C1}$ ($\alpha_{C1.2}$) |
|---|---|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [N/mm²] | [MPa] | [MPa] | [kN] | [kN] | [kN] | [-] |
| C.1.2 | 16 | 120 | 32,6 | 893 | 893 | 81,83 | 40,92 | 30 | 0,73 |

**Table No 85: Seismic shear test results**

| Serie | Anchor | $h_{nom}$ | Failure | $V_{Ru,20,mean,C1.1}$ | $C_{oV}$ (C1.2) | 160% $V_{C1,red}$ | min(1; $R_m$) |
|---|---|---|---|---|---|---|---|
| [-] | [-] | [mm] | [-] | [kN] | [%] | [kN] | [-] |
| C.1.2 | 16 | 120 | steel | 80,1 | 1 | 48 | 1 |

## 5. Disclamers

The Testing Laboratory declares that the test results relate only to the sample received.

The Laboratory is responsible for all information presented in this test report and for all stages of the test process, except for information provided by the Ordering Party and process stages performed by or under the responsibility of the Ordering Party (e.g. sample assembly). These are clearly identified in this report as information provided by the Ordering Party or activities performed by the Ordering Party.

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## 6. Annex

**END OF THE REPORT**

# Annex

## 1. Assessment of steel resistance

Considering a uniform section and steel hardness along the full anchor length, and according to drawings supplied by the manufacturer, following steel properties apply as per EAD 330232-01-060:2019 sections 2.2.1.1 and 2.2.7.1:

**Table No 86: Assessment of steel resistance**

| Size | $f_{uk}$ | $f_{yk}$ | $f_{yk}/f_{uk}$ | $N_{Rk,s}$ | $V_{Rk,s}$ | $M^0_{Rk,s}$ [1)] | $\gamma_{M,s}$ (tension) [2)] | $\gamma_{M,s}$ (shear) [3)] |
|---|---|---|---|---|---|---|---|---|
| | [MPa] | [MPa] | [MPa] | [kN] | [kN] | [Nm] | [--] | [--] |
| 6 | 800 | 640 | 0,80 | 19,7 | 9,8 | 16,6 | 1,50 | 1,25 |
| 8 | 800 | 640 | 0,80 | 35,3 | 17,7 | 39,8 | 1,50 | 1,25 |
| 10 | 800 | 640 | 0,80 | 57,9 | 29,0 | 83,4 | 1,50 | 1,25 |
| 12 | 800 | 640 | 0,80 | 79,5 | 39,8 | 134,2 | 1,50 | 1,25 |
| 16 | 800 | 640 | 0,80 | 142,3 | 71,1 | 321,3 | 1,50 | 1,25 |

Note:
1) Equation $M^0_{Rk,s} = 1,2 \times W_{el} \times f_{uk}$, when $W_{el} = \pi \times d^3/32$, $d = ((4 \times A_s)/\pi)^{0,5}$, $A_s$ from test N1
2) Equation $\gamma_{M,s} = 1,2/ f_{yk}/f_{uk} \geq 1,4$
3) Equation $\gamma_{M,s} = f_{uk}/f_{yk} \geq 1,25$, when $f_{uk} \leq 800$ N/mm² and $f_{yk}/f_{uk} \leq 0,8$ or $\gamma_{M,s} = 1,5$, when $f_{uk} > 800$ N/mm² or $f_{yk}/f_{uk} > 0,8$

## 2. Assessment of pull out resistance

Pull out failure resistance has been assessed according to EAD 330232-01-0601:2019 section 2.2.2.10.

