# TECHNICAL MANUAL

# ADJUSTA Joint Reinforcement

## Advanced Continuity Reinforcement System

Version PEIKKO GROUP 11/2019

# ADJUSTA Joint Reinforcement

## Advanced Continuity Reinforcement System

- Ensuring the continuity of reinforcement in connections between concrete components
- Simple formwork design and joint assembly
- Time-effective installation to formwork requires minimum labor for preparation and installation
- The pre-molded former board is customized to achieve all slab depths and concrete cover requirements
- Highly adaptable system with wide range of threaded bars from Ø12 to Ø32
- Former boards and connector plugs are made of durable HDPE and 100% recycled material and are reusable from floor to floor.

ADJUSTA Joint Reinforcement is a fast, simple and safe rebar-ferrule anchor connection system. The system provides continuity of reinforcement steel across concrete casting joint by overlapping threaded bars with the main reinforcement of the connected concrete element.

For easier installation, ferrule anchors secured by connector plugs against concrete infill are assembled to former board. The complete assembly of former board and ferrule anchors can be attached to a formwork or installed to a reinforcement of a concrete structure. It is not necessary to penetrate or further modify the formwork. Once the concrete has hardened, former boards and connector plugs are removed with special Peikko tools. Threaded bars are screwed into ferrule anchors and should overlap with the main reinforcement of the joined concrete element. The former board and connector plugs are made of recycled material and can be reused several times thanks to the durability of the material.

ADJUSTA Joint Reinforcement is available for different bar diameters (Ø12, Ø16, Ø20, Ø25 and Ø32) of 500 MPa yield strength with different former board widths. The wide spectrum of dimensions makes this system highly adaptable.

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# About ADJUSTA Joint Reinforcement

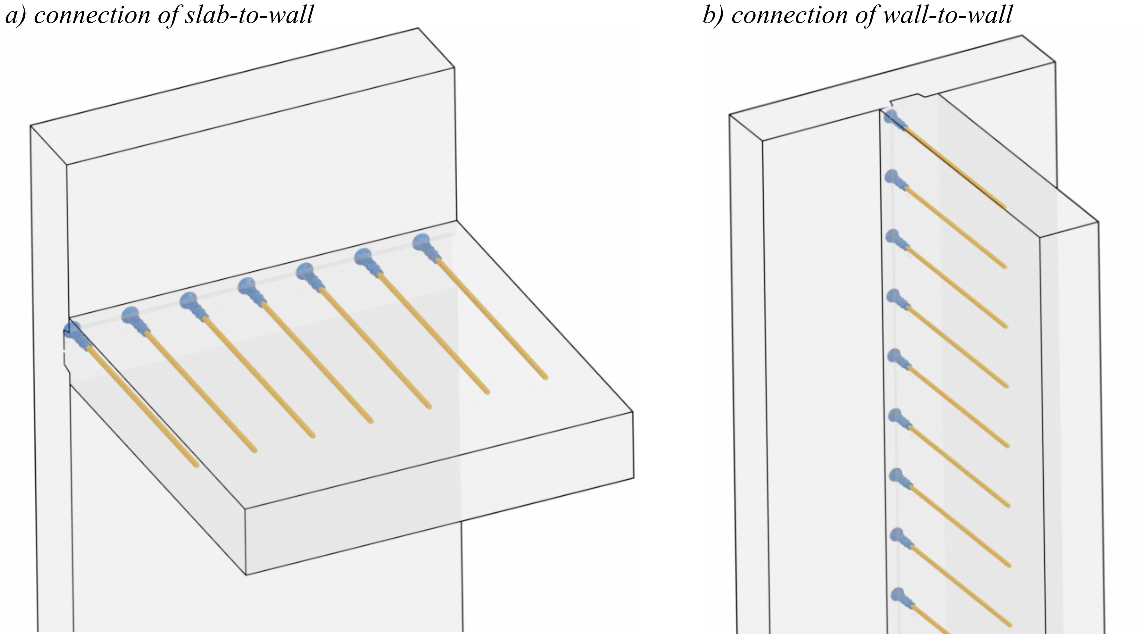
## 1. Product properties

ADJUSTA Joint Reinforcement is a connector system for reinforcement bars in concrete construction joints cast at different times. The system is designed for connecting interfacing monolithic concrete elements that have been split during the casting process:

- Slab-to-core connection
- Wall-to-wall connection
- Stair landing connection
- Penetration: Tower crane / concrete pump
- Precast element concrete connection

*Figure 1. Shape of product installed in concrete.*

*a) connection of slab-to-wall* *b) connection of wall-to-wall*

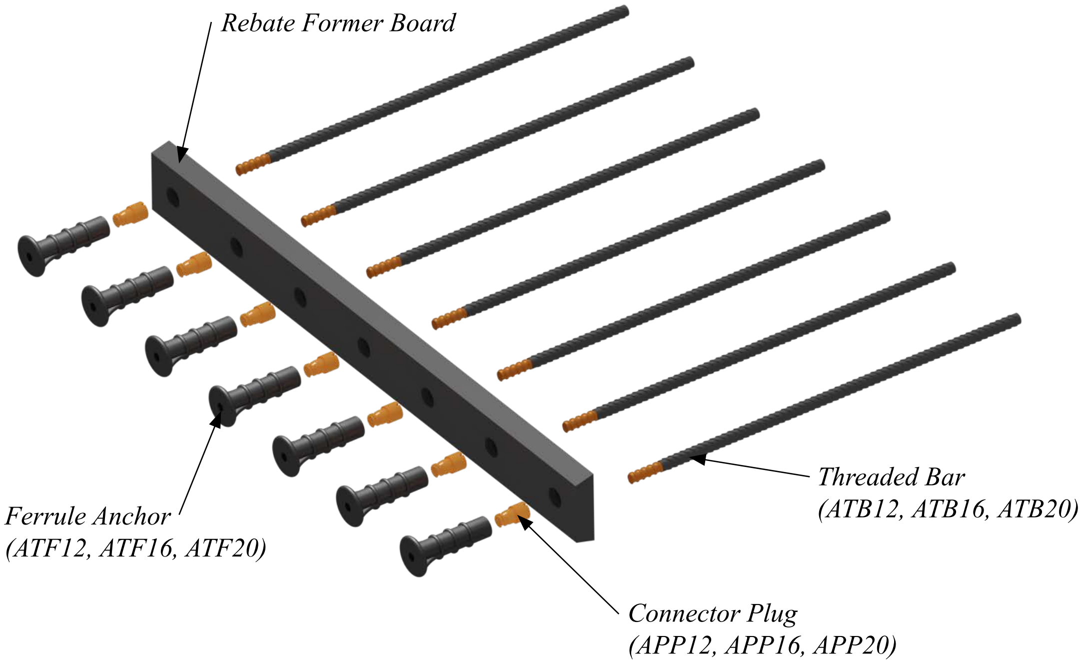


ADJUSTA Joint Reinforcement system consists of headed Ferrule Anchors and Threaded Bars in available diameters of 12, 16, 20, 25 and 32 mm. These components are combined with Rebate Former Board + Connector Plug or with Nailing Plate. Practical installation tools (see in Annex B - Accessories) are provided for assembling and disassembling.

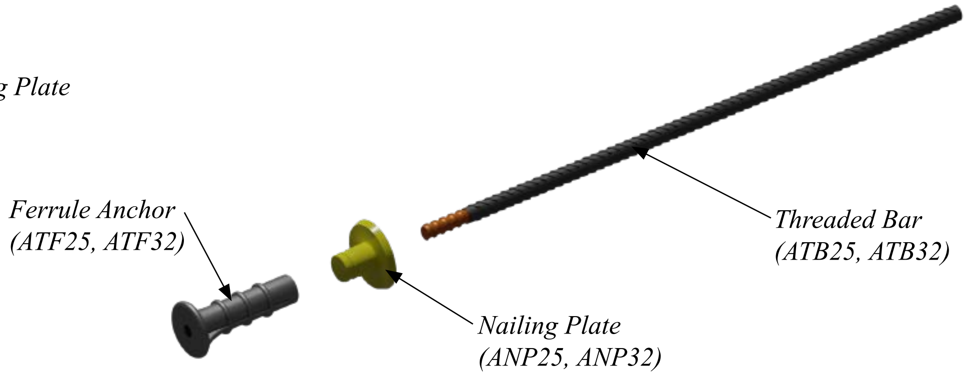
Ferrule Anchors (ATF) for Threaded Bars (ATB) of diameters 12 mm, 16 mm and 20 mm are combined in the installation process with Rebate Former Board with thickness of 30 mm (see *Figure 2a*). Ferrule Anchors for Threaded Bar diameters 25 mm and 32 mm use Nailing Plates instead of Rebate Former Board in the installation process, (see *Figure 2b*). ADJUSTA Joint Reinforcement secures the transfer of shear loads in the joint by using a shear key. The shear key is created by the Rebate Former Board in the installation process with models ATF12, ATF16 and ATF20. In case of models ATF25 and ATF32, Nailing Plates do not create the shear key. If shear connection is needed for models ATF25 and ATF32, it is necessary to create the shear key case-by-case with minimum thickness adequate to Rebate Former Board in the installation process.

*Figure 2. ADJUSTA Joint Reinforcement units.*

*a) using Rebate Former Board*




*b) using Nailing Plate*

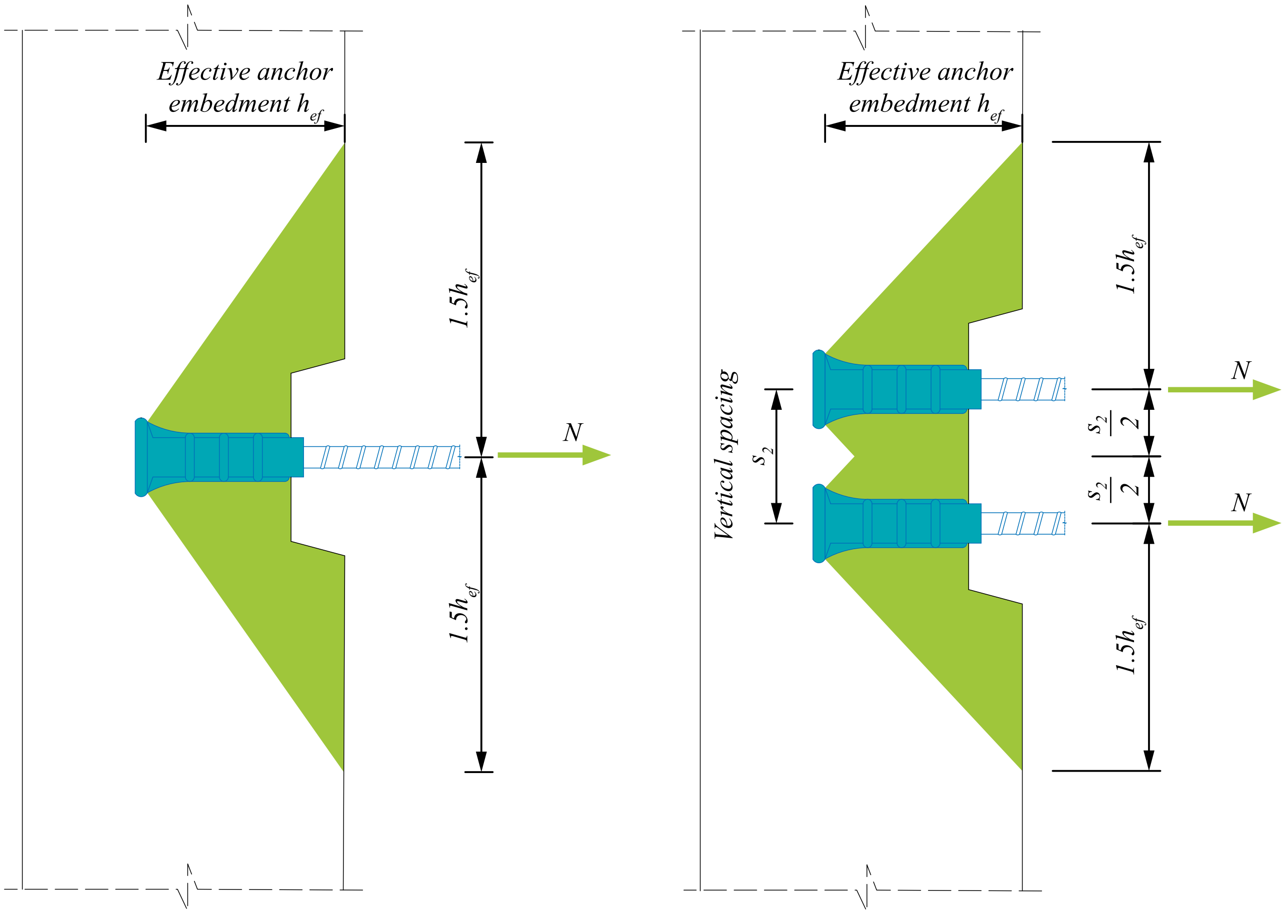



## 1.1 Structural behavior

Threaded Bars anchored by Ferrule Anchors in concrete act as steel ties crossing the concrete joint and are loaded by tensile forces. The load-bearing capacity of the tie is limited either by the tensile strength of the rebar with nominal diameter of the rebar (thread on the rebar has bigger resistance than the rebar itself) or the anchorage capacity (concrete breakout failure). In case of closely spaced Ferrule Anchors (spacing smaller than three times embedment depth), it is necessary to consider the overlapping of adjacent concrete cones.

