Anchor plates

Anchor plates manufactured by Anstar Oy are steel plates equipped with bonds and installed in the concrete before it hardens. Adjoining structural fastenings are made by welding directly onto the steel plate.
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Revision G, November 6, 2020

Resistance tables B-18 has been updated
Resistance calculations on FEM has been enhanced. New software version ASTEEL 2.1.

Revision F, January 31, 2020

Instructions for using anchor plates have been completely rewritten. The old instructions and design values are no longer used.

The anchor plates are designed according to the new standard EN 1992-4:2018 for the ultimate and accident limit states.

The old CEN/TS 1992-4.2 standard was abolished in 2018 and is no longer used.

The structure of the product has been updated, there are dimensional and structural changes in the products, and the product range has been expanded. The new AKLC-Custom anchor plate has been developed for project-specific custom fastening needs.

The AKLC anchor plate is designed for project-specific dimensions, loads and material strengths.

The anchor plates are designed using the ASTEEL software. Their use requires software version 2.1 or higher.

This user manual only applies to designing and using Anstar Dy products included in this document.

The manual or parts of it cannot be adapted or applied to designing other manufacturers’ products or manufacturing or using their anchor plates in concrete structures.

User manual

Anchor plates

Revision 11/2020
1 ANCHOR PLATES

Anchor plates are used in load-transferring welded connections between concrete structures and other structures. The plates are installed in cast-in-situ or element formwork and cast in concrete. Anchor plate connections can be designed using Anstar’s ASTEEL software, which is used for designing the plates for the loads on the structure and placing the plates at the edge of the structure. The software designs the reinforcement of the anchor plate as well as the profile welded to the plate and its welded connection. The connection is designed, and the strength calculations carried out at the same time.

Anstar’s anchor plate products are suitable for the following structures:

<table>
<thead>
<tr>
<th>Plate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKL</td>
<td>Transferring light loads in element and cast-in-situ structures.</td>
</tr>
<tr>
<td>KL</td>
<td>Transferring loads in a very narrow structure and at the edge of the structure with the full tensile resistance of the plate.</td>
</tr>
<tr>
<td>JAL</td>
<td>Transferring heavy loads in element and cast-in-situ structures.</td>
</tr>
<tr>
<td>AKLP</td>
<td>Long anchor plates are used in applications requiring several fastening points next to each other. AKLP and AKLJ plates are suitable for system fastening where preparations must be made for a subsequent fastening whose location is not known.</td>
</tr>
<tr>
<td>AKLJ</td>
<td>- AKKT fastening angle bars are used at the corners of columns.</td>
</tr>
<tr>
<td>AKKT</td>
<td>- Project-specific custom anchor plates are designed using the ASTEEL software. Anstar Oy performs the designing using the initial data provided by the designer.</td>
</tr>
</tbody>
</table>

![Figure 1. Anchor plate products](image)

2 USING ANCHOR PLATES

2.1 Introduction to anchor plate products

2.1.1 AKL and KL anchor plates

AKL and KL anchor plates transfer light loads from connected structures to the concrete base.

1. Applications for the anchor plates
   - AKL, KL anchor plates are used for concrete structure connections to transfer the forces acting on the structure through the plate to the base concrete.
   - The KL anchor plate has a straight rebar bond, thanks to which the plate can be used at the edge of the concrete structure with full tensile resistance.
   - The AKL anchor plate has short bonds and is suitable for shallow concrete.
   - Resistance values have been specified for the plate for both reinforced and non-reinforced concrete structures.
   - Surface plate materials: S355J2+N and austenitic 1.4301 and 1.4401.

2. Designing connection
   - The resistance values of the anchor plates are according to EN 1992-4:2018.
   - The anchor plate is designed using Anstar’s ASTEEL software.
   - The software calculates the anchor plate for loads in the ultimate and accident limit states.
   - The software calculates the reinforcement of the anchor plate.
The ASTEEL software is used to calculate the profile welded to the anchor plate and the connecting weld. The software produces the strength calculations for the anchor plate, connection profile and weld.

2.1.2 JAL anchor plate

JAL anchor plates transfer heavy loads from connected structures to the concrete base.

1. Applications for the anchor plates

- JAL anchor plates are used for connections of concrete element and cast-in-situ structures where the resistance values of AKL and KL plates are not sufficient in the corresponding size class.
- The connection transfers the forces to the base concrete.
- The plate has short bonds and is suitable for shallow structures.
- Resistance values have been specified for the plates for both reinforced and non-reinforced structures.
- The plate can be reinforced for tensile and shear forces.
- Surface plate materials: S355J2+N and austenitic 1.4301 and 1.4401

2. Designing a connection

- The resistance values of the anchor plates are specified in accordance with the EN 1992-4:2018 standard.
- The anchor plate connections are designed using Anstar’s ASTEEL software.
- The software calculates the selected anchor plate structure for loads in the ultimate and accident limit states.
- The software calculates the reinforcement of the anchor plate.
- The ASTEEL software is used to calculate the resistance of the profile welded to the anchor plate and the connecting weld.
- The software produces the strength calculations for the anchor plate, connection profile and weld.

Figure 2. AKL and KL anchor plates in a concrete structure

Figure 3. JAL anchor plate in a concrete structure
2.1.3 AKLP and AKLJ anchor plates

The structure of long anchor plates is a standard group of 2–3 bonds at a spacing of 200 mm, and the length of the plate is specified in the order. The plates are used for the following special applications.

<table>
<thead>
<tr>
<th>1. Applications for the anchor plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long AKLP and AKLJ anchor plates are suitable for applications requiring several fastening points next to each other.</td>
</tr>
<tr>
<td>The plates are also suitable for system fastening where preparations are made for the fastening of subsequent loads whose location is not known.</td>
</tr>
<tr>
<td>The plate structure is standard. The distance between bonds is a standard 200 mm, and the length of the plate is specified in the order.</td>
</tr>
<tr>
<td>The standard length of the plate is 2,000 mm, and plates can be ordered with lengths of 400 mm + n x 200 mm.</td>
</tr>
<tr>
<td>The anchor plate transfers the forces acting on the connected structure through the bonds to the base concrete.</td>
</tr>
<tr>
<td>Resistance values have been specified for the plate for non-reinforced structures, and the plate can be reinforced for tensile and shear forces.</td>
</tr>
<tr>
<td>Resistance values have been specified for a group of four bonds.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Designing a connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>The civil engineer specifies the length of the plate and the location and loads of the profiles to be welded to it.</td>
</tr>
<tr>
<td>The resistance values of the anchor plates are specified in accordance with the EN 1992-4:2018 standard.</td>
</tr>
<tr>
<td>The software calculates the reinforcement of the anchor plate.</td>
</tr>
<tr>
<td>The ASTEEL software is used to calculate the resistance of the profile welded to the anchor plate and the connecting weld.</td>
</tr>
<tr>
<td>The software produces the strength calculations for the anchor plate, connection profile and weld.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Technical support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anstar’s technical design department provides assistance in designing special applications.</td>
</tr>
</tbody>
</table>

Figure 4. Implementation options for the structure of AKLP and AKLJ anchor plates

2.1.4 AKLC-Custom anchor plate

AKLC-Custom is Anstar’s product for project-specific fastening for which the standard products are not suitable. The dimensions and materials of the AKLC anchor plate are designed according to the order. The plates are used for the following special applications.

<table>
<thead>
<tr>
<th>1. Applications for the anchor plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>The AKLC anchor plate is a special product for connections in element and cast-in-situ structures.</td>
</tr>
<tr>
<td>All the dimensions and resistance values of the anchor plate are determined project-specifically.</td>
</tr>
<tr>
<td>The anchor plate transfers the forces acting on the connected structure through the surface plate and bonds to the base concrete.</td>
</tr>
</tbody>
</table>
- The AKLC anchor plate is used for fastening in a shallow structure. In this case, short, upset bonds are used in the anchor plate.
- The anchor plate can also be provided with straight rebar bonds, allowing it to be pushed into dense reinforcement.
- The AKLC plate can be used for heavy-duty fastening. The size and thickness of the surface plate are selected, and the bond is either a straight or upset rebar bond.
- Resistance values can be specified for the plate for non-reinforced structures, and the plate can be reinforced for tensile and shear forces.

2. Designing a connection
- The civil engineer prepares a suggestion for the plate materials and dimensions and the spacing of the bonds, and also specifies the plate loads and connection profile dimensions.
- Anstar designs the plate using the ASTEEL software for the ultimate and accident limit state loads specified.
- The resistance values of the anchor plates are specified according to the EN 1992-4:2018 standard.
- The software calculates the reinforcement of the anchor plate.
- The ASTEEL software can be used to calculate the resistance of the profile welded to the anchor plate and the connecting weld.
- The software produces the strength calculations for the anchor plate, connection profile and weld for building control.
- Anstar manufactures the plate with the order code.
- The dimensions required for ordering the plate are presented in Section 2.8.

3. Technical support
- Anstar’s technical design department provides assistance in designing special applications.

---

Figure 5. Implementation options for the structure of the AKLC anchor plate

### 2.1.5 New design standard and designing theory for anchor plates

Anstar’s anchor plate products have been updated according to the following principles:

<table>
<thead>
<tr>
<th>1. Design standard</th>
<th>The design values of Anstar’s anchor plates have been specified according to the new EN 1992-4:2018 standard. The resistance values and other design criteria of the anchor plates have been specified to meet the requirements of the European standards.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Design situations</td>
<td>Resistance values are specified for the anchor plates for both ultimate and accident limit state design. The stress state and deformed geometry can be specified for the surface plate. The plates are designed using Anstar’s ASTEEL software.</td>
</tr>
<tr>
<td>3. Design a surface plate</td>
<td>The surface plate is designed elastic-plastically according to EN 1992-1-8; the software conducts a FEM analysis for the plate, meaning that the actual tensile forces of the bonds are calculated from the plate deformations.</td>
</tr>
<tr>
<td>4. Base concrete</td>
<td>The software performs the plate’s stress state calculation for the base concrete.</td>
</tr>
<tr>
<td>5. Prying forces</td>
<td>EN 1992-1-8 requires that, in base plate connections connected to concrete in tension, the prying forces on the anchors must be specified. The software takes into account the deformations of the surface plate bonds.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>6. Edge distances</strong></td>
<td>The resistances of plates can be calculated using the actual edge distance of the plate.</td>
</tr>
<tr>
<td><strong>7. Supplementary reinforcement</strong></td>
<td>The supplementary reinforcement for the plates can be calculated for the actual loads of the project and the strength of the base concrete.</td>
</tr>
<tr>
<td><strong>8. New plate resistances</strong></td>
<td>The anchor plate resistance values changed from the old user manual. The axial force resistance values remained at the same level or decreased slightly. The bending moment resistance values decreased due to the new design method in items 3 and 4. Surface plate slenderness and stress state became determining. The shear and torsional resistance values could be increased from the earlier level.</td>
</tr>
<tr>
<td><strong>9. Strength calculations</strong></td>
<td>Strength calculations for the anchor plate can be produced for project-specific use.</td>
</tr>
<tr>
<td><strong>10. Language</strong></td>
<td>The software language options are Finnish, Swedish, English and German.</td>
</tr>
</tbody>
</table>
2.2 Dimensions of fastening products

2.2.1 AKL anchor plate

The AKL anchor plate is suitable for shallow structures with space for the plate’s short bonds. The plate is placed at the edge of the structure; the minimum distance from the edge equals the thickness of the protective concrete layer (25 mm). The plate must always be reinforced when placed at the edge. The resistance values of the AKL anchor plate are specified according to the edge distance. There are three material options for the AKL plate.