**Table No 87: Assessment of pull out resistance, uncracked concrete**

| Value to the evaluation | Unit/Size | **6** | **8** | **10** | **12** | **16** |
|---|---|---|---|---|---|---|
| $N_{Rk,p,\ A1}$ | [kN] | 14,79 | 19,43 | 31,94 | 44,35 | 65,29 |
| $(\alpha_p/\text{req}\ \alpha_p)$ F4 | [-] | 1 | 1 | 1 | 1 | 1 |
| min $(\alpha_1/\text{req}\ \alpha_1)$ | [-] | 1 | 1 | 1 | 1 | 1 |
| min $(\alpha/\text{req}\ \alpha)$ F1 | [-] | 1 | 1 | 1 | 1 | 1 |
| min $(\alpha/\text{req}\ \alpha)$ F2 | [-] | 1 | 1 | 1 | 1 | 1 |
| min $(\alpha/\text{req}\ \alpha)$ F4 | [-] | 1 | 1 | 1 | 1 | 1 |
| min $(\beta cv)$ | [-] | 1 | 1 | 1 | 1 | 1 |
| $N_{RK,p}$ | [kN] | 14,79 | 19,43 | 31,94 | 44,35 | 65,29 |
| $h_{ef}$ | [mm] | 42 | 51 | 68 | 80 | 96 |
| $N_{Rk,c}$ | [kN] | 13,39 | 17,92 | 27,58 | 35,20 | 46,27 |
| Governs | [-] | Concrete cone | Concrete cone | Concrete cone | Concrete cone | Concrete cone |
| ETA | [kN] | - | - | - | - | - |

**Table No 88: Assessment of pull out resistance, cracked concrete**

| Value to the evaluation | Unit/Size | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|
| $N_{Rk,p,A3}$ | [kN] | 11,63 | 14,18 | 24,71 | 28,75 | 58,85 |
| min ($\alpha_p$/req $\alpha_p$) F3 | [-] | 1 | 1 | 1 | 1 | 1 |
| min ($\alpha_1$/req $\alpha_1$) | [-] | 1 | 1 | 1 | 1 | 1 |
| min ($\alpha$/req $\alpha$) F1 | [-] | 1 | 1 | 1 | 1 | 1 |
| min ($\alpha$/req $\alpha$) F2 | [-] | 1 | 1 | 1 | 1 | 1 |
| min ($\alpha$/req $\alpha$) F3 | [-] | 0,78 | 0,90 | 0,94 | 0,92 | 0,93 |
| min ($\alpha$/req $\alpha$) F4 | [-] | 1 | 1 | 1 | 1 | 1 |
| min ($\beta$cv) | [-] | 1 | 1 | 1 | 1 | 1 |
| $N_{RK,p}$ | [kN] | 9,07 | 12,76 | 23,23 | 26,45 | 54,73 |
| $h_{ef}$ | [mm] | 42 | 51 | 68 | 80 | 96 |
| $N_{Rk,c}$ | [kN] | 9,37 | 12,54 | 19,31 | 24,64 | 32,39 |
| Governs | [-] | Pull out | Concrete cone | Concrete cone | Concrete cone | Concrete cone |
| ETA | [kN] | 9 | - | - | - | - |

### 3. Displacements under service loads

Displacement under service loads have been taken from test series A1, A3 and V1.

**Table No 89: Displacements under tension service loads in uncracked concrete**

| Size | Unit | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|
| $h_{ef}$ | [mm] | 42 | 51 | 68 | 80 | 96 |
| $N_{Rk,p,A1}$ | [kN] | 14,79 | 19,43 | 31,94 | 44,35 | 65,29 |
| $\gamma_{inst,F9}$ | [-] | 1 | 1 | 1 | 1 | 1 |
| $\gamma_c$ | [-] | 1,5 | 1,5 | 1,5 | 1,5 | 1,5 |
| $\gamma_{Mc}=\gamma_{inst,F9} \times \gamma_c$ | [-] | 1,5 | 1,5 | 1,5 | 1,5 | 1,5 |
| $\gamma_F$ | [-] | 1,4 | 1,4 | 1,4 | 1,4 | 1,4 |
| $N_s=N_{Rk,p,A1} / \gamma_F \times \gamma_{Mc}$ | [kN] | 7,04 | 9,25 | 15,21 | 21,12 | 31,09 |
| $\delta_{N,0}$ | [mm] | 0,18 | 0,23 | 0,30 | 0,34 | 0,45 |
| $\delta_{F4,100000}$ | [mm] | 1,20 | 1,30 | 1,10 | 1,30 | 1,20 |
| $\delta_{N,F4,\infty}=\delta_{F4,100000}/2$ | [mm] | 0,60 | 0,65 | 0,55 | 0,65 | 0,60 |