*Figure 3. Acting the tensile force in Ferrule Anchors.*

*a) Full concrete cone breakout* *b) Modified concrete cone breakout*




## 1.1.1 Temporary conditions

The Rebate Former Board can be removed only after hardening the concrete element where it was installed. The Connector Plug or the Nailing Plate are to be removed directly before installing Threaded Bars. A Ferrule Anchor embedded in concrete without a Connector Plug and exposed to weather conditions for longer period can negatively influence the properties of the system.

## 1.1.2 Final conditions

The connection can be assumed as load-bearing after the Threaded Bars are properly tightened into Ferrule Anchors and both parts are embedded in adequately hardened concrete elements before applying any load to the structure.

## 1.2 Limitations for application

ADJUSTA Joint Reinforcement is designed to be used under the conditions stated in this chapter. If these conditions are not met, please contact Peikko Technical Support. ADJUSTA Joint Reinforcement is not determined for load applications that are predominantly high cycle fatigue or impact loads.

### 1.2.1 Loading and environmental conditions

ADJUSTA Joint Reinforcement is primarily designed to transfer static loads. Resistances of ADJUSTA Joint Reinforcement are determined in accordance with ACI 318-19, EN 1992-4:2018 and EN 1992-1-1:2004.
ADJUSTA Joint Reinforcement is designed to be installed indoors and in dry conditions. When using in other conditions, the surface treatment, concrete cover, and raw materials must be suitable for the environmental exposure class and intended operating life.

### 1.2.2 Positioning of ADJUSTA

ADJUSTA Joint Reinforcement is designed to be used in reinforced concrete connections with concrete strength 25 MPa or higher. Using a lower strength of concrete is possible but the resistance of the connection needs to be recalculated according to valid standards. The precise position of ADJUSTA is indicated in the design drawings created by the designer of the project. ADJUSTA Joint Reinforcement must be fixed to the formwork or attached to the reinforcement mesh of the concrete element to secure the correct position during casting of concrete. The system can be fixed to formworks by nailing or secured with tie wire to the reinforcement. The minimum concrete cover is secured during installation of ADJUSTA Joint Reinforcement. The examples of connection and its behavior are shown in *Annex A - Recommended connection design and resistances*.

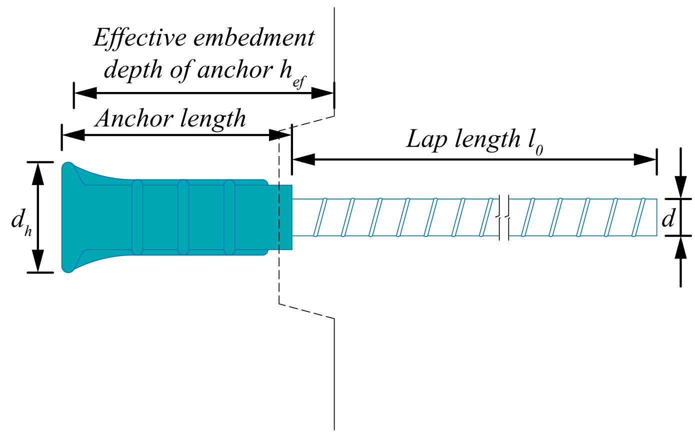
## 1.3 Other properties

**Rebate Former Board** High density polyethylene
**Ferrule Anchor** Graphite cast iron with tensile strength of 600 MPa
**Threaded Bar** Reinforcing steel with characteristic yield strength of $f_y$ = 500 MPa (500N)

Threaded Bar from reinforcing bar 500N, compliant to the AS/NZS 4671.2001 standard, has been determined with independent NATA Lab mechanical testing in accordance with AS1391:2020. All bars have an epoxy painted color cursor that guarantees full embedment depth of Threaded Bar and easy on-site inspection.

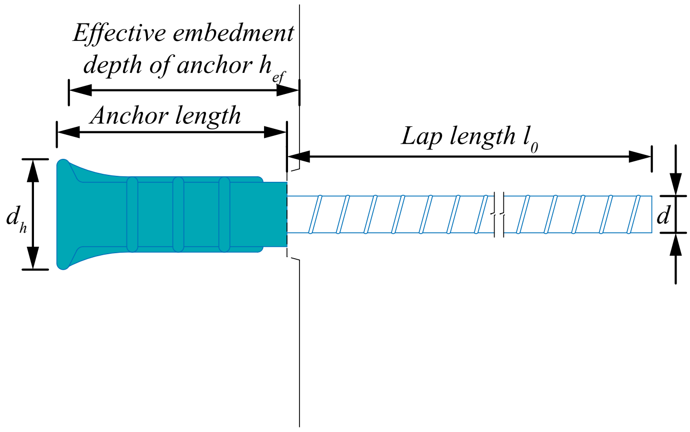
**Connector Plug** Recycled polyurethane

*Table 1. Dimensions of Ferrule Anchor and Threaded Bar using Rebate Former Board.*




| Ferrule Anchor | Threaded Bar | Diameter of head of anchor $d_h$ [mm] | Anchor length [mm] | Effective embedment depth of anchor $h_{ef}$ [mm] | Standard lap length of Threaded Bar $l_0$ [mm] |
|---|---|---|---|---|---|
| **ATF12** | ATB12 | 45 | 94 | 111 | 500 |
| **ATF16** | ATB16 | 60 | 125 | 141 | 600 |
| **ATF20** | ATB20 | 60 | 125 | 141 | 800 |

*Table 2. Dimensions of Ferrule Anchor and Threaded Bar using Nailing Plate.*




| Ferrule Anchor | Threaded Bar | Diameter of head of anchor $d_h$ [mm] | Anchor length [mm] | Effective embedment depth of anchor $h_{ef}$ [mm] | Standard lap length of Threaded Bar $l_0$ [mm] |
|---|---|---|---|---|---|
| **ATF25** | ATB25 | 75 | 156 | 155 | 950 |
| **ATF32** | ATB32 | 96 | 200 | 196 | 1400 |

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The products bear the inspection mark, the emblem of Peikko Group, the type of product, and the year and week of manufacturing.

# 2. Resistances

The resistances of Ferrule Anchor are defined according to spacing between adjacent anchors in the connection. All calculation methods are determined in accordance with the following standards:

- AS 3600- 2009
- ACI 318- 19
- EN 1992-4: 2018
- EN 1992-1-1: 2004

## 2.1 Tensile capacity of a single anchor

*Figure 4. The full projected area $A_{Nc0}$ of a single anchor not influenced by adjacent anchors or by close edges.*

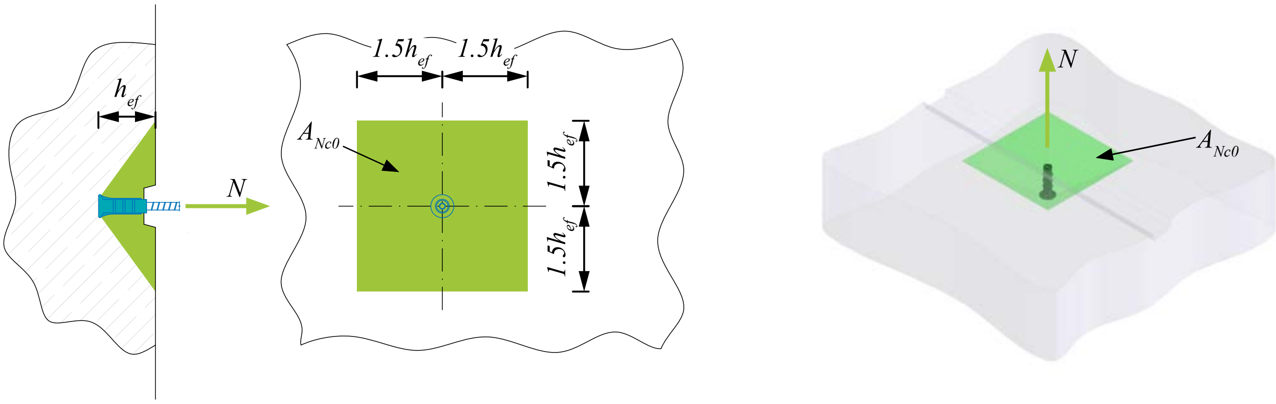



*Table 3. Nominal concrete breakout strength of a single anchor not influenced by adjacent anchors or close edges.*

| Ferrule Anchor | Threaded Bar | Design standard | Effective anchor embedment $h_{ef}$ [mm] | Nominal concrete breakout strength per anchor $N_{cb0}$ (ACI) $N^{0}_{Rk,c}$ (EN) [kN/ anchor] | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Concrete strength 25 MPa | Concrete strength 30 MPa | Concrete strength 32 MPa | Concrete strength 40 MPa | Concrete strength 50 MPa | Concrete strength 65 MPa |
| **ATF12** | ATB12 | ACI 318-19 | 111 | 73.09 | 80.07 | 82.69 | 92.45 | 103.37 | 117.86 |
| | | EN 1992-4 | | 74.26 | 81.35 | 84.02 | 93.93 | 105.02 | 119.74 |
| **ATF16** | ATB16 | ACI 318-19 | 141 | 104.64 | 114.63 | 118.39 | 132.36 | 147.99 | 168.73 |
| | | EN 1992-4 | | 106.32 | 116.46 | 120.28 | 134.48 | 150.35 | 171.43 |
| **ATF20** | ATB20 | ACI 318-19 | 141 | 104.64 | 114.63 | 118.39 | 132.36 | 147.99 | 168.73 |
| | | EN 1992-4 | | 106.32 | 116.46 | 120.28 | 134.48 | 150.35 | 171.43 |
| **ATF25** | ATB25 | ACI 318-19 | 155 | 120.61 | 132.12 | 136.45 | 152.56 | 170.57 | 194.48 |
| | | EN 1992-4 | | 122.54 | 134.23 | 138.64 | 155.00 | 173.30 | 197.59 |
| **ATF32** | ATB32 | ACI 318-19 | 196 | 171.50 | 187.87 | 194.03 | 216.93 | 242.54 | 276.54 |
| | | EN 1992-4 | | 174.24 | 190.87 | 197.13 | 220.40 | 246.42 | 280.96 |

**NOTE:**
Please note that all resistances are determined with the assumption that the minimum distance from concrete edges is $1.5h_{ef}$.