<table>
<thead>
<tr>
<th>AKL</th>
<th>The surface plate material is S355J2+N (black)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The bonds are rebar B500B or S235JR+AR</td>
</tr>
<tr>
<td></td>
<td>The top surface and sides of the plate are protected by painting.</td>
</tr>
<tr>
<td>AKLR</td>
<td>The surface plate material is 1.4301 (stainless)</td>
</tr>
<tr>
<td>AKLH</td>
<td>The surface plate material is 1.4401 (stainless)</td>
</tr>
<tr>
<td></td>
<td>The bonds are rebar B500B</td>
</tr>
</tbody>
</table>

Figure 6. Structure of the AKL anchor plate

Table 1. Dimensions of the AKL anchor plate

<table>
<thead>
<tr>
<th>AKL S355J2+N</th>
<th>AKLR 1.4301</th>
<th>AKLH 1.4401</th>
<th>B (mm)</th>
<th>L (mm)</th>
<th>H (mm)</th>
<th>T (mm)</th>
<th>A (mm)</th>
<th>C (mm)</th>
<th>Ø (mm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKL 100/100</td>
<td>AKLR 100/100</td>
<td>AKLH 100/100</td>
<td>100</td>
<td>100</td>
<td>68</td>
<td>8</td>
<td>60</td>
<td>60</td>
<td>12</td>
<td>1.0</td>
</tr>
<tr>
<td>AKL 100/150</td>
<td>AKLR 100/150</td>
<td>AKLH 100/150</td>
<td>100</td>
<td>150</td>
<td>70</td>
<td>10</td>
<td>60</td>
<td>90</td>
<td>12</td>
<td>1.5</td>
</tr>
<tr>
<td>AKL 150/150</td>
<td>AKLR 150/150</td>
<td>AKLH 150/150</td>
<td>150</td>
<td>150</td>
<td>162</td>
<td>12</td>
<td>90</td>
<td>90</td>
<td>12</td>
<td>2.8</td>
</tr>
<tr>
<td>AKL 100/200</td>
<td>AKLR 100/200</td>
<td>AKLH 100/200</td>
<td>100</td>
<td>200</td>
<td>162</td>
<td>12</td>
<td>60</td>
<td>120</td>
<td>12</td>
<td>2.3</td>
</tr>
<tr>
<td>AKL 100/300</td>
<td>AKLR 100/300</td>
<td>AKLH 100/300</td>
<td>100</td>
<td>300</td>
<td>165</td>
<td>15</td>
<td>60</td>
<td>180</td>
<td>16</td>
<td>4.7</td>
</tr>
<tr>
<td>AKL 200/200</td>
<td>AKLR 200/200</td>
<td>AKLH 200/200</td>
<td>200</td>
<td>200</td>
<td>162</td>
<td>12</td>
<td>120</td>
<td>120</td>
<td>16</td>
<td>5.0</td>
</tr>
<tr>
<td>AKL 250/250</td>
<td>AKLR 250/250</td>
<td>AKLH 250/250</td>
<td>250</td>
<td>250</td>
<td>165</td>
<td>15</td>
<td>170</td>
<td>170</td>
<td>16</td>
<td>8.6</td>
</tr>
<tr>
<td>AKL 200/300</td>
<td>AKLR 200/300</td>
<td>AKLH 200/300</td>
<td>200</td>
<td>300</td>
<td>165</td>
<td>15</td>
<td>120</td>
<td>180</td>
<td>16</td>
<td>8.4</td>
</tr>
<tr>
<td>AKL 300/300</td>
<td>AKLR 300/300</td>
<td>AKLH 300/300</td>
<td>300</td>
<td>300</td>
<td>165</td>
<td>15</td>
<td>180</td>
<td>180</td>
<td>16</td>
<td>9.8</td>
</tr>
</tbody>
</table>

Legend: B = Plate width
        L = Plate length
        H = Plate height
        T = Plate thickness
        A = Horizontal distance between bonds
        C = Vertical distance between bonds
        Ø = Bond diameter
        D = Upset head diameter = 2.2 x Ø

TS and AutoCAD blocks for AKL anchor plates: www.anstar.fi
Other AKL anchor plates: Order with AKLC-Custom plates.
2.2.2 KL anchor plate

The KL anchor plate is suitable for structures with space for the plate's long bonds. The plate can be placed at the edge of the structure; the minimum distance from the edge equals the thickness of the protective concrete layer (25 mm). The KL plate has full tensile and moment resistance even then. The plate must be reinforced when placed at the edge. The resistance values of the KL anchor plate are specified according to the edge distance. There are three material options for the KL plate.

<table>
<thead>
<tr>
<th>KL</th>
<th>KLR</th>
<th>KLH</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The surface plate material is S355J2+N (black)</td>
<td>- The surface plate material is 1.4301 (stainless)</td>
<td>- The surface plate material is 1.4401 (stainless)</td>
</tr>
<tr>
<td>- The bonds are rebar B500B</td>
<td>- The bonds are rebar B500B</td>
<td></td>
</tr>
<tr>
<td>- The top surface and sides of the plate are protected by painting.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7. Structure of the KL anchor plate

Table 2. Dimensions of the KL anchor plate

<table>
<thead>
<tr>
<th>KL</th>
<th>KLR</th>
<th>KLH</th>
<th>B</th>
<th>L</th>
<th>H</th>
<th>T</th>
<th>A</th>
<th>C</th>
<th>Ø</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>S355J2+N</td>
<td>1.4301</td>
<td>1.4401</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>kg</td>
</tr>
<tr>
<td>KL 100/100</td>
<td>KLR 100/100</td>
<td>KLH 100/100</td>
<td>100</td>
<td>100</td>
<td>218</td>
<td>8</td>
<td>60</td>
<td>60</td>
<td>12</td>
<td>1.4</td>
</tr>
<tr>
<td>KL 100/150</td>
<td>KLR 100/150</td>
<td>KLH 100/150</td>
<td>100</td>
<td>150</td>
<td>220</td>
<td>10</td>
<td>60</td>
<td>90</td>
<td>12</td>
<td>2.0</td>
</tr>
<tr>
<td>KL 150/150</td>
<td>KLR 150/150</td>
<td>KLH 150/150</td>
<td>150</td>
<td>150</td>
<td>222</td>
<td>12</td>
<td>90</td>
<td>90</td>
<td>16</td>
<td>3.6</td>
</tr>
<tr>
<td>KL 100/200</td>
<td>KLR 100/200</td>
<td>KLH 100/200</td>
<td>100</td>
<td>200</td>
<td>222</td>
<td>12</td>
<td>60</td>
<td>120</td>
<td>16</td>
<td>3.4</td>
</tr>
<tr>
<td>KL 100/300</td>
<td>KLR 100/300</td>
<td>KLH 100/300</td>
<td>100</td>
<td>300</td>
<td>315</td>
<td>15</td>
<td>60</td>
<td>180</td>
<td>20</td>
<td>6.8</td>
</tr>
<tr>
<td>KL 200/200</td>
<td>KLR 200/200</td>
<td>KLH 200/200</td>
<td>200</td>
<td>200</td>
<td>312</td>
<td>12</td>
<td>120</td>
<td>120</td>
<td>20</td>
<td>7.0</td>
</tr>
<tr>
<td>KL 250/250</td>
<td>KLR 250/250</td>
<td>KLH 250/250</td>
<td>250</td>
<td>250</td>
<td>315</td>
<td>15</td>
<td>150</td>
<td>150</td>
<td>20</td>
<td>10.5</td>
</tr>
<tr>
<td>KL 200/300</td>
<td>KLR 200/300</td>
<td>KLH 200/300</td>
<td>200</td>
<td>300</td>
<td>315</td>
<td>15</td>
<td>120</td>
<td>180</td>
<td>20</td>
<td>10.4</td>
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<td>KL 300/300</td>
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<td>15</td>
<td>180</td>
<td>180</td>
<td>20</td>
<td>14.0</td>
</tr>
</tbody>
</table>

Legend:  
B = Plate width  
L = Plate length  
H = Plate height  
T = Plate thickness  
A = Horizontal distance between bonds  
C = Vertical distance between bonds  
Ø = Bond diameter

TS and AutoCAD blocks for KL anchor plates: www.anstar.fi  
Other KL anchor plates: Order with AKLC-Custom plates.
2.2.3 JAL heavy-duty anchor plate

The JAL anchor plate is suitable for deep structures with space for the plate's long bonds. The plate is placed at the edge of the structure; the distance from the edge equals the thickness of the protective concrete layer (35 mm). The plate must be reinforced when placed at the edge. The resistance values of the JAL anchor plate are specified according to the placement distance. There are three material options for the JAL plate.

<table>
<thead>
<tr>
<th>JAL</th>
<th>- The surface plate material is S355J2+N (black)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JALR</td>
<td>- The top surface and sides of the plate are protected by painting.</td>
</tr>
<tr>
<td>JALH</td>
<td>- The surface plate material is 1.4301 (stainless)</td>
</tr>
<tr>
<td></td>
<td>- The bonds are rebar B500B.</td>
</tr>
</tbody>
</table>

**Equipment**

Vent holes can be added in the middle of the plate by special order.