**Table No 90: Displacements under tension service loads in cracked concrete**

| Size | Unit | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|
| $h_{ef}$ | [mm] | 42 | 51 | 68 | 80 | 96 |
| $N_{Rk,p,A3}$ | [kN] | 11,63 | 14,18 | 24,71 | 28,75 | 58,85 |
| $\gamma_{inst,F9}$ | [-] | 1 | 1 | 1 | 1 | 1 |
| $\gamma_c$ | [-] | 1,5 | 1,5 | 1,5 | 1,5 | 1,5 |
| $\gamma_{Mc}=\gamma_{inst,F9} \times \gamma_c$ | [-] | 1,5 | 1,5 | 1,5 | 1,5 | 1,5 |
| $\gamma_F$ | [-] | 1,4 | 1,4 | 1,4 | 1,4 | 1,4 |
| $N_s=N_{Rk,p,A3} / \gamma_F \times \gamma_{Mc}$ | [kN] | 5,54 | 6,75 | 11,77 | 13,69 | 28,02 |
| $\delta_{N,0}$ | [mm] | 0,23 | 0,30 | 0,45 | 0,66 | 0,74 |
| $\delta_{F3,1000}$ | [mm] | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 |
| $\delta_{N,\infty} = \delta_{F3,1000}/1,5$ | [mm] | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 |

**Table No 91: Displacements under shear service loads in uncracked concrete**

| Size | UNit | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|
| $V_{Rk,s}$ | [kN] | 9,8 | 17,7 | 29,0 | 39,8 | 71,1 |
| $\gamma_C$ | [-] | 1,5 | 1,5 | 1,5 | 1,5 | 1,5 |
| $\gamma_F$ | [-] | 1,4 | 1,4 | 1,4 | 1,4 | 1,4 |
| $V_s$ | [kN] | 4,69 | 8,42 | 13,79 | 18,93 | 33,84 |
| $\delta_{V,0}$ | [mm] | 0,44 | 0,54 | 0,62 | 0,69 | 0,76 |
| $\delta_{V,\infty}=1,5 \times \delta_{V,0}$ | [mm] | 0,66 | 0,81 | 0,93 | 1,04 | 1,14 |

**Table No 92: Displacements under shear service loads in cracked concrete**

| Size | Unit | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|
| $V_{Rk,s}$ | [kN] | 9,8 | 17,7 | 29,0 | 39,8 | 71,1 |
| $\gamma_C$ | [-] | 1,5 | 1,5 | 1,5 | 1,5 | 1,5 |
| $\gamma_F$ | [-] | 1,4 | 1,4 | 1,4 | 1,4 | 1,4 |
| $V_s$ | [kN] | 4,69 | 8,42 | 13,79 | 18,93 | 33,84 |
| $\delta_{V,0}$ | [mm] | 0,44 | 0,54 | 0,62 | 0,69 | 0,76 |
| $\delta_{V,\infty}=1,5 \times \delta_{V,0}$ | [mm] | 0,66 | 0,81 | 0,93 | 1,04 | 1,14 |