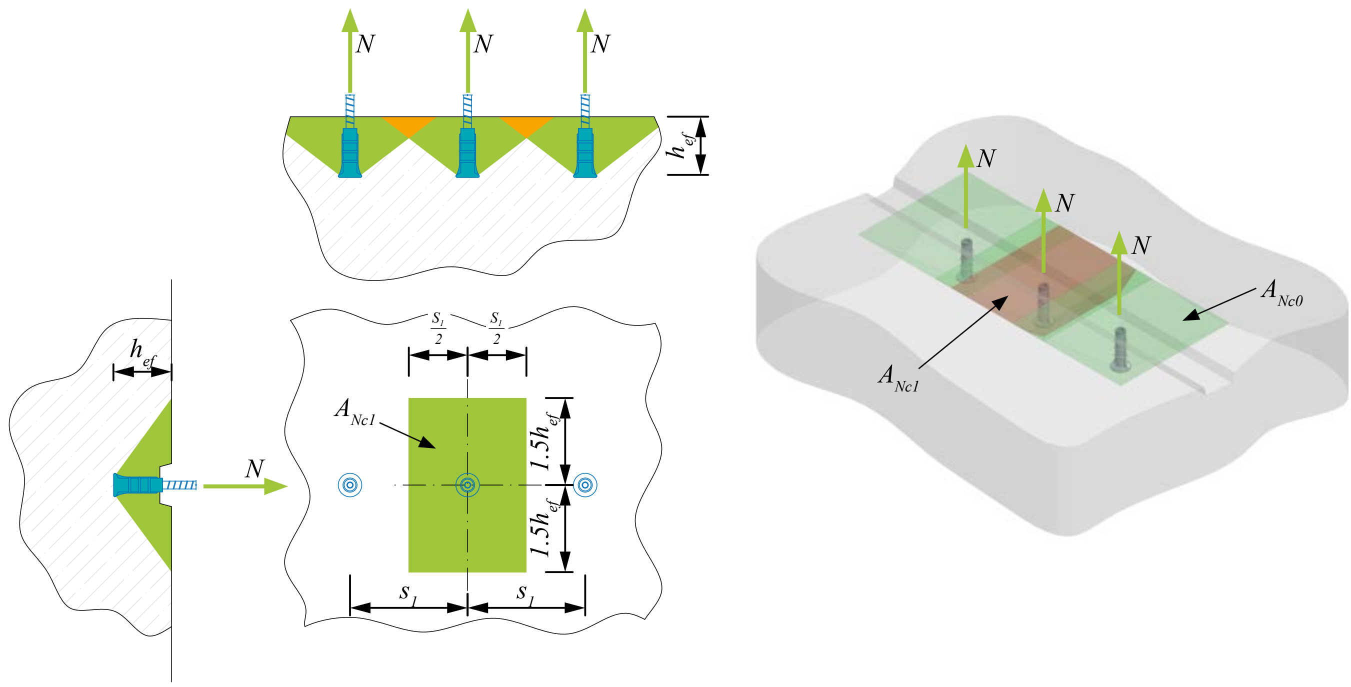
### Boundary conditions for determining characteristic values in *Table 3*

The characteristic concrete breakout strength in tension of a single anchor not influenced by any adjacent anchors or close edges of the concrete member are calculated in accordance with ACI 318-19, Section 17.6.2.2 and EN 1992-4: 2018, Section 7.2.14. The modification factors which influence the nominal concrete breakout strength are determined based on the expectation of cast-in anchors located in a region of a reinforced concrete member where analysis has indicated no cracking at service load levels.

## 2.2 Tensile capacity of a group of anchors in one row

The projected area ($A_{Nc1}$) of concrete breakout failure is influenced by adjacent anchors which affect the projected area of a single anchor ($A_{Nc0}$). Axial distance $s_1$ is less than $3h_{ef}$. Spacing in a row is standardized to 150 mm, 200 mm, 250 mm and 300 mm. The nominal concrete breakout strength per anchor is reduced by ratio of the areas $A_{Nc1} / A_{Nc0}$.

*Figure 5. The total projected area $A_{Nc1}$ of anchor groups with overlapping projected area.*




### 2.2.1 According to ACI 318-19, Section 17.6.2.1

$$\text{Design tensile load in one anchor} \leq min.\begin{cases} \phi \cdot N_{cb} \\ \phi \cdot A_s \cdot f_y \end{cases} \quad (1)$$

Where:

$\phi$ = Strength reduction factor for design values [-]

$$N_{cb} = \frac{A_{Nc1}}{A_{Nc0}} N_{cb0} \; [kN] \quad (2)$$

Where:

$N_{cb0}$ = The nominal concrete breakout strength in tension of a single anchor [kN]

**NOTE:**
*Table 4* shows the nominal steel strength of an anchor in tension and the nominal concrete breakout strength per anchor. For allowable design loads, reduction factor $\phi$ needs to be applied in accordance with 318-19, Section 17.5.3.

*Table 4. Nominal tensile capacity for a group of anchors in one row according to ACI 318-19.*

| Ferrule Anchor | Threaded Bar | Anchor spacing $s_1$ [mm] | Effective anchor embedment $h_{ef}$ [mm] | Nominal steel strength of anchor in tension $A_s \cdot f_y$ [kN] | Minimum ultimate strength of the bar $A_s \cdot f_u$ [kN] | Reduction factor of the projected area $\frac{A_{Nc1}}{A_{Nc0}}$ [-] | Nominal concrete breakout strength per anchor $N_{cb}$ [kN/ anchor] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Concrete strength 25 MPa | Concrete strength 30 MPa | Concrete strength 32 MPa | Concrete strength 40 MPa | Concrete strength 50 MPa | Concrete strength 65 MPa |
| **ATF12** | ATB12 | 300 | 111 | 56.55 | 61.07 | 0.90 | 65.85 | 72.13 | 74.50 | 83.29 | 93.12 | 106.18 |
| | | 250 | | | | 0.75 | 54.87 | 60.11 | 62.08 | 69.41 | 77.60 | 88.48 |
| | | 200 | | | | 0.60 | 43.90 | 48.09 | 49.67 | 55.53 | 62.08 | 70.78 |
| | | 150 | | | | 0.45 | 32.92 | 36.07 | 37.25 | 41.65 | 46.56 | 53.09 |
| **ATF16** | ATB16 | 300 | 141 | 100.53 | 108.57 | 0.71 | 74.21 | 81.30 | 83.96 | 93.87 | 104.96 | 119.67 |
| | | 250 | | | | 0.59 | 61.85 | 67.75 | 69.97 | 78.23 | 87.46 | 99.72 |
| | | 200 | | | | 0.47 | 49.48 | 54.20 | 55.98 | 62.58 | 69.97 | 79.78 |
| | | 150 | | | | 0.35 | 37.11 | 40.65 | 41.98 | 46.94 | 52.48 | 59.83 |
| **ATF20** | ATB20 | 300 | 141 | 157.08 | 169.65 | 0.71 | 74.21 | 81.30 | 83.96 | 93.87 | 104.96 | 119.67 |
| | | 250 | | | | 0.59 | 61.85 | 67.75 | 69.97 | 78.23 | 87.46 | 99.72 |
| | | 200 | | | | 0.47 | 49.48 | 54.20 | 55.98 | 62.58 | 69.97 | 79.78 |
| | | 150 | | | | 0.35 | 37.11 | 40.65 | 41.98 | 46.94 | 52.48 | 59.83 |
| **ATF25** | ATB25 | 300 | 155 | 245.44 | 265.07 | 0.65 | 77.81 | 85.24 | 88.03 | 98.43 | 110.04 | 125.47 |
| | | 250 | | | | 0.54 | 64.84 | 71.03 | 73.36 | 82.02 | 91.70 | 104.56 |
| | | 200 | | | | 0.43 | 51.87 | 56.83 | 58.69 | 65.62 | 73.36 | 83.65 |
| **ATF32** | ATB32 | 300 | 196 | 402.12 | 434.29 | 0.51 | 87.50 | 95.85 | 98.99 | 110.68 | 123.74 | 141.09 |
| | | 250 | | | | 0.43 | 72.92 | 79.88 | 82.50 | 92.23 | 103.12 | 117.57 |
| | | 200 | | | | 0.34 | 58.33 | 63.90 | 66.00 | 73.79 | 82.50 | 94.06 |

**NOTE:**
Please note that the values of the nominal concrete breakout strength in *Table 4* are already reduced by reduction factor of the projected area $A_{Nc1} / A_{Nc0}$.

## 2.2.2 According to EN 1992-4:2018, Section 7.2.1.4

The design resistance of an anchor influenced by other anchors in one row is the minimum value of concrete breakout strength reduced by ratio of influenced and uninfluenced projected areas $A_{Nc1} / A_{Nc0}$ and the maximum tensile steel failure of anchor.

$$N_{Rd} = min.\begin{cases} N_{Rd,c} \\ N_{Rd,s} \end{cases} \quad (3)$$

$$N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}} \; [kN] \quad (4)$$

Where:

$\gamma_{Mc}$ = Partial factor for concrete breakout failure according to EN 1992-4:2018, *Table 4*.1 [-]
1.5

$$N_{Rk,c} = N^{0}_{Rk,c} \frac{A_{Nc1}}{A_{Nc0}} \psi_{s,N} \; \psi_{re,N} \; \psi_{ec,N} \; \psi_{M,N} \; [kN] \quad (5)$$

$N^{0}_{Rk,c}$ = The characteristic resistance of a single fastener placed in concrete and not influenced by adjacent fasteners or edges of the concrete member [kN]
(*Table 2*)

The modification factors $\psi_{s,N}, \psi_{re,N}, \psi_{ec,N}, \psi_{M,N}$ consider the distribution of stresses in the concrete to the proximity of edges of concrete member, eccentricity load or a different tension load acting according to EN 1992-4:2018, Section 7.2.1.4.

$$N_{Rd,s} = \frac{f_{uk} \cdot A_s}{\gamma_{Ms}} \; [kN] \quad (6)$$

Where:

$f_{uk}$ = The nominal characteristic steel ultimate tensile strength [N/mm2]
$A_s$ = Cross sectional area of anchor [mm2]
$\gamma_{Ms}$ = Partial factor for steel failure according to EN 1992-4:2018, *Table 4*.1 [-]

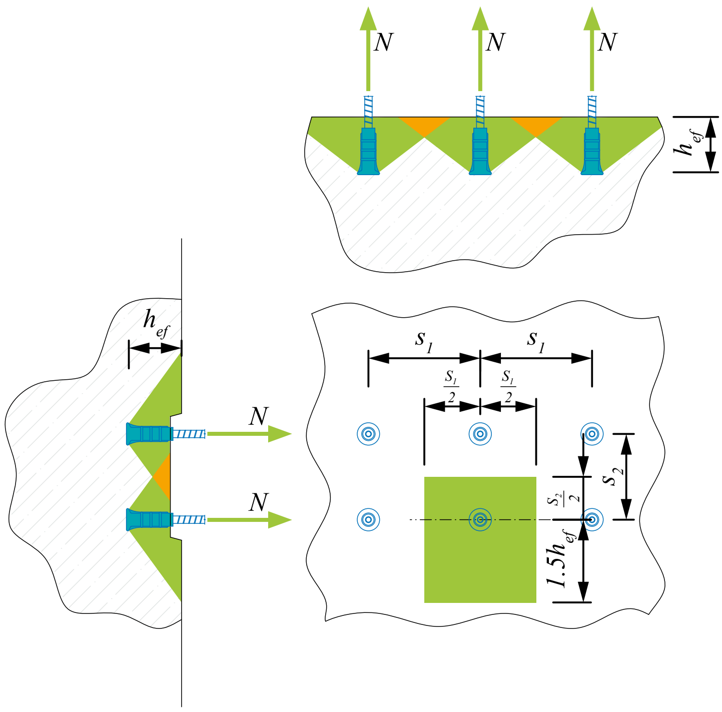
*Table 5. Design tensile capacity for group of anchors in one row according to EN 1992-4: 2018.*