![Figure 8. Structure of the JAL anchor plate](image)

**Table 3. Dimensions of the JAL anchor plate**

<table>
<thead>
<tr>
<th>JAL S355J2+N</th>
<th>JALR 1.4301</th>
<th>JALH 1.4401</th>
<th>B mm</th>
<th>L mm</th>
<th>H mm</th>
<th>T mm</th>
<th>A mm</th>
<th>C mm</th>
<th>Ø mm</th>
<th>Weight kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAL 150/150</td>
<td>JALR 150/150</td>
<td>JALH 150/150</td>
<td>150</td>
<td>150</td>
<td>220</td>
<td>25</td>
<td>90</td>
<td>90</td>
<td>16</td>
<td>6.0</td>
</tr>
<tr>
<td>JAL 150/200</td>
<td>JALR 150/200</td>
<td>JALH 150/200</td>
<td>150</td>
<td>200</td>
<td>220</td>
<td>25</td>
<td>90</td>
<td>120</td>
<td>20</td>
<td>8.5</td>
</tr>
<tr>
<td>JAL 150/250</td>
<td>JALR 150/250</td>
<td>JALH 150/250</td>
<td>150</td>
<td>250</td>
<td>220</td>
<td>25</td>
<td>90</td>
<td>190</td>
<td>20</td>
<td>10.0</td>
</tr>
<tr>
<td>JAL 200/200</td>
<td>JALR 200/200</td>
<td>JALH 200/200</td>
<td>200</td>
<td>200</td>
<td>220</td>
<td>25</td>
<td>120</td>
<td>120</td>
<td>20</td>
<td>10.3</td>
</tr>
<tr>
<td>JAL 200/250</td>
<td>JALR 200/250</td>
<td>JALH 200/250</td>
<td>200</td>
<td>250</td>
<td>220</td>
<td>25</td>
<td>120</td>
<td>190</td>
<td>20</td>
<td>12.4</td>
</tr>
<tr>
<td>JAL 200/300</td>
<td>JALR 200/300</td>
<td>JALH 200/300</td>
<td>200</td>
<td>300</td>
<td>280</td>
<td>25</td>
<td>120</td>
<td>200</td>
<td>25</td>
<td>17.0</td>
</tr>
<tr>
<td>JAL 300/300</td>
<td>JALR 300/300</td>
<td>JALH 300/300</td>
<td>300</td>
<td>300</td>
<td>280</td>
<td>25</td>
<td>200</td>
<td>200</td>
<td>25</td>
<td>23.0</td>
</tr>
<tr>
<td>JAL 400/400</td>
<td>JALR 400/400</td>
<td>JALH 400/400</td>
<td>400</td>
<td>400</td>
<td>285</td>
<td>30</td>
<td>300</td>
<td>300</td>
<td>25</td>
<td>43.0</td>
</tr>
<tr>
<td>JAL 500/500</td>
<td>JALR 500/500</td>
<td>JALH 500/500</td>
<td>500</td>
<td>500</td>
<td>285</td>
<td>30</td>
<td>400</td>
<td>400</td>
<td>25</td>
<td>64.0</td>
</tr>
<tr>
<td>JAL 600/600</td>
<td>JALR 600/600</td>
<td>JALH 600/600</td>
<td>600</td>
<td>600</td>
<td>285</td>
<td>30</td>
<td>500</td>
<td>500</td>
<td>25</td>
<td>91.0</td>
</tr>
</tbody>
</table>

Legend:
- B = Plate width
- L = Plate length
- H = Plate height
- T = Plate thickness
- A = Horizontal distance between bonds
- C = Vertical distance between bonds
- Ø = Bond diameter
- D = Upset head diameter = 2.3 x Φ

TS and AutoCAD blocks for JAL anchor plates: [www.anstar.fi](http://www.anstar.fi)

Other JAL anchor plates: Order with AKLC-Custom plates.
2.2.4 AKLP and AKLJ long anchor plate

AKLP and AKLJ anchor plates are suitable for shallow structures with space for the plate’s short bonds. The plate can also be used without reinforcement. The plate is placed at the edge of the structure; the minimum distance from the edge equals the thickness of the protective concrete layer (25 mm). The plate must be reinforced when placed at the edge. The resistance values of the anchor plate are specified according to the placement distance. The length of the anchor plate is based on the order. There are three material options for the anchor plate.

<table>
<thead>
<tr>
<th>AKLP</th>
<th>AKLJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AKLPR, AKLJR</th>
<th>AKLPH, AKLJH</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Standard product: The standard length of the plates is 2,000 mm. The length can be specified in the order.

![Structure of the AKLP and AKLJ anchor plates](image)

Figure 9. Structure of the AKLP and AKLJ anchor plates

<table>
<thead>
<tr>
<th>AKLP S355J2+N</th>
<th>AKLPR 1.4301</th>
<th>AKLPH 1.4401</th>
</tr>
</thead>
<tbody>
<tr>
<td>B mm</td>
<td>H mm</td>
<td>T mm</td>
</tr>
<tr>
<td>A mm</td>
<td>C mm</td>
<td>Ø mm</td>
</tr>
<tr>
<td>Weight kg/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>AKLP 100/L</td>
<td>AKLPR 100/L</td>
<td>AKLPH 100/L</td>
</tr>
<tr>
<td>100</td>
<td>115</td>
<td>12</td>
</tr>
<tr>
<td>60</td>
<td>200</td>
<td>16</td>
</tr>
<tr>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AKLP 150/L</td>
<td>AKLPR 150/L</td>
<td>AKLPH 150/L</td>
</tr>
<tr>
<td>150</td>
<td>115</td>
<td>12</td>
</tr>
<tr>
<td>90</td>
<td>200</td>
<td>16</td>
</tr>
<tr>
<td>16.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AKLP 200/L</td>
<td>AKLPR 200/L</td>
<td>AKLPH 200/L</td>
</tr>
<tr>
<td>200</td>
<td>115</td>
<td>12</td>
</tr>
<tr>
<td>100</td>
<td>200</td>
<td>16</td>
</tr>
<tr>
<td>21.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AKLP 300/L</td>
<td>AKLPR 300/L</td>
<td>AKLPH 300/L</td>
</tr>
<tr>
<td>300</td>
<td>115</td>
<td>12</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>16</td>
</tr>
<tr>
<td>30.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AKLP 400/L</td>
<td>AKLPR 400/L</td>
<td>AKLPH 400/L</td>
</tr>
<tr>
<td>400</td>
<td>115</td>
<td>12</td>
</tr>
<tr>
<td>300</td>
<td>200</td>
<td>16</td>
</tr>
<tr>
<td>40.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AKLJ S355J2+N</th>
<th>AKLJR 1.4301</th>
<th>AKLJH 1.4401</th>
</tr>
</thead>
<tbody>
<tr>
<td>B mm</td>
<td>H mm</td>
<td>T mm</td>
</tr>
<tr>
<td>A mm</td>
<td>C mm</td>
<td>Ø mm</td>
</tr>
<tr>
<td>Weight kg/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>AKLJ 300/L</td>
<td>AKLJR 300/L</td>
<td>AKLJH 300/L</td>
</tr>
<tr>
<td>300</td>
<td>215</td>
<td>20</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AKLJ 400/L</td>
<td>AKLJR 400/L</td>
<td>AKLJH 400/L</td>
</tr>
<tr>
<td>400</td>
<td>220</td>
<td>25</td>
</tr>
<tr>
<td>300</td>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AKLJ 500/L</td>
<td>AKLJR 500/L</td>
<td>AKLJH 500/L</td>
</tr>
<tr>
<td>500</td>
<td>220</td>
<td>25</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>109</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AKLJ 600/L</td>
<td>AKLJR 600/L</td>
<td>AKLJH 600/L</td>
</tr>
<tr>
<td>600</td>
<td>220</td>
<td>25</td>
</tr>
<tr>
<td>250</td>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>129</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:

- **B** = Plate width
- **L** = Plate length. Specified in the order code.
- **H** = Plate height
- **T** = Plate thickness
- **A** = Horizontal distance between bonds
- **C** = Vertical distance between bonds
- **Ø** = Bond diameter
- **D** = Upset head diameter = 2.3 x Ø

TS and AutoCAD blocks for the anchor plates: [www.anstar.fi](http://www.anstar.fi)

Other AKLP anchor plates: Order with AKLC-Custom plates.
2.2.5 AKLC-Custom anchor plate

AKLC-Custom is a product that the civil engineer can use to create a project-specific anchor plate for special applications. The designer specifies the forces on the plate, its distance in the base as well as its dimensions and materials from the materials in Table 5 and sends them to Anstar. Anstar designs the AKLC plate using the design principles for standard anchor plates. On the basis of the information in Table 5, Anstar creates an order code.

![AKLC anchor plate structure and order code dimensions.](image)

Figure 10. AKLC anchor plate structure and order code dimensions.

Table 5. Standard structural components of the AKLC anchor plate

<table>
<thead>
<tr>
<th>Plate</th>
<th>Material code</th>
<th>Standard plate thicknesses with different materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>M = S355J2+N</td>
<td>8, 10, 12, 15, 20, 25, 30, 35, 40, 50, 60, 70</td>
<td></td>
</tr>
<tr>
<td>R = 1.4301</td>
<td>8, 10, 12, 15, 20, 25, 30</td>
<td></td>
</tr>
<tr>
<td>H = 1.4401</td>
<td>8, 10, 12, 15, 20, 25, 30</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface plate dimensions</th>
<th>T = thickness</th>
<th>B = width</th>
<th>L = height</th>
</tr>
</thead>
<tbody>
<tr>
<td>The surface plate dimensions can be freely selected, but the location of the bonds on the plate must be taken into account. By default, the plate is a rectangle where the distance of the bond from the edge is ≥ 25 mm.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bonds</th>
<th>Straight bond</th>
<th>Straight rebar, bond lengths. Material B500B</th>
</tr>
</thead>
<tbody>
<tr>
<td>T12/H1</td>
<td>TT12/90 TT12/150</td>
<td></td>
</tr>
<tr>
<td>T16/H1</td>
<td>TT16/100 TT16/150 T16/195 TT16/280</td>
<td></td>
</tr>
<tr>
<td>T20/H1</td>
<td>TT20/195 TT20/430</td>
<td></td>
</tr>
<tr>
<td>T25/H1</td>
<td>TT25/250 TT25/430</td>
<td></td>
</tr>
<tr>
<td>T32/H1</td>
<td>TT28/485</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Upset bond</th>
<th>Standard bonds, diameter and length. Material B500B</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT12/H1</td>
<td>TT16/100 TT16/150</td>
</tr>
<tr>
<td>TT16/H1</td>
<td>TT20/195 TT20/430</td>
</tr>
<tr>
<td>TT20/H1</td>
<td>TT25/250 TT25/430</td>
</tr>
<tr>
<td>TT25/H1</td>
<td>TT28/485 TT28/500 TT28/665 TT32/500 TT32/665 TT32/865 TT40/700 TT40/865</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location of the bond on the plate</th>
<th>Bonds per horizontal row</th>
<th>n1 = 2–20 pcs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = horizontal distance</td>
<td>Bond rows vertically</td>
<td>n2 = 2–20 pcs.</td>
</tr>
<tr>
<td>C = vertical distance</td>
<td>The minimum number of bonds is 4. The maximum number can be selected.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The minimum distance of the bond from the edge of the plate is 25 mm.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The bonds are placed in the plate at equal intervals, equalising the dimensions to the edges of the plate.</td>
<td></td>
</tr>
<tr>
<td>Minimum distances between bonds on the plate: A, C = min. 60 mm.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plate order code</th>
<th>The plate order code consists of the following information:</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKLC - (material code M, R, H) - T/B/L - (bond code) - n1/A x n2/C</td>
<td></td>
</tr>
<tr>
<td>Example: AKLC - M - 20/300/500 - TT16/150 - 3/100 x 4/140.</td>
<td></td>
</tr>
</tbody>
</table>