## 4. Proposed ETA values

## EAD 330232-01-0601:2019 and EN 1992-4

**Table No 93: Characteristic values to tension loads of design method A according to EN 1992-4**

| **Characteristic values of resistance to tension loads according to design method A** | | | | **Performances** | | | | |
|---|---|---|---|---|---|---|---|---|
| **Anchor size** | | | | 6 | 8 | 10 | 12 | 16 |
| $h_{nom}$ | Nominal embedment depth: | | [mm] | 55 | 65 | 85 | 100 | 120 |
| **Tension loads: steel failure** | | | | | | | | |
| $N_{Rk,s}$ | Characteristic resistance: | | [kN] | 19.7 | 35,3 | 57,9 | 79,5 | 142,3 |
| $\gamma_{Ms}$ | Partial safety factor [1]: | | [-] | 1,5 | | | | |
| **Tension loads: pull-out failure in concrete** | | | | | | | | |
| $N_{Rk,p}$ | Characteristic resistance in C20/25 uncracked concrete: | | [kN] | -[1] | -[1] | -[1] | -[1] | -[1] |
| $N_{Rk,p}$ | Characteristic resistance in C20/25 cracked concrete: | | [kN] | 9 | -[1] | -[1] | -[1] | -[1] |
| $\Psi_c$ | Increasing factor for concrete | C30/37 | [--] | 1,07 | 1,08 | 1,06 | 1,07 | 1,05 |
| | | C40/45 | [--] | 1,13 | 1,14 | 1,10 | 1,12 | 1,08 |
| | | C50/60 | [--] | 1,17 | 1,19 | 1,14 | 1,15 | 1,11 |
| **Tension loads: concrete cone and splitting failure** | | | | | | | | |
| $h_{ef}$ | Effective anchorage depth: | | [mm] | 42 | 51 | 68 | 80 | 96 |
| $k_{ucr,N}$ | Factor for uncracked concrete: | | [-] | 11,0 | 11,0 | 11,0 | 11,0 | 11,0 |
| $k_{cr,N}$ | Factor for cracked concrete: | | [-] | 7,7 | 7,7 | 7,7 | 7,7 | 7,7 |
| $s_{cr,N}$ | **Concrete cone failure** | Spacing | [mm] | 3 x $h_{ef}$ | 3 x $h_{ef}$ | 3 x $h_{ef}$ | 3 x $h_{ef}$ | 3 x $h_{ef}$ |
| $c_{cr,N}$ | | edge distance | [mm] | 1,5 x $h_{ef}$ | 1,5 x $h_{ef}$ | 1,5 x $h_{ef}$ | 1,5 x $h_{ef}$ | 1,5 x $h_{ef}$ |
| $s_{cr,sp}$ | Spitting failure | Spacing | [mm] | 126 | 153 | 204 | 240 | 288 |
| $c_{cr,sp}$ | | edge distance | [mm] | 63 | 76,5 | 102 | 120 | 144 |
| $\gamma_{inst}$ | Robustness | | [-] | 1,2 | | | | |

[1] *Pull-out doesn't decide. Characteristic resistances based on the formula from EN 1992-4, section 7.2.1.4, formula 7.2*

**Table No 94: Characteristic values to shear loads of design method A according to EN 1992-4**

| **Characteristic values of resistance to tension loads according to design method A** | | | **Performances** | | | | |
|---|---|---|---|---|---|---|---|
| **Anchor size** | | | 6 | 8 | 10 | 12 | 16 |
| $h_{nom}$ | Nominal embedment depth: | [mm] | 55 | 65 | 85 | 100 | 120 |
| **Shear loads: steel failure without lever arm** | | | | | | | |
| $V_{Rk,s}$ | Characteristic resistance: | [kN] | 9,8 | 17,7 | 29,0 | 39,8 | 71,1 |
| $k_7$ | Ductility factor: | [--] | 1,0 | | | | |
| $\gamma_{Ms}$ | Partial safety factor [1]: | [--] | 1,25 | | | | |
| **Shear loads: steel failure with lever arm** | | | | | | | |
| $M^0_{Rk,s}$ | Characteristic bending moment: | [Nm] | 16,6 | 39,8 | 83,4 | 134,2 | 321,3 |
| $\gamma_{Ms}$ | Partial safety factor [1]: | [-] | 1,25 | | | | |
| **Shear loads: concrete pryout failure** | | | | | | | |
| $k_8$ | Pryout factor: | [mm] | 1 | 1 | 2 | 2 | 2 |
| $\gamma_{ins}$ | Installation safety factor: | [--] | 1,2 | | | | |
| **Shear loads: concrete edge failure** | | | | | | | |
| $l_f$ | Effective length of fastener under shear loads: | [mm] | 42 | 51 | 68 | 80 | 96 |
| $d_{nom}$ | Outside fastener diameter: | [mm] | 6 | 8 | 10 | 12 | 16 |
| $\gamma_{ins}$ | Installation safety factor: | [--] | 1,2 | | | | |