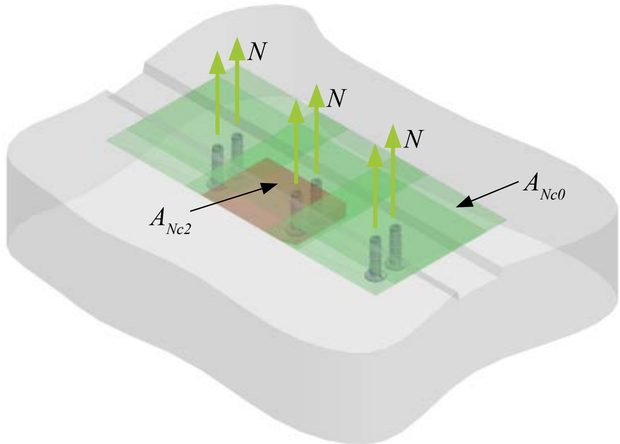
| Ferrule Anchor | Threaded Bar | Anchor spacing $s_1$ [mm] | Effective anchor embedment $h_{ef}$ [mm] | Reduction factor of the projected area $\frac{A_{Nc1}}{A_{Nc0}}$ [-] | Design tensile capacity per anchor $N_{Rd}$ [kN/ anchor] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concrete strength C25/30 | Concrete strength C30/37 | Concrete strength C32/40 | Concrete strength C40/50 | Concrete strength C50/60 | Concrete strength C65/80 |
| **ATF12** | ATB12 | 300 | 111 | 0.90 | 43.62 | 43.62 | 43.62 | 43.62 | 43.62 | 43.62 |
| | | 250 | | 0.75 | 37.17 | 40.71 | 42.05 | 43.62 | 43.62 | 43.62 |
| | | 200 | | 0.60 | 29.73 | 32.57 | 33.64 | 37.61 | 42.05 | 43.62 |
| | | 150 | | 0.45 | 22.30 | 24.43 | 25.23 | 28.21 | 31.54 | 35.96 |
| **ATF16** | ATB16 | 300 | 141 | 0.71 | 50.27 | 55.07 | 56.87 | 63.58 | 71.09 | 77.55 |
| | | 250 | | 0.59 | 41.89 | 45.89 | 47.39 | 52.99 | 59.24 | 67.55 |
| | | 200 | | 0.47 | 33.51 | 36.71 | 37.91 | 42.39 | 47.39 | 54.04 |
| | | 150 | | 0.35 | 25.13 | 27.53 | 28.44 | 31.79 | 35.54 | 40.53 |
| **ATF20** | ATB20 | 300 | 141 | 0.71 | 50.27 | 55.07 | 56.87 | 63.58 | 71.09 | 81.05 |
| | | 250 | | 0.59 | 41.89 | 45.89 | 47.39 | 52.99 | 59.24 | 67.55 |
| | | 200 | | 0.47 | 33.51 | 36.71 | 37.91 | 42.39 | 47.39 | 54.04 |
| | | 150 | | 0.35 | 25.13 | 27.53 | 28.44 | 31.79 | 35.54 | 40.53 |
| **ATF25** | ATB25 | 300 | 155 | 0.65 | 52.70 | 57.73 | 59.63 | 66.67 | 74.54 | 84.98 |
| | | 250 | | 0.54 | 43.92 | 48.11 | 49.69 | 55.56 | 62.11 | 70.82 |
| | | 200 | | 0.43 | 35.14 | 38.49 | 39.75 | 44.44 | 49.69 | 56.66 |
| **ATF32** | ATB32 | 300 | 196 | 0.51 | 59.27 | 64.92 | 67.05 | 74.97 | 83.82 | 95.56 |
| | | 250 | | 0.43 | 49.39 | 54.10 | 55.88 | 62.47 | 69.85 | 79.64 |
| | | 200 | | 0.34 | 39.51 | 43.28 | 44.70 | 49.98 | 55.88 | 63.71 |

**NOTE:**
Please note that *Table 5* already presents the design values of tensile capacity.

## 2.3 Tensile capacity of a group of anchors in two rows

The projected area ($A_{Nc2}$) of the concrete breakout failure of anchors in two rows is determined by the projected area of a single anchor ($A_{Nc0}$) affected by adjacent anchors. The spacing between anchors ($s_1$) or between rows ($s_2$) is less than $3h_{ef}$. The spacing in a row ($s_1$) is standardized to 150 mm, 200 mm, 250 mm and 300 mm. Spacing $s_2$ is standardized to 75 mm but can be customized. The ultimate tensile strength is reduced by ratio of the areas $A_{Nc2}$ and $A_{Nc0}$. The reduction factors of the projected areas $A_{Nc2} / A_{Nc0}$ are presented in the graphs in Section 2.3.3 (Graph 1 - Graph 4).



## 2.3.1 According to ACI 318-19

The values of nominal concrete breakout strength of anchor $N_{cb0}$ in *Table 6* need to be reduced by reduction factor of the projected area $A_{Nc2} / A_{Nc0}$ taken from the graphs (see Graph 1 - Graph 4 acc. model) based on spacing between anchors.

*Table 6. Nominal tensile capacity of a single anchor not influenced by adjacent anchors or close edges according to ACI 318-19.*

| Ferrule Anchor | Threaded Bar | Effective anchor embedment $h_{ef}$ [mm] | Nominal steel strength of anchor in tension $A_s \cdot f_y$ [kN] | Minimum ultimate strength of the bar $A_s \cdot f_u$ [kN] | Nominal concrete breakout strength per anchor $N_{cb0}$ [kN/ anchor] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concrete strength 25 MPa | Concrete strength 30 MPa | Concrete strength 32 MPa | Concrete strength 40 MPa | Concrete strength 50 MPa | Concrete strength 65 MPa |
| **ATF12** | ATB12 | 111 | 56.55 | 61.07 | 73.09 | 80.07 | 82.69 | 92.45 | 103.37 | 117.86 |
| **ATF16** | ATB16 | 141 | 100.53 | 108.57 | 104.64 | 114.63 | 118.39 | 132.36 | 147.99 | 168.73 |
| **ATF20** | ATB20 | 141 | 157.08 | 169.65 | 104.64 | 114.63 | 118.39 | 132.36 | 147.99 | 168.73 |
| **ATF25** | ATB25 | 155 | 245.44 | 265.07 | 120.61 | 132.12 | 136.45 | 152.56 | 170.57 | 194.48 |
| **ATF32** | ATB32 | 196 | 402.12 | 434.29 | 171.50 | 187.87 | 194.03 | 216.93 | 242.54 | 276.54 |

**NOTE:**
*Table 6* shows the nominal steel strength of anchor and the nominal concrete breakout strength per anchor. For Ultimate Limit State design, reduction factor $\phi$ needs to be applied in accordance with ACI 318-19, Section 17.5.3.

**NOTE:**
The nominal tensile capacity of the anchor is also limited by steel strength of the anchor in tension according to ACI 318-19:

$$minimum\ of \begin{cases} \dfrac{A_{Nc2}}{A_{nc0}} \cdot N_{cb0} \\ A_s \cdot f_y \end{cases} \tag{7}$$

For the values of $N_{cb0}$ and $A_s \cdot f_y$ please see *Table 6*.

## 2.3.2 According to EN 1992-4:2018

The values of design tensile strength of anchor $N_{Rd,c}$ in *Table 7* need to be reduced by reduction factor $A_{Nc2} / A_{Nc0}$ taken from the graphs (see Graph 4 acc. model) based on spacing between anchors.

*Table 7. Design tensile capacity of a single anchor not influenced by adjacent anchors or close edges.*

| Ferrule Anchor | Threaded Bar | Effective anchor embedment $h_{ef}$ [mm] | Maximum design steel strength of anchor in tension $N_{Rd,s}$ [kN] | Design tensile capacity in case of concrete cone failure per anchor $N_{Rd,c}$ [kN/ anchor] | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Concrete strength C25/30 | Concrete strength C30/37 | Concrete strength C32/40 | Concrete strength C40/50 | Concrete strength C50/60 | Concrete strength C65/80 |
| **ATF12** | ATB12 | 111 | 43.62 | 49.51 | 54.23 | 56.01 | 62.62 | 70.01 | 79.83 |
| **ATF16** | ATB16 | 141 | 77.55 | 70.88 | 77.64 | 80.19 | 89.65 | 100.24 | 114.29 |
| **ATF20** | ATB20 | 141 | 121.18 | 70.88 | 77.64 | 80.19 | 89.65 | 100.24 | 114.29 |
| **ATF25** | ATB25 | 155 | 189.34 | 81.69 | 89.49 | 92.42 | 103.33 | 115.53 | 131.72 |
| **ATF32** | ATB32 | 196 | 310.21 | 116.16 | 127.25 | 131.42 | 146.94 | 164.28 | 187.31 |

**NOTE:**
It is necessary to verify also steel strength failure of the anchor casted in concrete according to EN 1992-4: 2018, Section 7.2.1.3:

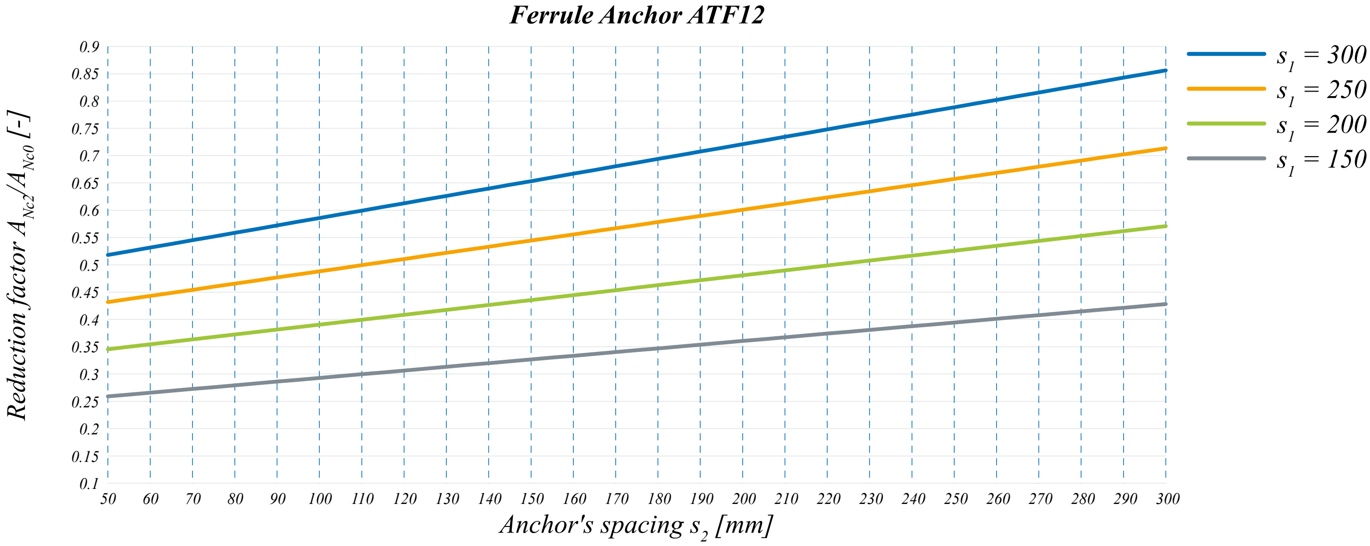
$$\text{minimum of} \begin{cases} \dfrac{A_{Nc2}}{A_{nc0}} \cdot N_{Rd,c} \\ N_{Rd,s} \end{cases} \quad (8)$$

For the values of $N_{Rd,c}$ and $N_{Rd,s}$ please see *Table 7*.

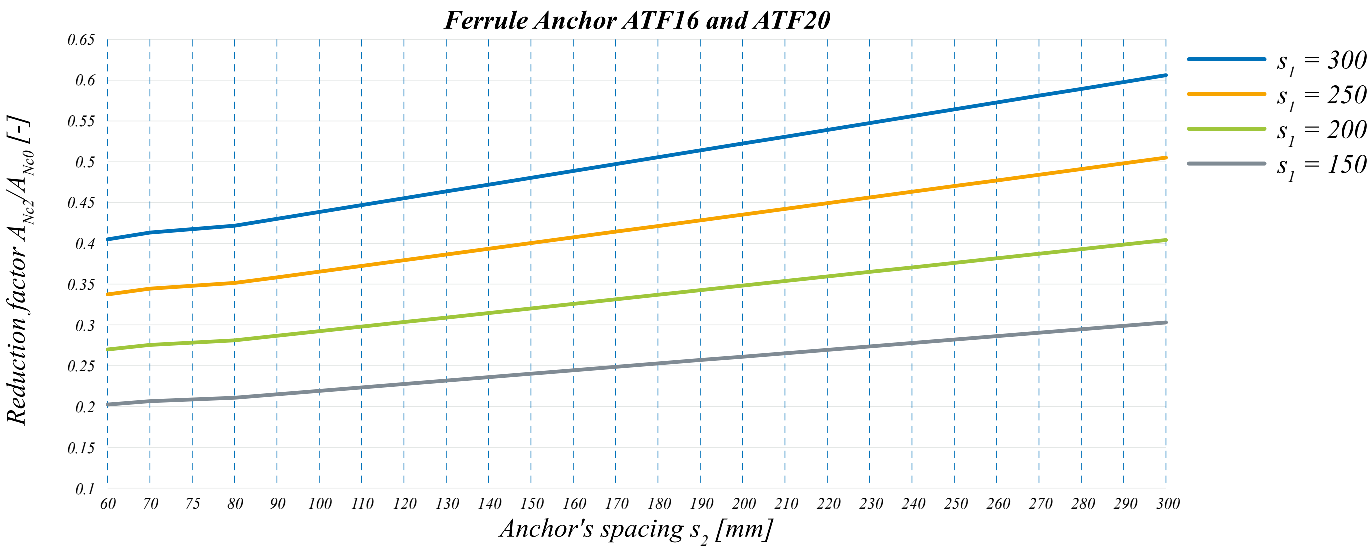
## 2.3.3 Reduction factors for the projected concrete failure area of group of anchors:

Reduction factor of the projected area $A_{Nc2} / A_{Nc0}$designates how the concrete cone of concrete breakout failure of one anchor is affected by other adjacent anchors. It is determined by spacing $s_1$ and $s_2$ between adjacent anchors. The graphs are determined for different ADJUSTA models.