| Drawing, load and other information | For designing the plates, Anstar needs the information about the plate location and edge distances in the base, the preliminary drawing of the plate as well as the dimensions of the profile to be welded and its location on the plate. In addition, load combinations are needed for designing the plate. Anstar provides the plate order code and strength calculations. If the profile is not specified, the default profile is used for the calculations. |
2.2.6 AKKT fastening angle bar

The AKKT fastening angle bar is used at the corners of the structure to protect the concrete against impact. The angle bar is suitable for structures with space for the bonds. The angle bar is available in four materials, which are indicated in the code.

<table>
<thead>
<tr>
<th>Material</th>
<th>Bond Material</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>S235JR+AR</td>
<td>B500B (black)</td>
<td>Top surface and sides of the L steel are protected by painting.</td>
</tr>
<tr>
<td>1.4301 (stainless)</td>
<td>B500B (black)</td>
<td></td>
</tr>
<tr>
<td>1.4401 (stainless)</td>
<td>B500B (black)</td>
<td></td>
</tr>
</tbody>
</table>

- The angle bar material is S235JR+AR (black)
- The bonds are rebar B500B. (black)
- The top surface and sides of the L steel are protected by painting.

Table 6. Dimensions of AKKT fastening angle bars

<table>
<thead>
<tr>
<th>AKKT S235JR+AR</th>
<th>AKKTR 1.4301</th>
<th>AKKTH 1.4401</th>
<th>B (mm)</th>
<th>H (mm)</th>
<th>C (mm)</th>
<th>Ø (mm)</th>
<th>Weight (kg/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKKT 50-L</td>
<td>AKKTR 50-L</td>
<td>AKKTH 50-L</td>
<td>50</td>
<td>120</td>
<td>250</td>
<td>12</td>
<td>5.3</td>
</tr>
<tr>
<td>AKKT 80-L</td>
<td>AKKTR 80-L</td>
<td>AKKTH 80-L</td>
<td>80</td>
<td>120</td>
<td>250</td>
<td>12</td>
<td>11.2</td>
</tr>
<tr>
<td>AKKT100-L</td>
<td>AKKTR100-L</td>
<td>AKKTH100-L</td>
<td>100</td>
<td>160</td>
<td>200</td>
<td>16</td>
<td>18.0</td>
</tr>
</tbody>
</table>

Legend: B = Profile width  
        L = Bar length  
        H = Height  
        C = Distance between bonds  
        Ø = Bond diameter
3 MANUFACTURING INFORMATION

ANSTAR Oy has entered into a quality control agreement with KIWA Inspecta Oy regarding the manufacture of anchor plates. The manufacturing information is as follows:

<table>
<thead>
<tr>
<th>1. Manufacturing markings</th>
<th>Anchor plate manufacturing markings:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Anstar’s code.</td>
</tr>
<tr>
<td></td>
<td>- Product identifier.</td>
</tr>
<tr>
<td></td>
<td>- Packaging: shrink-wrapped on a pallet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Materials</th>
<th>Manufacturing materials:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Surface plate EN 10025-2 S355J2+N</td>
</tr>
<tr>
<td></td>
<td>- Surface plate EN 10088 1.4301</td>
</tr>
<tr>
<td></td>
<td>- Surface plate EN 10088 1.4401</td>
</tr>
<tr>
<td></td>
<td>- Angle bars EN 10025-2 S235JR+AR</td>
</tr>
<tr>
<td></td>
<td>- Upset bond EN 10080, SFS 1300, B500B</td>
</tr>
<tr>
<td></td>
<td>- Upset bond EN 10025-2 S235JR+AR</td>
</tr>
<tr>
<td></td>
<td>- Rebars EN 10080,SFS 1300, B500B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Manufacturing method</th>
<th>Anchor plate manufacture:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Plates are manufactured according to EN 1090-2:2018 in EXC2.</td>
</tr>
<tr>
<td></td>
<td>By special order, plates can be manufactured in execution class EXC3. [2]</td>
</tr>
<tr>
<td></td>
<td>- The welding class is C as standard and B by special order.</td>
</tr>
<tr>
<td></td>
<td>- Pin welding method: MAG manual or robot welding.</td>
</tr>
<tr>
<td></td>
<td>- Rebar welding EN 17660-1 [16]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Surface treatment methods</th>
<th>Anchor plate surface treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard delivery: Visible surface and sides protected by painting A40 μm.</td>
</tr>
<tr>
<td></td>
<td>Special order: Epoxy painting or hot-dip galvanisation HDG.</td>
</tr>
<tr>
<td></td>
<td>Austenitic: Surface plate in the normal state.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Product approval and quality control</th>
<th>Product quality control: Certificate 0416-CPR-7247-03.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Product declaration: CE marking according to EN 1090-1.</td>
</tr>
<tr>
<td></td>
<td>European Countries: Sweden, Denmark, Norway, Austria, Estonia, Latvia, Lithuania.</td>
</tr>
<tr>
<td></td>
<td>Additional information: <a href="http://www.anstar.fi/en">www.anstar.fi/en</a></td>
</tr>
</tbody>
</table>

Table 7. Anstar’s anchor bolt and anchor plate product manufacturing programme

<table>
<thead>
<tr>
<th>Products</th>
<th>User manual</th>
<th>Typical application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ATP AHP</td>
<td>Rebar bolts</td>
<td>Foundation bolt connections in office, commercial and public buildings. Concrete and steel frames as well as composite column frames.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bolt connections of light industrial building foundations in concrete and steel frames.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light connections of machinery and equipment foundations to concrete.</td>
</tr>
<tr>
<td>2 ALP-LC ALP-PC ALP-P2 and S series with removable thread</td>
<td>Anchor bolts</td>
<td>Heavy-duty foundation connections of industrial concrete element frames.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moment rigid beam-to-column connections in concrete element frames.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Foundation connections in shear walls.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heavy-duty column-to-foundation connections.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other heavy-duty bolt connections to concrete.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heavy-duty connections of machinery and equipment foundations to concrete.</td>
</tr>
<tr>
<td>3 ARJ</td>
<td>Reinforcement coupler</td>
<td>Reinforcement coupler connection.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bolt applications in reinforcement couplers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moment rigid beam-to-column connection.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tension bar structures.</td>
</tr>
<tr>
<td>4 KL, AKL, JAL AKLP, Aklj,</td>
<td>Anchor plates</td>
<td>Anchor plates placed in concrete structures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project-specific custom anchor plates.</td>
</tr>
<tr>
<td>5 ADE-T, -P ADK-T, -P</td>
<td>Bracing connections</td>
<td>Anchor components for stabilising steel bracings in concrete element frames.</td>
</tr>
</tbody>
</table>
4 DESIGN CRITERIA

4.1 Design and manufacturing standards

1. Finnish standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFS-EN 13670</td>
<td>Execution of concrete structures, execution class 2 or 3. [17]</td>
</tr>
</tbody>
</table>

2. Other countries in the European Code area

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EN-1992-4:2018</td>
</tr>
<tr>
<td>Germany</td>
<td>DIN-EN 1992-1-1 +NA/2013-04</td>
</tr>
</tbody>
</table>

3. Connection piece manufacture

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN 1090-1</td>
<td>Execution of steel structures. Part 1: Requirements for conformity assessment of structural components. [1]</td>
</tr>
<tr>
<td>EN 13670</td>
<td>Execution of concrete structures. Execution class 2 or 3. [17]</td>
</tr>
</tbody>
</table>

4.2 Anchor plate resistance

4.2.1 Calculation theory

1. Calculation method

The resistance values of the anchor plates are specified in accordance with the EN 1992-4:2018 [24] standard. For the other structures of the plate, European standards [6][8] are followed where applicable. If necessary, the plate can be analysed according to the older standard CEN/TS 1992-4-2. [9][10].

The resistance values of the anchor plate are determined, and the strength calculation performed using Anstar’s ASTEEL software. The profile welded to the plate transfers the forces to the bonds, from which they are transferred to the concrete through the failure criteria of standard [24]. The anchor plate calculations are performed using the FEM method, with which the actual force quantities (= prying effect) are determined on the basis of the plate deformations and displacements. The shape and location of the profile to be welded to the surface can be freely selected, in which case the forces on the bonds are determined by the shape and actual location of the connected profile and the rigidity of the plate.

The anchor plate calculation method is elastic-plastic (semi rigid), taking into account the displacement caused by the plasticisation of the surface plate and determining the forces on the bonds on the basis of the deformations of the plate. The software performs the surface plate’s stress state and deformation state calculation for the base concrete. Designing for ultimate and accident limit state loads is performed for the anchor plate using
failure criteria in accordance with standard [24]. For the KL anchor plate, the corresponding failure criteria are analysed where applicable for the plate structure.

The anchor plate is designed for use in a reinforced structure where the forces are transferred using reinforcement added in the plate area. The plate can be designed without reinforcement. The reinforcement criteria and edge distance requirements are specified in Section 4.3.1.

2. Partial safety factors
The partial safety factors for plate resistances are taken into account in the ultimate and accident limit states according to EN 1992-4:2018, Table 4.1. Resistance values to which standard [24] cannot be applied are designed according to European standards [6] and [8].