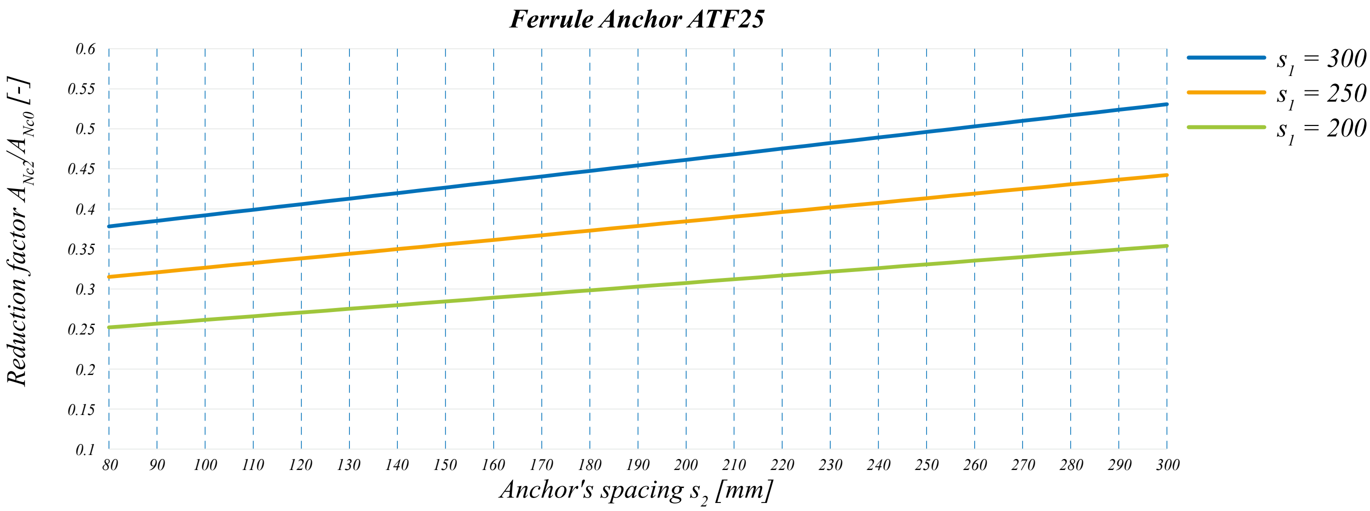
*Graph 1. Reduction factor $A_{Nc2} / A_{Nc0}$ for Ferrule Anchor ATF 12.*



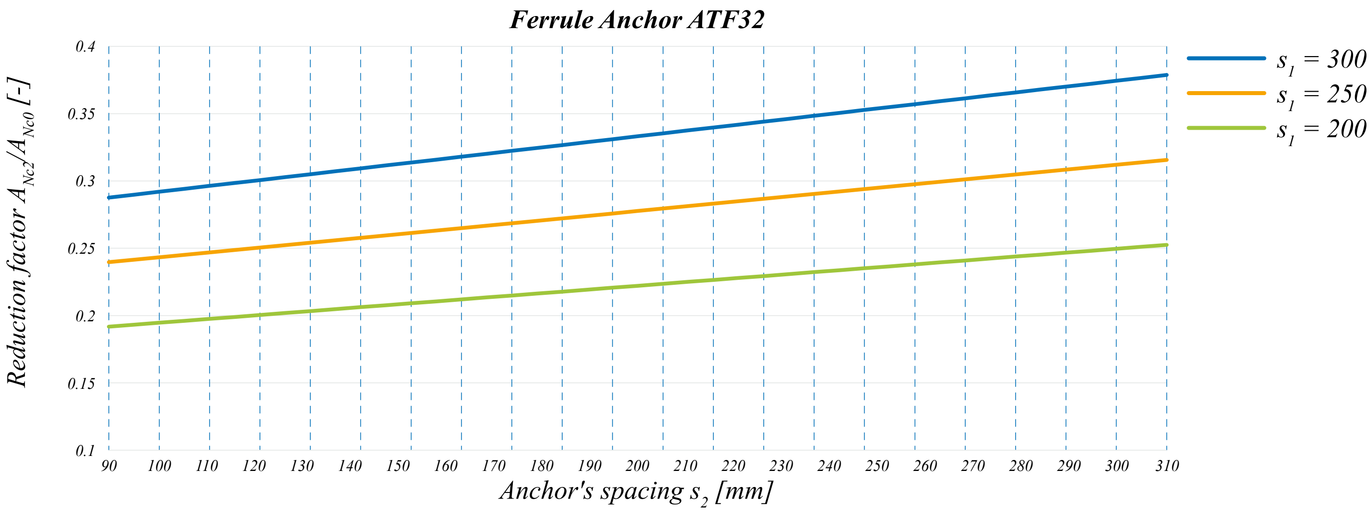

*Graph 2. Reduction factor $A_{Nc2} / A_{Nc0}$ for Ferrule Anchor ATF 16 and ATF 20.*



*Graph 3. Reduction factor $A_{Nc2} / A_{Nc0}$ for Ferrule Anchor ATF 25.*




*Graph 4. Reduction factor $A_{Nc2} / A_{Nc0}$ for Ferrule Anchor ATF 32.*




The projected areas of concrete breakout failure are possible to calculate if the effective embedment of anchor and spacing between them is known. The projected concrete failure area of a single anchor with an edge distance equal to or greater than $1.5h_{ef}$ is calculated as follows:

$$A_{Nc0} = 9h_{ef}^2 \ [kN] \tag{9}$$

The projected concrete failure area of a single anchor that is approximated as the base of the rectilinear geometrical figure that results from projecting the failure surface outward $1.5h_{ef}$ from the centerlines of the anchor, or in the case of a group of anchors, from a line through a row of adjacent anchors can be determined as follows:

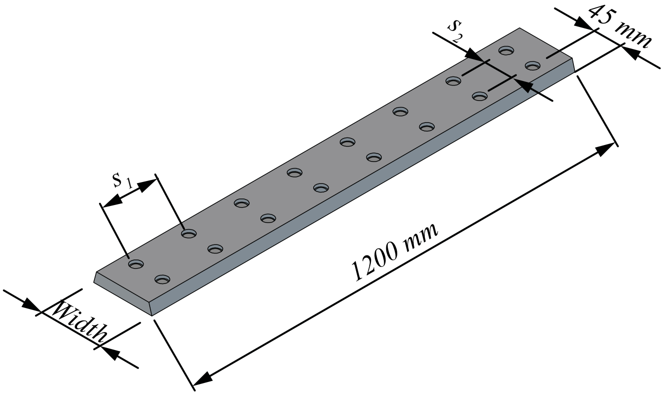
$$A_{Nc2} = s_1 \cdot \left(1.5h_{ef} + \frac{s_2}{2}\right) \ [kN] \tag{10}$$

## 2.4 Fire resistance

The concrete cover of Threaded Bars must be at least equivalent to the concrete cover of the reinforcement of the concrete element. If the fire resistance of the connection is judged to be insufficient, the concrete cover of Threaded Bars must be increased.

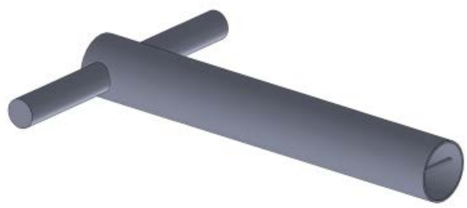
# 3. Selecting ADJUSTA

A summary of ADJUSTA Joint Reinforcement parts specified in order is presented in the following table.

| Rebate Former Board | Dimensions |
|---|---|
|  | Width: 110 (single row),<br>165 (single and double row),<br>Width can be customized<br><br>Spacing $s_1$: 150, 200, 250, 300 mm (standardized)<br><br>Spacing $s_2$ is standardized to 75 mm (can be customized)<br><br>Position of holes:<br>a) Central – C<br>b) Top and Bottom – T+B<br><br>**Length × Width – spacing $s_1$ + position of holes**<br>**Example:** Rebate Former Board 1200×165–200T+B |

| Ferrule Anchor | Model | Threaded Bar | Model |
|---|---|---|---|
|  | ATF12 |  | ATB12 |
| | ATF16 | | ATB16 |
| | ATF20 | | ATB20 |
| | ATF25 | | ATB25 |
| | ATF32 | | ATB32 |

| Connector Plug | Model | Nailing Plate | Model |
|---|---|---|---|
|  | APP12 |  | ANP25 |
| | APP16 | | ANP32 |
| | APP20 | | |

| Removing Tools | |
|---|---|
| Board Release Key | Plug Release Key |
|  |  |

Please fill in *Table 8* with your specified parts. Consider the pieces of reusable parts. An example for selecting is shown in Sections 3.1 and 3.2.

*Table 8. ADJUSTA Order Form.*

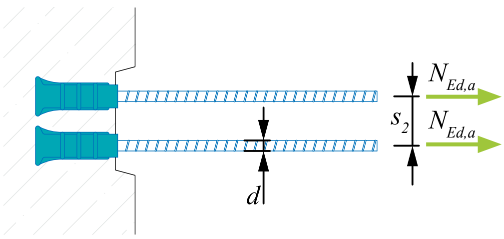
| Model/Dimension | Quantity [pcs] | Description |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

Examples of the procedure used for the design and selection of ADJUSTA in the connection of slab-to-wall in accordance with ACI 318-19.

## 3.1 Example 1

**Input data:**

| | |
|---|---|
| Concrete strength | 32 MPa |
| Height of slab | $h$ = 230 mm |
| Bar diameter | $d$ = 16 mm |
| Spacing between anchors in one row | $s_1$ = 200 mm |
| Spacing between rows of anchors | $s_2$ = 75 mm |
| Number of anchors in a meter | $n$ = 10 pcs |
| Tension load in the connection of slab-to-wall | $N_{Ed,a}$ = 22.8 kN/anchor |




**Designed tensile capacity of an anchor influenced by other anchors:**

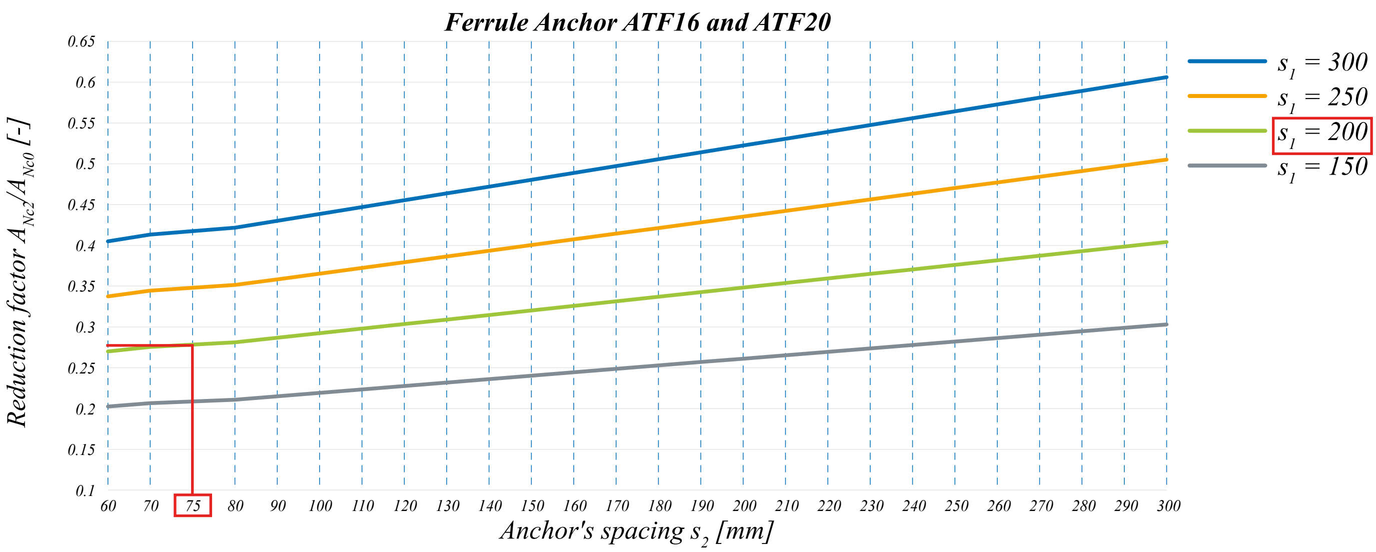
$$\phi N_{cb} = \phi \cdot \frac{A_{Nc2}}{A_{Nc0}} \cdot N_{cb0}$$