4.2.2 Failure criteria

1. Axial force and bending moment
Axial force failure criteria analyse according to standard [24] are conducted for the anchor plate. Analyses other than items 3 and 4 are conducted for the KL plate. The failure criteria take into account the distance of the bonds from the edge of the structure and other bonds as well as from the adjacent anchor plate and the openings in the structure. The analysis is performed for the plate and all the bonds, the most dominant of which design the anchor plate.

<table>
<thead>
<tr>
<th>Failure criterion</th>
<th>Variable</th>
<th>Calculation method and applicable standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Steel failure</td>
<td>( N_{Rd,s} )</td>
<td>The steel tensile resistance of the bond is calculated using the partial safety factors of materials indicated in EN 1992-4:2018, Table 4.1.</td>
</tr>
<tr>
<td>2. Concrete cone</td>
<td>( N_{Rd,c} )</td>
<td>The concrete cone failure criterion is calculated for bonds in tension.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The anchoring of the bonds of KL anchor plates is based on the anchoring resistance of the rebar bond according to the standard:</td>
</tr>
<tr>
<td>3. Pull-out</td>
<td>( N_{Rd,p} )</td>
<td>The pull-out failure criterion is calculated for the bond.</td>
</tr>
<tr>
<td>4. Blow-out</td>
<td>( N_{Rd,cb} )</td>
<td>The blow-out failure criterion is calculated for bonds at the edge of the structure.</td>
</tr>
<tr>
<td>5. Tensile resistance of reinforcement</td>
<td>( N_{Rd,reb} )</td>
<td>The reinforcement and tensile resistance of the anchor plate are determined by the condition:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ( N_{Rd,reb} &gt; N_{Rd,c} ).</td>
</tr>
<tr>
<td>6. Tensile resistance of the plate and bond</td>
<td>( N_{Rd} )</td>
<td>The tensile resistance the anchor plate and bond is determined as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Non-reinforced structure:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ( N_{Rd} = \min(N_{Rd,s}; N_{Rd,c}; N_{Rd,p}; N_{Rd,cb}) )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Structure with tensile reinforcement:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ( N_{Rd} = \min(N_{Rd,s}; N_{Rd,re}; N_{Rd,p}; N_{Rd,cb}), )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>when ( N_{Rd,reb} &gt; N_{Rd,c} ).</td>
</tr>
<tr>
<td>7. Surface plate stress state</td>
<td>( \delta_{ vert } )</td>
<td>FEM analysis is conducted for the surface plate, and von Mises stress state is calculated for the forces coming through the profile to be connected. The plate’s stress state safety factor level and utilisation rate are calculated according to the standard:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Elastic-plastic, semi rigid joint ( \delta_{ vert } = f_{U} / \gamma_{M2}, \gamma_{M2} = 1.25 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Elastic, rigid joint ( \delta_{ vert } = f_{U} / \gamma_{M} , \gamma_{M} = 1 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The deformed geometry from deformations is calculated for the plate.</td>
</tr>
</tbody>
</table>
8. Design of the profile and weld

<table>
<thead>
<tr>
<th>$F_{w, Rd}$</th>
<th>The stress and utilisation rate are calculated for the profile to be welded to the anchor plate. The analysis is performed at the surface of the plate.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- EN 1993-1-1, Section 6.2, Formula 6.1. This method does not perform slenderness analysis of the sheet metal parts for the profile.</td>
</tr>
<tr>
<td></td>
<td>The profile’s fillet weld to the plate is designed according to the standard:</td>
</tr>
<tr>
<td></td>
<td>- EN 1993-1-8, Section 4.5, Formula 4.</td>
</tr>
<tr>
<td></td>
<td>- The standard to be applied for butt and double-bevel butt welds is EN 1993-1-1, Formula 6.1.</td>
</tr>
</tbody>
</table>

9. Stress state of the base concrete

<table>
<thead>
<tr>
<th>$\delta_c$</th>
<th>As regards the base concrete of the surface plate, the axial force coming from the plate is subjected to stress analysis in the FEM calculation.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- The design criterion for the compressive stress of the concrete has been limited to the value specified in EN 1992-1-1: $\delta_c \leq f_{cd}$</td>
</tr>
<tr>
<td></td>
<td>- For plates under heavy compressive loads, the concrete stress analysis can be performed even if the other resistances of the plate are not dominant.</td>
</tr>
</tbody>
</table>

10. Supplementary reinforcement stress state for characteristic value of loads.

<table>
<thead>
<tr>
<th>$\delta_i$</th>
<th>The stress state caused by characteristic value of loads is calculated for the plate’s reinforcement, enabling concrete crack analysis at the edge of the structure.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Shear force and torsional moment

The following shear force failure criteria analyses according to standard [24] are conducted for the anchor plates. The same analyses, except for item 2, are conducted for KL plates. The failure criteria take into account the distance of the bonds from the edge of the structure and other bonds as well as from the adjacent anchor plate and the openings in the structure. The calculation is performed for the plate and all the bonds, the most dominant of which design the anchor plate.

<table>
<thead>
<tr>
<th>1. Steel failure</th>
<th>$V_{Rd,s}$</th>
<th>The steel shear resistance of the bond arm is calculated using the partial safety factors indicated in EN 1992-4:2018, Table 4.1, and using Formula 7.34.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Pry-out</td>
<td>$V_{Rd,cp}$</td>
<td>The pry-out failure criterion is calculated for the plate and bond.</td>
</tr>
<tr>
<td>3. Concrete edge</td>
<td>$V_{Rd,c}$</td>
<td>The bond’s edge compression resistance $V_{Rd,c}$ is determined according to EN 1992-4:2018, Formula 7.40. Reinforcement coefficient $q_{re,v} = 1.0$. The value is calculated for the bond towards the nearest edge or in the direction of the shear force. Minimum shear resistance of the bond: $V_{Rd,c, min} = \min(V_{Rd,s} ; V_{Rd,cp} ; V_{Rd,c})$ Anchor plate shear resistance: $V_{Rd,c, levy} = n \times V_{Rd,c, min}$, where $n = \text{number of bonds per plate}$ and $V_{Rd,c, min} = \text{minimum shear resistance of the bonds}$.</td>
</tr>
<tr>
<td>Edge compression resistance. Without shear reinforcement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Concrete edge</td>
<td>$V_{Rd,c}$</td>
<td>The bond’s edge compression resistance $V_{Rd,c}$ is determined according to EN 1992-4:2018, Formula 7.40. Reinforcement coefficient $q_{re,v} = 1.4$. The value is calculated for the bond closest to the edge and in the direction of the shear force. Minimum shear resistance of the bond, reinforced: $V_{Rd,c, min} = \min(V_{Rd,s} ; V_{Rd,cp} ; V_{Rd,re})$, when $\min(V_{Rd,c}) \neq 0$. Anchor plate shear resistance: $V_{Rd,c, levy} = n \times V_{Rd,c, min}$, where $n = \text{number of bonds per plate}$ and $V_{Rd,c, min} = \text{minimum shear resistance of the bond}$. The shear force is transferred using supplementary reinforcement.</td>
</tr>
<tr>
<td>Edge compression resistance. With shear reinforcement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

User manual  
Anchor plates  
Revision 11/2020
5. Reinforcement resistance  \( V_{Rd,re} \) The reinforcement of the bond for shear force is determined by the condition:
- \( V_{Rd,re} \geq V_{Rd,c} \)

6. Torsional moment  \( V_{Rd,c} \) The torsional moment is converted into shear force components for all the bonds at their distance from the centre of the plate. The diagonal shear force component of the bond is further divided into forces in the directions of the major axes, which are then added to the external shear force on the bond. The torsional and shear force components are calculated as follows:
\[
V_{xi} = V_{x,so} / h + T_d x_i / (\Sigma (x_i^2 + y_i^2))
\]
The resistances are calculated as in items 3, 4 and 5.

7. Resultant of the torsional and shear forces  \( V_{Rd,s} \) The shear and torsional force components are used to calculate the shear resultant for which the steel shear resistance is calculated.

### 3. Combined resistance, tension and shear
The tensile and shear force failure criteria are combined for the anchor plate according to the following principles. The calculation is performed for each individual bond, the largest of which is dominant in terms of the resistance of the plate.

1. Steel resistance of the plate anchors
   - The combined steel tensile and shear resistance is calculated for the bond.
   - \( (N_{Ed} / N_{Rd,i})^2 + (V_{Ed} / V_{Rd,i})^2 \leq 1 \) (7.54)

2. Concrete resistance of the plate anchors
   - Combined concrete tensile and shear resistance is calculated for the bond using formulas 7.55 and 7.56 in a situation where reinforcement is not used or where both force components are transferred through the reinforcement.
   - The formula takes into account steel resistance, if it is determining.
   - \( (N_{Ed} / N_{Rd,i})^{1.5} + (V_{Ed} / V_{Rd,i})^{1.5} \leq 1 \) (7.55)
   - or \( (N_{Ed} / N_{Rd,i}) + (V_{Ed} / V_{Rd,i}) \leq 1.2 \) (7.56)

3. Concrete resistance of the plate anchors
   - Combined concrete tensile and shear resistance is calculated for the bond using formula 7.57 in a situation where only one force component (tensile or shear) is transferred through the reinforcement and the other through the bond.
   - Exponent \( k_{11} = 0.67 \).
   - The formula takes into account steel resistance, if it is determining.
   - \( (N_{Ed} / N_{Rd,i})^{k_{11}} + (V_{Ed} / V_{Rd,i})^{k_{11}} \leq 1 \) (7.57)

4. Anchor plate resistance
   - The anchor plate resistance is determined by the highest utilisation rate in the combination of the bond failure criteria.

### 4.3 Anchor plate resistances

#### 4.3.1 Design criteria
The resistance tables for anchor plate have been specified according to the following principles:

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Resistant tables have been prepared for concrete C25/30, grade 2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The concrete is cracked.</td>
<td></td>
</tr>
<tr>
<td>- The bonding condition for reinforcement and the KL plate bonds is good.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resistances</th>
<th>The following resistance design values are calculated for the anchor plates:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- ( N_{Rd} = ) Axial force resistance, design value.</td>
<td></td>
</tr>
<tr>
<td>- ( M_{Rxd} = ) Bending moment resistance, design value in the X direction.</td>
<td></td>
</tr>
<tr>
<td>- ( M_{Ryd} = ) Bending moment resistance, design value in the Y direction.</td>
<td></td>
</tr>
</tbody>
</table>
- $V_{Rxd} = \text{Shear force resistance, design value in the X direction.}$
- $V_{Ryd} = \text{Shear force resistance, design value in the Y direction.}$
- $T_{Rd} = \text{Torsional moment resistance, design value.}$

The values in the table represent the maximum resistance of each design value with the materials, reinforcement, edge distance and basic eccentricity provided, while the other design forces are simultaneously zero. If the plate is subject to two or more design forces at the same time, its resistance must be calculated using the ASTEEL software. In this case, the tables cannot be used. The accident limit state must be calculated using the ASTEEL software.

3. Reinforcing a connection

**Non-reinforced structure:**
- The anchor plates are placed in a structure with the minimum splitting or stirrup reinforcement or other reinforcement for structures in accordance with EN 1992-1-1.
- No plate-specific reinforcement is placed in the area of the anchor plate.
- The distance of the anchor plate from the edge of the structure is in accordance with item 8/1.
- The anchor plate may also be located in a fully non-reinforced structure, which is non-splitting and is in a permanently compressed state. (= top surface of slab/footing/beam, heavy-duty column/wall)

**Reinforced structure:**
- The anchor plates are placed in a structure with the minimum splitting or stirrup reinforcement for structures in accordance with EN 1992-1-1.
- All the forces on the anchor plate are transferred through plate-specific tensile and/or shear reinforcement.

4. Edge distances

The anchor plate resistances have been calculated according to four minimum edge distances, taking into account the anchor plate reinforcement. An edge distance limiting the resistance of the plate is formed in the following conditions:
- There is at least one base edge near the plate that is parallel to the edge of the plate.
- There is an opening or other significant weakening in the structure next to the plate.
- There is another anchor plate or other significant point load near the plate.
- The structure’s thickness $h$ is lower than $h < 1.5 h_{ef}$.

5. Fastening area and calculation profile

The tables have been calculated with a rectangular hollow section welded to the plate through which the forces are transferred to the anchor plate. The calculation profile transfers the forces according to the resistance values to the plate. The calculation profile represents the calculated fastening area according to the resistance in the table. The profile type and location affect the resistance values. If the profile is changed, the effect must be assessed using the software.

6. Eccentricity of the connected profile

The calculated eccentricity of the resistance table profile in the directions of the X- and Y-axes is 10% of the surface plate side length in the direction of the axis or a maximum of 20 mm. (5 mm manufacturing and 15 mm installation tolerance.)

7. Design a surface plate

The surface plate resistance has been calculated with the ASTEEL software as a semi rigid joint. The von Mises stress state of the plate has been calculated according to EN 1993-1-8, Formula 6.1. The surface plate materials are: S355J2+N, 1.4301 and 1.4401. The resistance values in the tables are only valid for the material in question. Other materials must be checked using the ASTEEL software.

8. Table preparation principles

The resistance tables have been calculated for three edge distances: **Tables 8, 11 and 14. Plate is locator on large structure**

1. **Maximum axial force resistance non-reinforced structure.**
   - Dimensions X1 and Y1 are the minimum distance from the centre of the plate to the edge of the structure when:
     - the determining failure criterion is concrete Cone resistance and bending resistance of base plate
     - there is not additional tension reinforcement.

2. **Maximum axial force resistance reinforced structure.**
Dimensions X2 and Y2 are the minimum distance from the centre of the plate to the edge of the structure when:
- the determining failure criterion is concrete Cone resistance with additional reinforcement and bending resistance of base plate
- there are additional tension reinforcement around the plate

<table>
<thead>
<tr>
<th>Tables 9, 12 and 15. Plate is located on large structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Maximum shear force resistances non reinforced structure.</td>
</tr>
<tr>
<td>Dimensions X1 and Y2 are the distance from the centre of the plate to the edge of the structure when:</td>
</tr>
<tr>
<td>- the determining failure criterion is concrete shear resistance without supplementary shear reinforcement. $V_{Rd} = V_{Rd,c} \geq V_{Rd,s}$</td>
</tr>
<tr>
<td>- there is not additional shear reinforcement.</td>
</tr>
</tbody>
</table>

Dimensions X1 and Y2 are the distance from the centre of the plate to the edge of the structure when:
- the determining failure criterion is concrete shear resistance with supplementary shear reinforcement. $V_{Rd} = V_{Rd,c} \geq V_{Rd,s}$
- there are additional shear reinforcement.

<table>
<thead>
<tr>
<th>Tables 10, 13 and 16. Plate is located on the corner of structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Maximum axial and shear force resistances on the edge of structure</td>
</tr>
<tr>
<td>Dimensions X3 and Y3 are the distance from the centre of the plate to the edge of the structure when:</td>
</tr>
<tr>
<td>- KL base plate is 25 mm distance of the edge of structure</td>
</tr>
<tr>
<td>- AKL base plate is 35 mm distance of the edge of structure</td>
</tr>
<tr>
<td>- JAL base plate is 50 mm distance of the edge of structure</td>
</tr>
<tr>
<td>- the determining failure criterion is concrete shear resistance with supplementary shear reinforcement. $V_{Rd} = V_{Rd,c} \geq V_{Rd,s}$</td>
</tr>
<tr>
<td>- there are additional shear reinforcement.</td>
</tr>
</tbody>
</table>

### 4.3.2 Anchor plate edge distance

When designing anchor plates, the edge distances are specified in the software as follows:

<table>
<thead>
<tr>
<th>1. Origin of the base and plate</th>
<th>The origin of the structure is located on the top surface in the middle of the anchor plate, from which the base distances (±X axis, ±Y axis) to the edge of the structure are measured.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Specifying the edge of the structure</td>
<td>The edge is either the physical or calculated edge of the base, and it is parallel to the edge of the surface plate.</td>
</tr>
<tr>
<td>3. Opening in the structure</td>
<td>An opening in the structure forms a calculated edge for the anchor plate.</td>
</tr>
<tr>
<td>4. Adjacent anchor plate</td>
<td>An adjacent anchor plate forms a calculated edge for the plate, located halfway between the plates.</td>
</tr>
<tr>
<td>5. Point load or other weakening</td>
<td>A point load on the base or other weakening of the structure forms a calculated edge for the plate. The designer assesses the significance of items 3, 4 and 5 for the plate in the dimensions of the base.</td>
</tr>
<tr>
<td>6. Minimum edge distance and thickness of the base</td>
<td>The anchor plate resistance for the edge distance does not usually become dominant if the distance of the centre of the plate from the edge of the structure is $d \geq s/2+1.5h_{ref}$. If the plate is closer to the edge, it must always be reinforced, and the resistances checked. The plate can also be placed at the edge of the structure at a distance equal to</td>
</tr>
</tbody>
</table>
4.3.3 KL anchor plate

The resistance values of the individual force quantities of KL anchor plates are presented in tables 8–9 for the forces in the ultimate limit state. The resistance is only valid for one force at a time.

Table 8. KL anchor plate axial force resistances, design values.

<table>
<thead>
<tr>
<th>KL</th>
<th>KLR</th>
<th>KLH</th>
<th>Anchor plate axial force resistance</th>
<th>Minimum edge distance axial force</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N_Rd</td>
<td>M_Rvd</td>
<td>M_Ryd</td>
</tr>
<tr>
<td>KL 100/100</td>
<td>55</td>
<td>1,8</td>
<td>1,8</td>
<td>75/75</td>
<td>75/75</td>
</tr>
<tr>
<td>KL 100/150</td>
<td>69</td>
<td>3,2</td>
<td>2,0</td>
<td>75/100</td>
<td>75/100</td>
</tr>
<tr>
<td>KL 150/150</td>
<td>90</td>
<td>4,9</td>
<td>4,9</td>
<td>100/100</td>
<td>100/100</td>
</tr>
<tr>
<td>KL 100/200</td>
<td>87</td>
<td>6,5</td>
<td>3,0</td>
<td>75/125</td>
<td>75/125</td>
</tr>
<tr>
<td>KL 100/300</td>
<td>140</td>
<td>20,0</td>
<td>6,0</td>
<td>75/175</td>
<td>75/175</td>
</tr>
<tr>
<td>KL 200/200</td>
<td>146</td>
<td>8,5</td>
<td>8,5</td>
<td>125/125</td>
<td>125/125</td>
</tr>
<tr>
<td>KL 250/250</td>
<td>146</td>
<td>16,0</td>
<td>16,0</td>
<td>150/150</td>
<td>150/150</td>
</tr>
<tr>
<td>KL 200/300</td>
<td>165</td>
<td>22,6</td>
<td>12,0</td>
<td>125/175</td>
<td>125/175</td>
</tr>
<tr>
<td>KL 300/300</td>
<td>165</td>
<td>24,0</td>
<td>24,0</td>
<td>175/175</td>
<td>175/175</td>
</tr>
</tbody>
</table>

Table 9. KL anchor plate shear force resistances, design values.

<table>
<thead>
<tr>
<th>KL</th>
<th>KLR</th>
<th>KLH</th>
<th>Anchor plate shear force resistance</th>
<th>Minimum edge distance shear force X1 or X2 is direction of force</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>V_Rvd</td>
<td>V_Ryd</td>
<td>T_Rd</td>
</tr>
<tr>
<td>KL 100/100</td>
<td>53</td>
<td>53</td>
<td>3,1</td>
<td>300/450</td>
<td>230/350</td>
</tr>
<tr>
<td>KL 100/150</td>
<td>53</td>
<td>45</td>
<td>4,3</td>
<td>300/450</td>
<td>230/350</td>
</tr>
<tr>
<td>KL 150/150</td>
<td>74</td>
<td>74</td>
<td>6,7</td>
<td>400/600</td>
<td>320/480</td>
</tr>
<tr>
<td>KL 100/200</td>
<td>74</td>
<td>60</td>
<td>7,0</td>
<td>400/600</td>
<td>320/480</td>
</tr>
<tr>
<td>KL 100/300</td>
<td>125</td>
<td>115</td>
<td>18,0</td>
<td>610/920</td>
<td>480/720</td>
</tr>
<tr>
<td>KL 200/200</td>
<td>125</td>
<td>125</td>
<td>16,7</td>
<td>610/920</td>
<td>480/720</td>
</tr>
<tr>
<td>KL 250/250</td>
<td>125</td>
<td>125</td>
<td>21,0</td>
<td>610/920</td>
<td>480/720</td>
</tr>
<tr>
<td>KL 200/300</td>
<td>125</td>
<td>115</td>
<td>18,0</td>
<td>610/920</td>
<td>480/720</td>
</tr>
<tr>
<td>KL 300/300</td>
<td>133</td>
<td>133</td>
<td>26,0</td>
<td>610/920</td>
<td>480/720</td>
</tr>
</tbody>
</table>
### 4.3.4 AKL anchor plate

The resistance values of the individual force of AKL anchor plates are presented in tables 11–13 for the forces in the ultimate limit state. The resistance is only valid for one force at a time.