$N_{cb0} = 118.9\ kN/anchor$ ⇨ Ultimate tensile strength per anchor not influenced by other anchors or edges according to *Table 3*.

| Ferrule Anchor | Threaded Bar | Effective anchor embedment $h_{ef}$ [mm] | Nominal steel strength of anchor in tension $A_s \cdot f_y$ [kN] | Minimum ultimate strength of the bar $A_s \cdot f_u$ [kN] | Nominal concrete breakout strength per anchor $N_{cb0}$ [kN/anchor] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concrete strength 25 MPa | Concrete strength 30 MPa | Concrete strength 32 MPa | Concrete strength 40 MPa | Concrete strength 50 MPa | Concrete strength 65 MPa |
| **ATF12** | ATB12 | 111 | 56.55 | 61.07 | 73.09 | 80.07 | 82.69 | 92.45 | 103.37 | 117.86 |
| **ATF16** | ATB16 | 141 | 100.53 | 108.57 | 104.64 | 114.63 | 118.39 | 132.36 | 147.99 | 168.73 |
| **ATF20** | ATB20 | 141 | 157.08 | 169.65 | 104.64 | 114.63 | 118.39 | 132.36 | 147.99 | 168.73 |
| **ATF25** | ATB25 | 155 | 245.44 | 265.07 | 120.61 | 132.12 | 136.45 | 152.56 | 170.57 | 194.48 |
| **ATF32** | ATB32 | 196 | 402.12 | 434.29 | 171.50 | 187.87 | 194.03 | 216.93 | 242.54 | 276.54 |

Reduction factor of the projected area from Graph 2 (ATF16 and ATF20) influenced by anchors $A_{Nc2} / A_{Nc0}$ according to spacing $s_1$ and $s_2$:

$$\frac{A_{Nc2}}{A_{Nc0}} = 0.27$$




The design value of the tensile capacity of anchor based on the used reduction factor $\phi$ for anchors in concrete.

⇨ *Tensile resistance of anchor based on the yield strength of steel* $\phi = 0.75$

$$\phi A_s \cdot f_y = 0.75 \cdot 100.53 = 75.4 \ kN/anchor$$

⇨ Tensile resistance of cast-in headed studs governed by concrete breakout $\phi = 0.75$

$$\phi N_{cb} = \phi \cdot \frac{A_{Nc2}}{A_{Nc0}} \cdot N_{cb0} = 0.75 \cdot 0.27 \cdot 118.39 = 23.97 \ kN/anchor$$

$$N_{Ed,a} \leq min.\begin{cases} \phi \cdot A_s \cdot f_y = 75.4 \ kN/anchor \\ \phi \cdot N_{cb} = 23.97 \ kN/anchor \end{cases}$$

$$N_{Ed,a} \leq \phi N_{cb}$$

$$22.80 \ kN/anchor < 23.97 \ kN/anchor$$

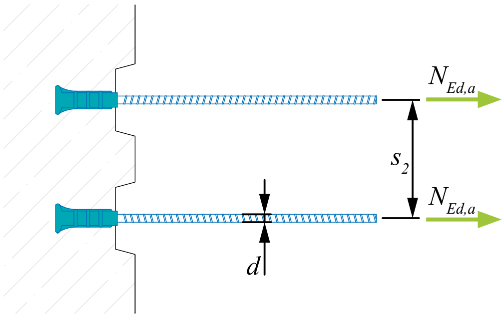
## Order Form

| Model/Dimension | Quantity [pcs] | Description |
|---|---|---|
| ATF16 | 120 | |
| ATB16 | 120 | |
| APP16 | 40 | |
| Rebate Former Board 1200x165-200T+B | 20 | |
| Board Release Key | 3 | |
| Plug Release Key | 3 | |
| | | |
| | | |

## 3.2 Example 2

**Input data:**

| | |
|---|---|
| Concrete strength | 65 MPa |
| Bar diameter | $d$ = 12 mm |
| Spacing between anchors in one row | $s_1$ = 250 mm |
| Spacing between rows of anchors | $s_2$ = 180 mm |
| Number of anchors in a meter | $n$ = 8 pcs |
| Tension load in the connection of slab-to-wall | $N_{Ed,a}$ = 39.3 kN/anchor |




**Designed tensile capacity of an anchor influenced by other anchors:**

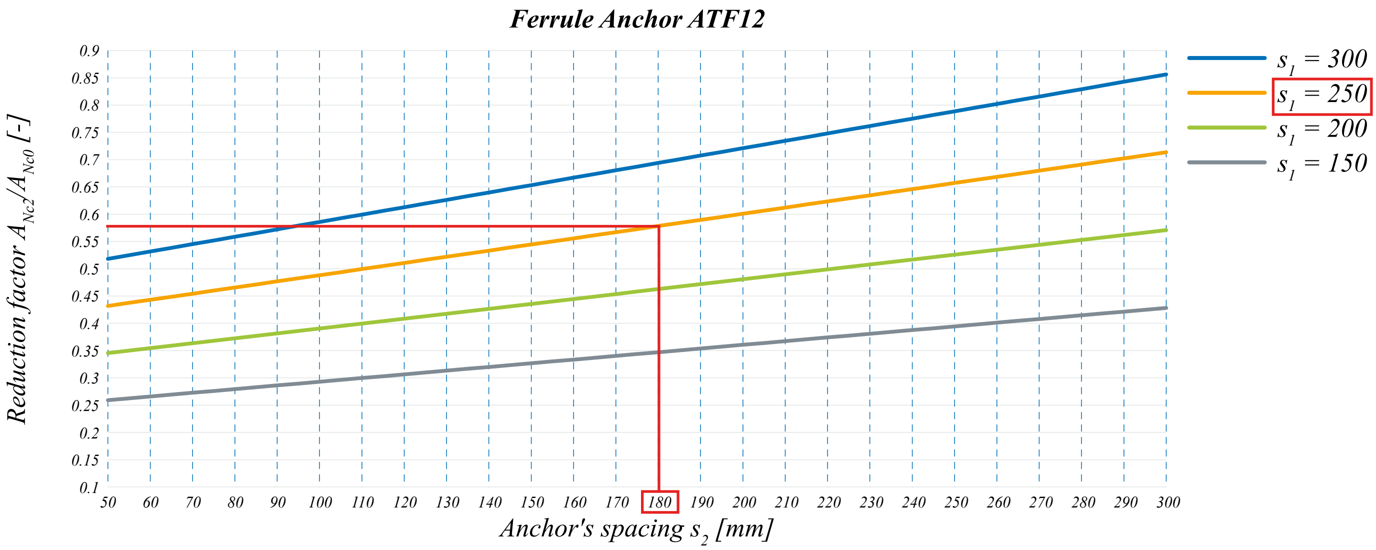
$$\phi N_{cb} = \phi \cdot \frac{A_{Nc2}}{A_{Nc0}} \cdot N_{cb0}$$

$N_{cb0}$ = *117.86 kN/anchor* ⇨ Ultimate tensile strength per anchor not influenced by other anchors or edges according to *Table 3*.

| Ferrule Anchor | Threaded Bar | Effective anchor embedment $h_{ef}$ [mm] | Nominal steel strength of anchor in tension $A_s \cdot f_y$ [kN] | Minimum ultimate strength of the bar $A_s \cdot f_u$ [kN] | Nominal concrete breakout strength per anchor $N_{cb0}$ [kN/anchor] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Concrete strength 25 MPa | Concrete strength 30 MPa | Concrete strength 32 MPa | Concrete strength 40 MPa | Concrete strength 50 MPa | Concrete strength 65 MPa |
| **ATF12** | ATB12 | 111 | 56.55 | 61.07 | 73.09 | 80.07 | 82.69 | 92.45 | 103.37 | 117.86 |
| **ATF16** | ATB16 | 141 | 100.53 | 108.57 | 104.64 | 114.63 | 118.39 | 132.36 | 147.99 | 168.73 |
| **ATF20** | ATB20 | 141 | 157.08 | 169.65 | 104.64 | 114.63 | 118.39 | 132.36 | 147.99 | 168.73 |
| **ATF25** | ATB25 | 155 | 245.44 | 265.07 | 120.61 | 132.12 | 136.45 | 152.56 | 170.57 | 194.48 |
| **ATF32** | ATB32 | 196 | 402.12 | 434.29 | 171.50 | 187.87 | 194.03 | 216.93 | 242.54 | 276.54 |

Reduction factor of the projected area from Graph 1 (ATF12) influenced by anchors $A_{Nc2} / A_{Nc0}$ according to spacing $s_1$ and $s_2$:

$$\frac{A_{Nc2}}{A_{Nc0}} = 0.58$$



The design value of the tensile capacity of anchor based on the used reduction factor $\phi$ for anchors in concrete.

⇨ *Tensile resistance of anchor based on the yield strength of steel* $\phi = 0.75$

$$\phi A_s \cdot f_y = 0.75 \cdot 56.55 = 42.41 \text{ kN/anchor}$$

⇨ Tensile resistance of cast-in headed studs governed by concrete breakout $\phi = 0.75$

$$\phi N_{cb} = \phi \cdot \frac{A_{Nc2}}{A_{Nc0}} \cdot N_{cb0} = 0.75 \cdot 0.58 \cdot 117.86 = 51.27 \text{ kN/anchor}$$

$$N_{Ed,a} \leq min.\begin{cases} \phi \cdot A_s \cdot f_y = 42.41 \text{ kN/anchor} \\ \phi \cdot N_{cb} = 51.27 \text{ kN/anchor} \end{cases}$$

$$N_{Ed,a} \leq \phi A_s \cdot f_y$$

$$39.3 \text{ kN/anchor} < 42.41 \text{ kN/anchor}$$

## Order Form

| Model/Dimension | Quantity [pcs] | Description |
|---|---|---|
| ATF12 | 230 | |
| ATB12 | 230 | |
| APP12 | 85 | |
| Rebate Former Board 1200x110-250C | 50 | |
| Board Release Key | 5 | |
| Plug Release Key | 5 | |
| | | |
| | | |

# 4. Annex A – Recommended connection design and resistances

Annex A describes the recommended general design methods for the assessment of the shear and bending resistance of ADJUSTA Joint Reinforcement. The recommended design procedure must be validated case by case by the designer of the project. The resistances presented in this Annex depend on the layout and dimensions of connected concrete elements. A general design procedure is available for transverse shear resistance and bending resistance.

## 4.1 Transverse shear resistance

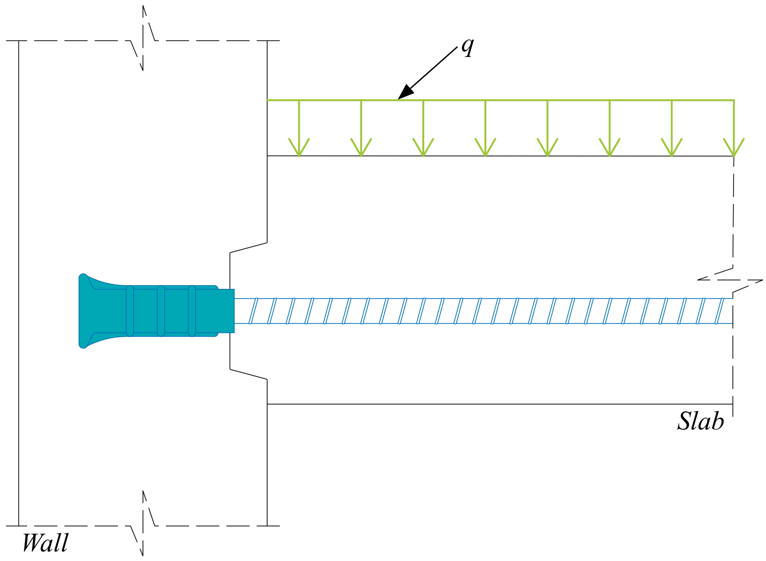
The design procedure of the shear resistance of connection needs to be applied in two steps:

1. Estimate the resistance of concrete console formed by Rebate Former Board
2. Assess the shear capacity of the slab

### Step 1.

As a Threaded Bar is intended to transfer primarily tensile loads, it is recommended to secure the transfer of shear loads in the joint using shear keys. With models ATF12, ATF16 and ATF20, the shear key is created by using Rebate Former Board in the installation. With models ATF25 and ATF32, it is necessary to create the shear key by using adequate inserts in the formwork of the concrete member.