#### Table 11. AKL anchor plate axial force resistances, design values.

<table>
<thead>
<tr>
<th>KL</th>
<th>KLR</th>
<th>KLH</th>
<th>Anchor plate resistance values axial and shear force</th>
<th>Fastening area</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$N_{Rd}$ kN $M_{Rxd}$ kNm $M_{Ryd}$ kNm $V_{Rxd}$ kN $V_{Ryd}$ kN $T_{Rd}$ kNm</td>
<td>Additional reinforcing X3/Y3</td>
<td>Calculation profile</td>
</tr>
<tr>
<td>KL 100/100</td>
<td>55</td>
<td>1,8</td>
<td>1,8</td>
<td>8,3</td>
<td>8,3</td>
</tr>
<tr>
<td>KL 100/150</td>
<td>69</td>
<td>3,2</td>
<td>2,0</td>
<td>11,1</td>
<td>8,9</td>
</tr>
<tr>
<td>KL 150/150</td>
<td>90</td>
<td>4,9</td>
<td>4,9</td>
<td>13,8</td>
<td>13,8</td>
</tr>
<tr>
<td>KL 100/200</td>
<td>87</td>
<td>6,5</td>
<td>3,0</td>
<td>17,5</td>
<td>11,3</td>
</tr>
<tr>
<td>KL 100/300</td>
<td>140</td>
<td>20,0</td>
<td>6,0</td>
<td>21,5</td>
<td>12,5</td>
</tr>
<tr>
<td>KL 200/200</td>
<td>146</td>
<td>8,5</td>
<td>8,5</td>
<td>20,1</td>
<td>20,1</td>
</tr>
<tr>
<td>KL 250/250</td>
<td>146</td>
<td>16,0</td>
<td>16,0</td>
<td>25,4</td>
<td>25,4</td>
</tr>
<tr>
<td>KL 200/300</td>
<td>165</td>
<td>22,6</td>
<td>12,0</td>
<td>29,8</td>
<td>20,5</td>
</tr>
<tr>
<td>KL 300/300</td>
<td>165</td>
<td>24,0</td>
<td>24,0</td>
<td>30,9</td>
<td>30,9</td>
</tr>
</tbody>
</table>

#### Table 12. AKL anchor plate shear force resistances, design values.

<table>
<thead>
<tr>
<th>AKL</th>
<th>AKLR</th>
<th>AKLH</th>
<th>Anchor plate shear force resistance</th>
<th>Minimum edge distance shear force</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$V_{Rxd}$ kN $V_{Ryd}$ kN $T_{Rd}$ kNm</td>
<td>No additional reinforcing X1/Y1</td>
<td>Additional reinforcing X2/Y2</td>
</tr>
<tr>
<td>AKL 100/100</td>
<td>28</td>
<td>0,9</td>
<td>0,9</td>
<td>130/130</td>
<td>85/85</td>
</tr>
<tr>
<td>AKL 100/150</td>
<td>31</td>
<td>1,4</td>
<td>0,7</td>
<td>130/150</td>
<td>85/110</td>
</tr>
<tr>
<td>AKL 150/150</td>
<td>84</td>
<td>5,7</td>
<td>5,7</td>
<td>150/150</td>
<td>110/110</td>
</tr>
<tr>
<td>AKL 100/200</td>
<td>70</td>
<td>5,5</td>
<td>2,8</td>
<td>130/170</td>
<td>85/135</td>
</tr>
<tr>
<td>AKL 100/300</td>
<td>103</td>
<td>12,7</td>
<td>6,1</td>
<td>130/250</td>
<td>85/185</td>
</tr>
<tr>
<td>AKL 200/200</td>
<td>113</td>
<td>10,0</td>
<td>10,0</td>
<td>170/170</td>
<td>135/135</td>
</tr>
<tr>
<td>AKL 250/250</td>
<td>102</td>
<td>16,3</td>
<td>16,3</td>
<td>220/220</td>
<td>160/160</td>
</tr>
<tr>
<td>AKL 200/300</td>
<td>112</td>
<td>16,1</td>
<td>11,7</td>
<td>170/250</td>
<td>135/185</td>
</tr>
<tr>
<td>AKL 300/300</td>
<td>135</td>
<td>21,5</td>
<td>21,5</td>
<td>250/250</td>
<td>185/185</td>
</tr>
</tbody>
</table>

#### Table 13. AKL anchor plate at the edge of structure, design values. Plate’s edge distance 25 mm.

<table>
<thead>
<tr>
<th>KL</th>
<th>KLR</th>
<th>KLH</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Calculation profile</td>
</tr>
<tr>
<td>KL 100/100</td>
<td>55</td>
<td>1,8</td>
<td>75/75</td>
</tr>
<tr>
<td>KL 100/150</td>
<td>69</td>
<td>3,2</td>
<td>75/100</td>
</tr>
<tr>
<td>KL 150/150</td>
<td>90</td>
<td>4,9</td>
<td>100/100</td>
</tr>
<tr>
<td>KL 100/200</td>
<td>87</td>
<td>6,5</td>
<td>75/125</td>
</tr>
<tr>
<td>KL 100/300</td>
<td>140</td>
<td>20,0</td>
<td>75/175</td>
</tr>
<tr>
<td>KL 200/200</td>
<td>146</td>
<td>8,5</td>
<td>125/125</td>
</tr>
<tr>
<td>KL 250/250</td>
<td>146</td>
<td>16,0</td>
<td>150/150</td>
</tr>
<tr>
<td>KL 200/300</td>
<td>165</td>
<td>22,6</td>
<td>125/175</td>
</tr>
<tr>
<td>KL 300/300</td>
<td>165</td>
<td>24,0</td>
<td>175/175</td>
</tr>
</tbody>
</table>

Note: Additional reinforcing profiles X3/Y3 and X2/Y2 are shown in the calculation profile column.
### 4.3.5 JAL anchor plate

The resistance values of the individual force of JAL anchor plates are presented in tables 14–16 for the forces in the ultimate limit state. The resistance is only valid for one force at a time.

#### Table 14. JAL anchor plate axial force resistances, design values.

<table>
<thead>
<tr>
<th>KL</th>
<th>KLR</th>
<th>KLH</th>
<th>Anchor plate resistance values (axial and shear force)</th>
<th>Minimum edge distance (axial force)</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$N_{Rd}$, kN</td>
<td>$M_{Rxd}$, kNm</td>
<td>$M_{Ryd}$, kNm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 150/150</td>
<td>161</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 150/200</td>
<td>173</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 150/250</td>
<td>154</td>
<td>15.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 200/200</td>
<td>162</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 200/250</td>
<td>193</td>
<td>37.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 250/250</td>
<td>200</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 300/300</td>
<td>262</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 400/400</td>
<td>310</td>
<td>52.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 500/500</td>
<td>425</td>
<td>140.0</td>
</tr>
</tbody>
</table>

#### Table 15. JAL anchor plate shear force resistances, design values.

<table>
<thead>
<tr>
<th>AKL</th>
<th>AKLR</th>
<th>AKLH</th>
<th>Anchor plate shear force resistance</th>
<th>Minimum edge distance (shear force)</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$V_{Rxd}$, kN</td>
<td>$V_{Ryd}$, kN</td>
<td>$T_{Rd}$, kNm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 150/150</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 150/200</td>
<td>187</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 150/250</td>
<td>195</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 200/200</td>
<td>195</td>
<td>195</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 200/250</td>
<td>198</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 250/250</td>
<td>204</td>
<td>204</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 300/300</td>
<td>310</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 300/300</td>
<td>327</td>
<td>327</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 400/400</td>
<td>335</td>
<td>335</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AKL 500/500</td>
<td>340</td>
<td>340</td>
</tr>
</tbody>
</table>
Table 16. AKL anchor plate at the edge of structure, design values. Plate’s distance 35 mm.

<table>
<thead>
<tr>
<th>KL</th>
<th>KLR</th>
<th>KLH</th>
<th>Anchor plate resistance values</th>
<th>Fastening area</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N_{Rd} kN</td>
<td>M_{Rxd} kN</td>
<td>M_{Ryd} kN</td>
</tr>
<tr>
<td>JAL 150/150</td>
<td>161</td>
<td>13.5</td>
<td>13.5</td>
<td>18.0</td>
<td>18.0</td>
</tr>
<tr>
<td>JAL 150/200</td>
<td>173</td>
<td>17.0</td>
<td>16.9</td>
<td>22.5</td>
<td>21.0</td>
</tr>
<tr>
<td>JAL 150/250</td>
<td>154</td>
<td>15.8</td>
<td>15.0</td>
<td>28.5</td>
<td>23.0</td>
</tr>
<tr>
<td>JAL 200/200</td>
<td>192</td>
<td>26.0</td>
<td>26.0</td>
<td>25.0</td>
<td>25.0</td>
</tr>
<tr>
<td>JAL 200/250</td>
<td>193</td>
<td>37.0</td>
<td>21.0</td>
<td>29.2</td>
<td>27.3</td>
</tr>
<tr>
<td>JAL 250/250</td>
<td>200</td>
<td>40.0</td>
<td>40.0</td>
<td>30.2</td>
<td>30.2</td>
</tr>
<tr>
<td>JAL 200/300</td>
<td>262</td>
<td>45.0</td>
<td>24.0</td>
<td>40.1</td>
<td>31.4</td>
</tr>
<tr>
<td>JAL 300/300</td>
<td>289</td>
<td>52.0</td>
<td>52.0</td>
<td>40.0</td>
<td>40.0</td>
</tr>
<tr>
<td>JAL 400/400</td>
<td>365</td>
<td>100.0</td>
<td>100.0</td>
<td>52.0</td>
<td>52.0</td>
</tr>
<tr>
<td>JAL 500/500</td>
<td>425</td>
<td>140.0</td>
<td>140.0</td>
<td>53.0</td>
<td>53.0</td>
</tr>
</tbody>
</table>

4.3.6 AKLP and AKLJ anchor plates

The resistances of AKLP and AKLJ anchor plates have been specified as follows:

1. Resistances
   - Resistance values have been calculated for a group of four bonds located at the centre of the profile. See the figure.
   - The plate is loaded with several connection profiles whose c/c distance is ≥ 200 < 400 mm. The resistances are provided in Table 14.
   - If the distance of the connection profiles in the Y direction is ≥ 400 mm, the resistance values can be approximately doubled.
   - Table 15 should also be used if there will only be one profile on the plate.
   - Cases deviating from the tables are calculated using the ASTEEL software.