*Figure 6. Acting external load on the connection of slab-to-wall.*




It is assumed that within the joint, the transverse shear load is bearing on the concrete console (see *Figure 7*). The concrete console resistances are pre-calculated in *Table 9* assuming a thickness of 30 mm corresponding to the standard Rebate Former Board.

Figure 7. Shear capacity of the concrete console.

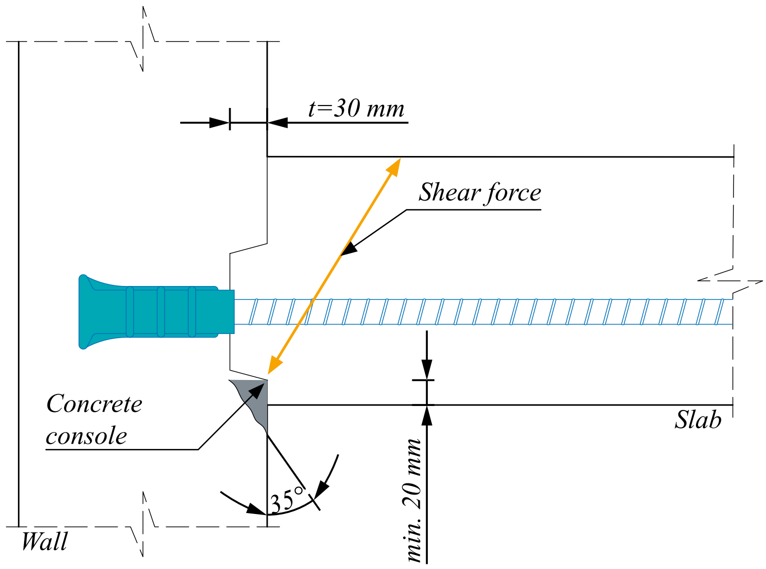



Table 9. The recommended design values of transverse shear resistance based on concrete console resistance.

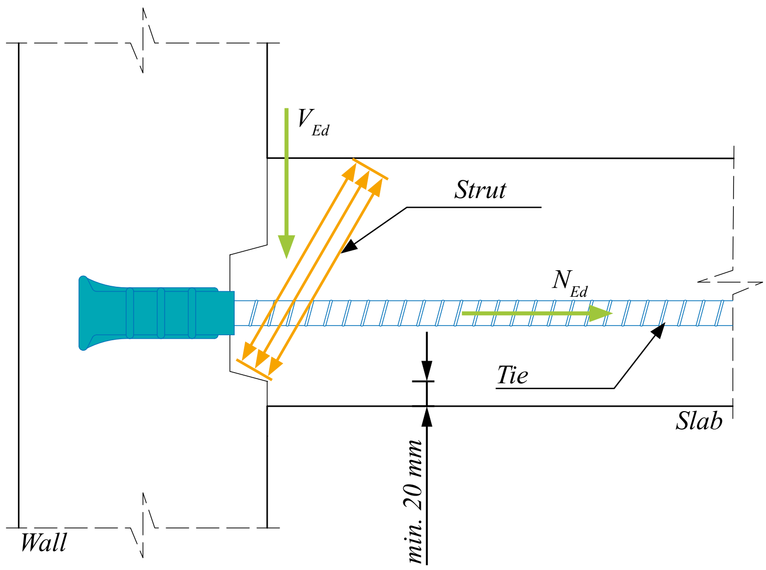
| Ferrule Anchor | Threaded Bar | Console width $t$ [mm] | Design shear capacity of the console $V_{Rd,1}$ [kN/ m] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Concrete strength 25 MPa | Concrete strength 30 MPa | Concrete strength 32 MPa | Concrete strength 40 MPa | Concrete strength 50 MPa | Concrete strength 65 MPa |
| **ATF12** | ATB12 | 30 | 38.56 | 42.84 | 45.34 | 53.56 | 62.12 | 67.28 |
| **ATF16** | ATB16 | 30 | 38.56 | 42.84 | 45.34 | 53.56 | 62.12 | 67.28 |
| **ATF20** | ATB20 | 30 | 38.56 | 42.84 | 45.34 | 53.56 | 62.12 | 67.28 |

### Step 2.

Design slab element based on strut-and-tie model or other appropriate design model. The shear resistance of a slab element can be increased with stirrups or double-headed studs.

An indented arrangement of the joint (see *Figure 8*) develops a strut-and-tie model in the connection, where compression is transferred by “concrete strut” and tension is transferred by “anchored threaded bar”.

*Figure 8. Strut-and-tie model for shear load transfer.*




## 4.2 Bending resistance

If ADJUSTA Joint Reinforcement is placed at the same level and spliced with the bending reinforcement of the slab, the connection can transfer also bending moment. The general calculation procedure of bending moment is shown in *Figure 10*. The tensile loads carried by Threaded Bar should be limited by the anchorage capacity of Ferrule Anchor determined in Section 2. of this manual. The detailing of splicing (length of the bar and needed transverse reinforcement) must be verified case by case by the designer of the project.

*Figure 9. Acting external bending moment and transverse shear force on the connection of slab-to-wall.*

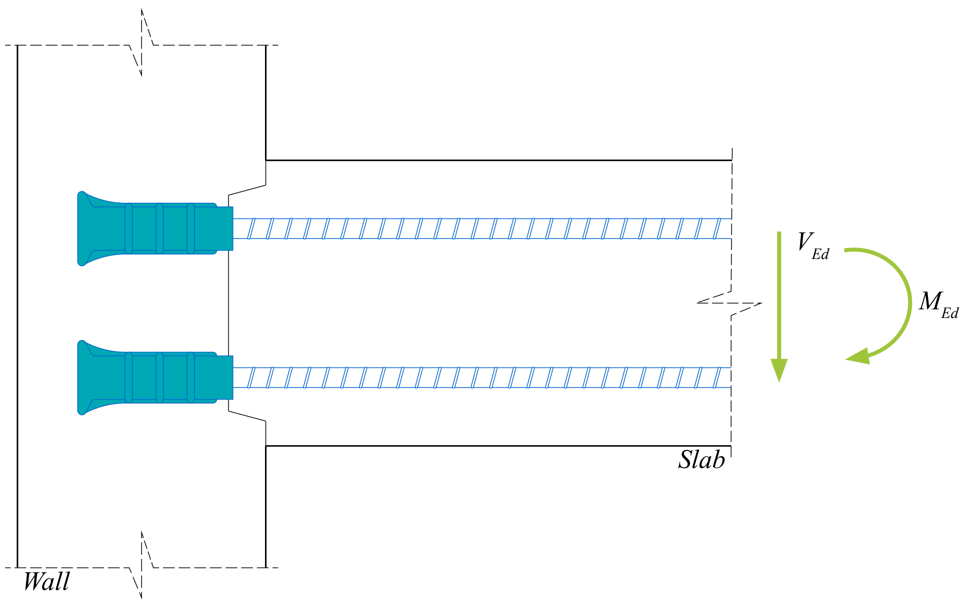
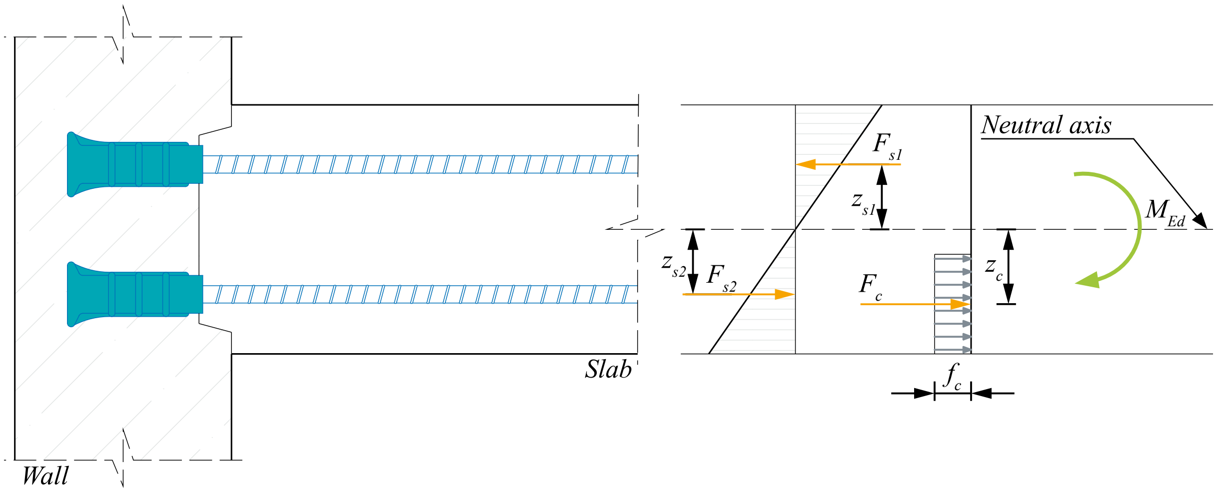


*Figure 10. General structural behavior of transferring the bending moment.*




$$M = F_{s1} \cdot z_{s1} + F_{s2} \cdot z_{s2} + F_c \cdot z_c \qquad (11)$$

Where:

| | | |
|---|---|---|
| $F_{s1}$ | = | Tensile strength in Threaded Bar [kN] |
| $z_{s1}$ | = | Distance from Neutral Axis to the middle of tension bar [mm] |
| $F_{s2}$ | = | Compressive strength in Threaded Bar [kN] |
| $z_{s2}$ | = | Distance from Neutral Axis to the middle of compressed bar [mm] |
| $F_c$ | = | Arm of compressive strength of the concrete [kN] |
| $z_c$ | = | Distance from Neutral Axis to the middle of compressed concrete section [mm] |

**NOTE:**
Please note that along with bending moment, the connection also involves transverse shear force which needs to be considered and evaluated based on an appropriate model as described in 4.1 (see *Figure 8*) of Annex A.

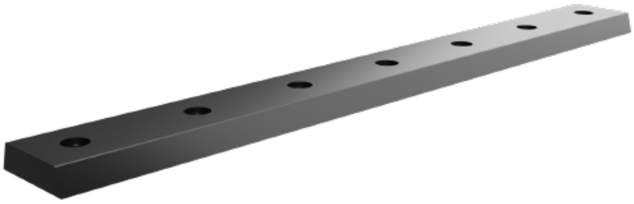
# 5. Annex B - Accessories

When using concrete elements, it is important to ensure that the rebar system is placed and fixed appropriately in the correct position. Peikko accessories can ensure that ADJUSTA Joint Reinforcement is correctly fixed to the formwork.

The accessories mentioned below are optional and must be ordered in addition to Ferrule Anchors and Threaded Bars.

## Rebate Former Board

The HDPE Rebate Former Board is customized to the engineer's specified spacing and starter bar layout. It holds Ferrule Anchors in correct position and creates transverse shear resistance corbel. Rebate Former Board made of recycled material is resistant to petrochemicals and heat ensuring its durability and longevity. Rebate Former Board can be reused several times from floor to floor. The length of each board is standardized to 1.2 m but can be adapted at the installer's requests. Each board has three board release half nuts installed to assist with stripping the rebate former after pour. Rebate Former Board is used for the ATF12, ATF16 and ATF20 models with standard longitudinal spacing $s_l$ between Ferrule Anchors 150, 200, 250, 300 mm.



## Connector Plug (APP12, APP16, APP20)

A plug and O-ring sealer is used in the ATF12, ATF16 and ATF20 models. It is manufactured from recycled materials and is durable and reusable from floor to floor. The O-ring provides a pipe seal around the mouth of the Ferrule Anchor during concrete pour and inhibits any grout/slurry intrusion. It is removed directly before fitting the Threaded Bar.

## Nailing Plate (ANP25, ANP32)

Nailing Plates are used mostly with models ATF25 and ATF32. They replace the role of Former Board and should fix ADJUSTA system to the mold in the correct position on the construction site.

## Board Release Key

After Ferrule Anchors are concreted and the concrete has reached the required strength, the Rebate Former Board can be removed. A special Board Release Key is needed for this action.

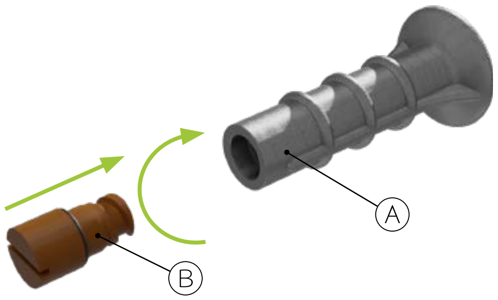
## Plug Release Key

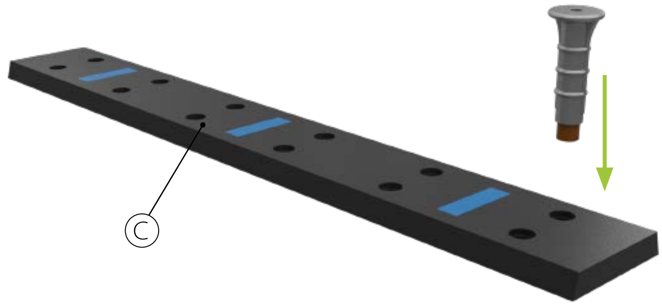
A special tool used for removing protective Connector Plug assembled in Ferrule Anchor before Threaded Bar is installed.

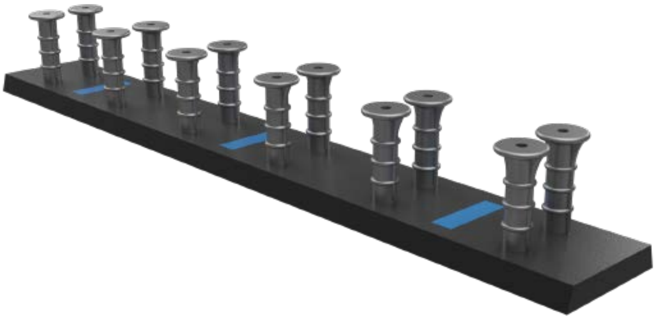
# INSTALLING ADJUSTA Joint Reinforcement

## Installation using Rebate Former Board

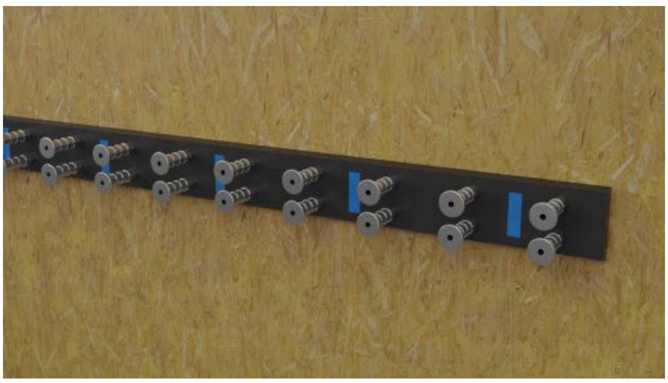
1. Assemble Ferrule Anchors Ⓐ with Connector Plugs Ⓑ into the prepared holes within Rebate Former Board Ⓒ.



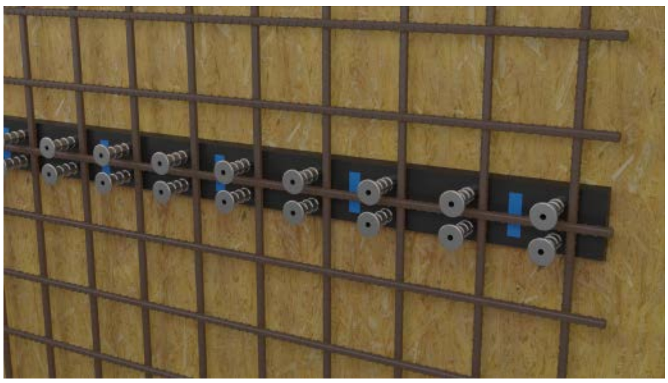



2. After fitting Ferrule Anchors in the right position on the Rebate Former Board, fix ADJUSTA system (Rebate Former Board with Ferrule Anchors) in the required position according to design by attaching it with nails onto the wooden formwork or connecting it to the existing reinforcement of the concrete element with wires.

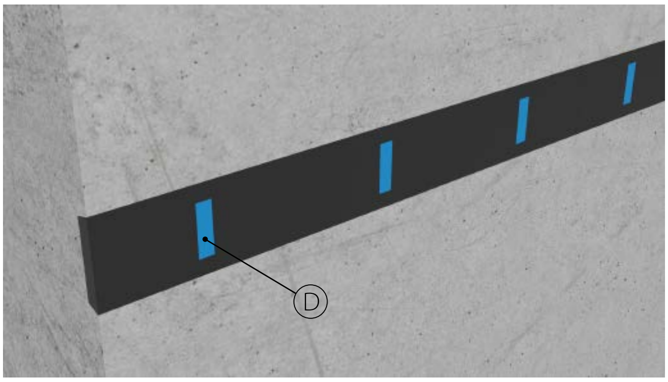


3. Install the main reinforcement of the concrete element.

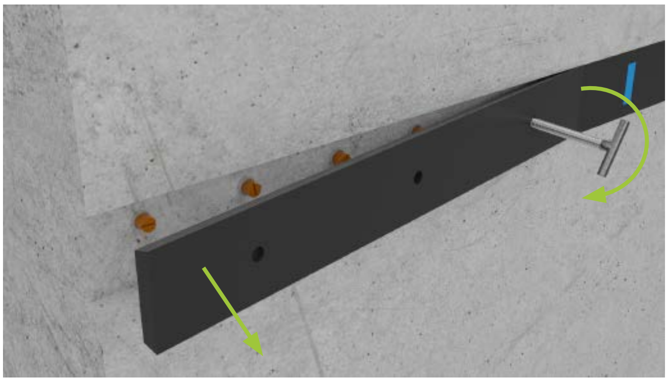


4. Pour concrete into the formwork with the main reinforcement of the concrete element.

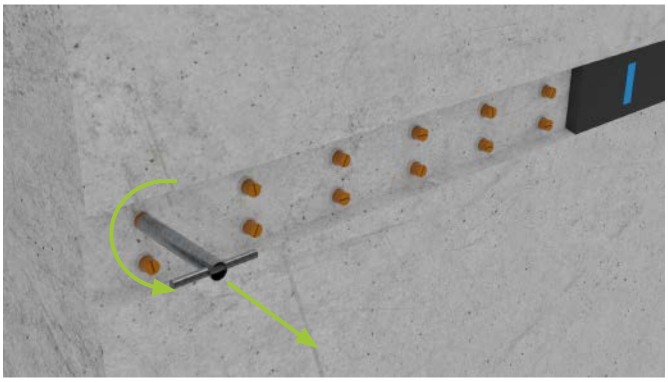
5. When the formwork is removed, the Rebate Former Board is revealed. The holes for removing Rebate Former Boards are protected from concrete by tapes Ⓓ, which need to be peeled off before removing the Rebate Former Board.



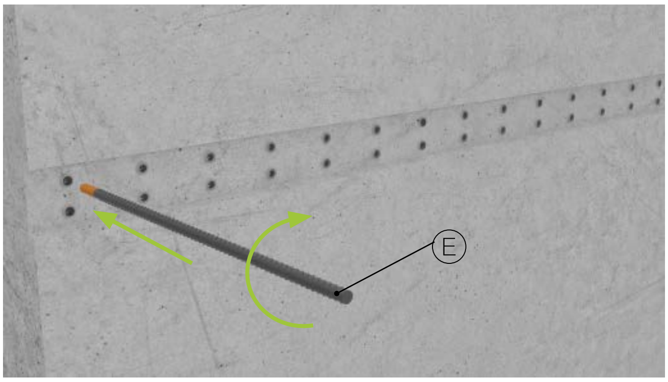

6. Remove the Rebate Former Board by using the Board Release Key (see Annex B - Accessories).



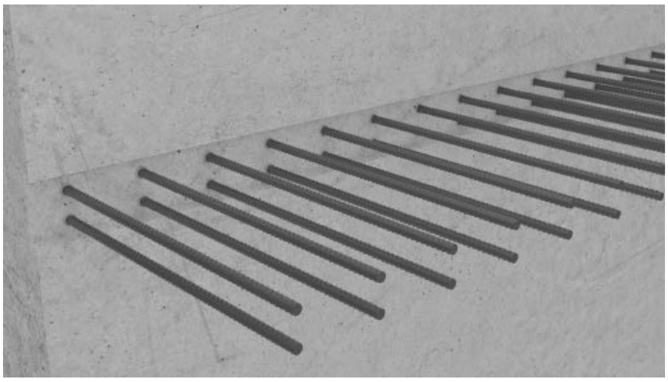
7. After removing the Rebate Former Board, the Connector Plugs are visible. Screw them off using the Plug Release Key (see Annex B - Accessories). Connector Plugs can be removed just before assembling Threaded Bars.



8. Easy fitting of Threaded Bars Ⓔ to Ferrule Anchors by screwing in. Threaded Bars are fully tigthened when the colored part of Threaded Bar is completely hidden in the Ferrule Anchor.

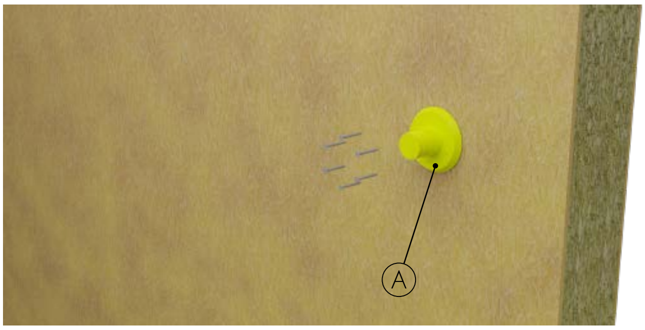



9. Once the bars are assembled in Ferrule Anchors, they are ready for overlapping with the other element reinforcement and pouring the concrete.

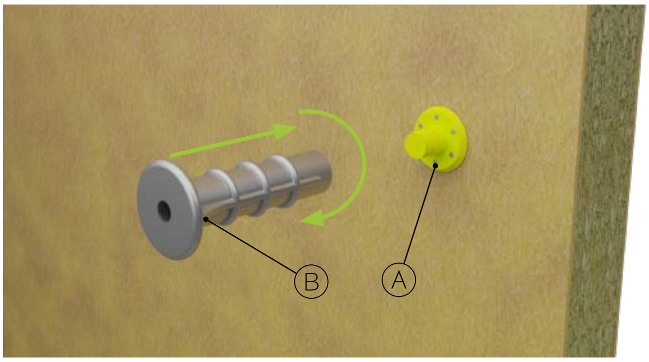


## Installation using Nailing Plates

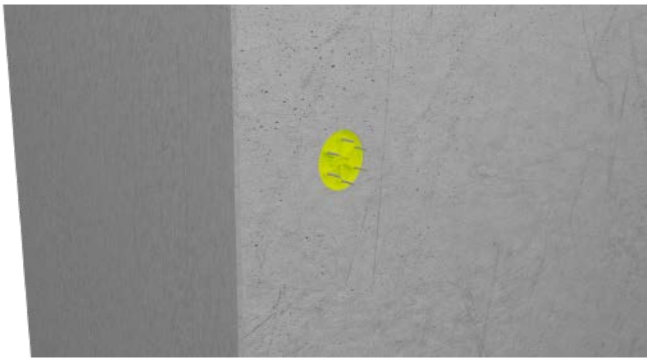
1. Nailing Plate Ⓐ must be attached to the formwork in the right position with nails.



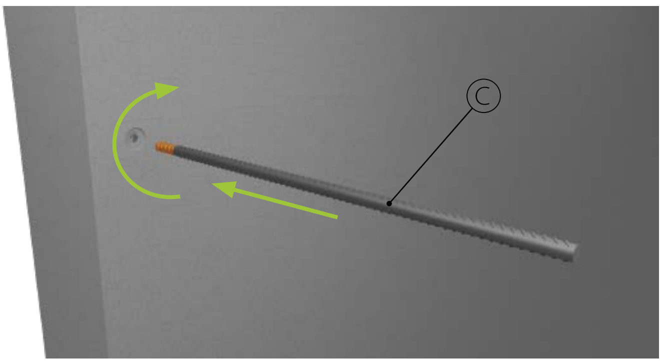

2. Ferrule Anchor Ⓑ is screwed onto Nailing Plate Ⓐ.




3. When the Ferrule Anchor is fixed with the Nailing Plate to the formwork, it can be filled with concrete. After removing the formwork, the Nailing Plate is visible.



4. After the Nailing Plate is removed, the Threaded Bar Ⓒ is ready for assembling to the Ferrule Anchor. Threaded Bars are fully tigthened when the colored part of the Threaded Bar is completely hidden in the Ferrule Anchor.



## NOTES

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# Technical Manual Revisions

**Version: PEIKKO GROUP 11/2019. Revision: 001**

- First publication

# Resources

### DESIGN TOOLS

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