2. Supplementary reinforcement
   - Long anchor plates do not require tensile and shear reinforcement with the design criteria of tables 14 and 15.
   - Other reinforcement of the structure is used to replace plate-specific A_{st} supplementary reinforcement.
   - Standard stirrup reinforcement is used as the reinforcement for columns and beams.
   - Structural surface meshes are used as the reinforcement for slabs and walls.

3. Using the ASTEEL software
   - The plate is always calculated in the ASTEEL software as a group of four bonds whose edge distances in the Y direction are ± 200 mm. The edge distance in the X direction is determined case-specifically.
   - The acceptance limit for utilisation rates in the software is as follows:
     - If the c/c distance of the connection profiles is 200–400 mm, the utilisation rates are left at the ≤ 0.5 level.
     - If the c/c distance of the connection profiles is ≥ 400 mm, utilisation rates of ≤ 1.0 are acceptable.

4. Using the resistance tables
   - Table 17.
     - The resistance values in the table have been calculated for several profiles, whose c/c distance is in the range of ≥ 200 < 400 mm.
     - The resistance values in the table have been calculated for the Y direction edge distance of ± 200 mm.
     - The edge distance in the X direction has been specified with the column dimensions 280–480 mm.
   - Table 18.
     - The resistance values in the table have been calculated for several profiles, whose c/c distance is in the range of ≥ 400 mm.
- The resistance values in the table have been calculated for the Y direction edge distance of ≥ 200 mm.
- The edge distance in the X direction has been specified with the column dimensions 280–480 mm.
- With this edge placement, supplementary reinforcement is provided for the plates in accordance with Table 20.
- Anchor plate close to the edge of the structure
- If the plate is close to the edge of the structure in the X direction (≥ 35 mm), the resistances are calculated using the ASTEEL software.

### Table 17. AKLP, -J plate resistances, design values. Profile spacing c/c ≥ 200 < 400 mm.

<table>
<thead>
<tr>
<th>AKLP and AKLJ plate</th>
<th>Anchor plate resistance values</th>
<th>Minimum edge distance</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$N_{Rd}$ kN</td>
<td>$M_{Rxd}$ kNm</td>
<td>$M_{Ryd}$ kNm</td>
</tr>
<tr>
<td>AKLJ 100/L</td>
<td>32</td>
<td>3.2</td>
<td>1.3</td>
</tr>
<tr>
<td>AKLJ 150/L</td>
<td>35</td>
<td>3.5</td>
<td>2.0</td>
</tr>
<tr>
<td>AKLJ 200/L</td>
<td>46</td>
<td>4.2</td>
<td>2.8</td>
</tr>
<tr>
<td>AKLJ 300/L</td>
<td>47</td>
<td>4.5</td>
<td>4.4</td>
</tr>
<tr>
<td>AKLJ 400/L</td>
<td>47</td>
<td>4.6</td>
<td>4.5</td>
</tr>
<tr>
<td>AKLJ 300/L</td>
<td>80</td>
<td>8.0</td>
<td>7.7</td>
</tr>
<tr>
<td>AKLJ 400/L</td>
<td>84</td>
<td>8.5</td>
<td>12.0</td>
</tr>
<tr>
<td>AKLJ 500/L</td>
<td>110</td>
<td>12.0</td>
<td>20.0</td>
</tr>
<tr>
<td>AKLJ 600/L</td>
<td>120</td>
<td>12.0</td>
<td>25.0</td>
</tr>
</tbody>
</table>

### Table 18. AKLP and AKLJ plate resistances, design values. Profile spacing c/c ≥ 400 mm.

<table>
<thead>
<tr>
<th>AKLP and AKLJ plate</th>
<th>Anchor plate resistance values</th>
<th>Minimum edge distance</th>
<th>Fastening area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$N_{Rd}$ kN</td>
<td>$M_{Rxd}$ kNm</td>
<td>$M_{Ryd}$ kNm</td>
</tr>
<tr>
<td>AKLJ 100/L</td>
<td>66</td>
<td>7.0</td>
<td>2.5</td>
</tr>
<tr>
<td>AKLJ 150/L</td>
<td>70</td>
<td>6.9</td>
<td>3.6</td>
</tr>
<tr>
<td>AKLJ 200/L</td>
<td>90</td>
<td>8.5</td>
<td>5.0</td>
</tr>
<tr>
<td>AKLJ 300/L</td>
<td>82</td>
<td>7.7</td>
<td>8.5</td>
</tr>
<tr>
<td>AKLJ 400/L</td>
<td>92</td>
<td>9.1</td>
<td>9.1</td>
</tr>
<tr>
<td>AKLJ 300/L</td>
<td>160</td>
<td>16.0</td>
<td>15.4</td>
</tr>
<tr>
<td>AKLJ 400/L</td>
<td>150</td>
<td>16.6</td>
<td>26.0</td>
</tr>
<tr>
<td>AKLJ 500/L</td>
<td>225</td>
<td>20.0</td>
<td>40.0</td>
</tr>
<tr>
<td>AKLJ 600/L</td>
<td>230</td>
<td>22.0</td>
<td>50.0</td>
</tr>
</tbody>
</table>

### 4.4 Anchor plate design instructions for the main civil engineer

The following design criteria and standards are considered in designing anchor plates:

1. **Design standards and calculating the forces on the connection**
   - The anchor plate is designed according to the EN 1992-4:2018 standard.
   - The rest of the structure is designed according to European standards [6][8].
   - The combinations of forces are calculated in the ultimate and accident limit states with the partial safety factors of loads using another software application.
   - The anchor plate is selected for the final design loads using the ASTEEL software.

2. **Design for the erection state**
   - No separate designing for the erection state is performed for the anchor plate.
   - The connection profile is welded to the plate after the concrete has hardened, and the structure is loaded after the concrete has reached the design strength.
   - The designer specifies the final time at which the plate can be loaded.
3. **Ultimate limit state design (ULS)**

   - The factors of consequence classes CC1–CC3 are already taken into account in the load combination. The connection works when the concrete has hardened, and the connection profile has been welded.

4. **Eccentricities**

   - The connected profile can be located anywhere on the plate.
   - The software calculates the anchor plate resistances with the profile placement specified.
   - The basic eccentricity in the table is 10% of the plate dimension or a maximum of 20 mm.
   - Basic eccentricity in the direction that becomes dominant must be added to the actual placement of the profile in the software. The software cannot do this independently. The addition is determined by the designer.
   - The plate can be designed with a central placement that can be provided with basic eccentricity, which only affects the location of the shear force.

5. **Design for fire**

   - The fire resistance class of the anchor plate is the same with the connected profile.
   - The connected profile and surface plate must be fire-protected.
   - The designer specifies the fire resistance class and need for protection.

6. **Dynamic loads**

   - Dynamic loads are calculated according to EN 1990-1, Section 4.1.5, by multiplying the static specific loads by the dynamic factors.

7. **Loads caused by earthquakes**

   - The loads are specified in the load combination.
   - With the forces calculated in this way, the designing is performed as a static situation.
   - The performance of the connection has not been tested in structures in earthquake zones. Its use must be considered by the designer.

8. **Fatigue actions**

   - The anchor plate resistance values have not been specified for fatigue actions. Fatigue designing is performed separately on a case-specific basis according to the principles in EN 1990-1, Section 4.1.4. [4]

9. **Accident limit state design (ALS)**

   - The anchor plate is calculated for the accident limit state according to EN 1992-4:2018, using the accident limit state partial safety factors of materials provided in Table 4.1 to specify the connection resistance.
   - Designing is used for determining the failure tolerance of the connection in CC3 structures in the accident limit state. The calculation is performed using the accident limit state loads.
   - The analysis is performed using the ASTEEEL software. The combination of forces in the accident limit state is calculated using a separate software application, and the forces on the connection are provided as “Loads in the accident limit state”. The designer determines the partial safety factors for loads to be entered case-specifically.
   - The software calculates the accident limit state resistance values and utilisation rates for various parts of the connection. The partial safety factor level of the profile materials in the accident limit state is structural steel and rebar $\gamma_s = 1.0$. The partial safety factor level of the anchor plate materials and failure criteria is specified in EN 1992-4:2018 (Table 4.1).

10. **Design the surface plate resistance and displacement. Torsion of the connected profile**

    - The software calculates the surface plate resistance using the FEM method. The von Mises stress state of the plate is calculated according to EN 1993-1-8, Formula 6.1. The software calculates the surface plate deflections, concrete compressive stresses under the surface plate and separation of the plate from the base.
    - The calculation method is semi rigid joint, with which the plate is plasticised, and the acceptable level of plasticisation is:
      - Elastic-plastic, semi rigid joint, von Mises $\delta_{vert} = f_{u}/\gamma M2$. $\gamma M2 = 1.25$
      - If torsion is not allowed for the connected profile, the designing of the plate can be performed as a rigid joint, in which case the plate is not plasticised.
      - Elastic, rigid joint, von Mises $\delta_{vert} = f_{y}/\gamma M$. $\gamma M = 1.0$
    - The surface plate stress state and displacements are illustrated using 3D graphics.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>11. Design a bond</strong></td>
<td>- The software calculates the bond resistances in all states according to the failure criteria in EN 1992-4:2018 [24].</td>
</tr>
<tr>
<td><strong>12. Using the connection at low temperatures</strong></td>
<td>- The impact strength of the surface plate material is sufficient for –20 °C with the design values specified in the tables. At lower temperatures, the minimum operating temperature corresponding to the end plate is determined in accordance with EN 1993-1-10, Section 2.3.2 and Table 2.1.[8]</td>
</tr>
</tbody>
</table>
| **13. Supplementary reinforcement required by the connection** | - The software calculates the anchor plate reinforcement for the forces on the connection, and the minimum reinforcement amounts are output in the calculations.  
- Another option is to use maximum reinforcements calculated according to the plate’s resistance values. Section 5.6. |
| **14. Splitting of the concrete at the edge of the structure** | - The software calculates the reinforcement stress state for the specific loads.  
- The stress state is calculated for reinforcement for tensile and shear forces, and base splitting analysis can be performed, EN 1992-1-1, Section 7.3. |
| **15. Serviceability limit state design (SLS)** | - The serviceability limit state design for the connection is performed according to EN 1992-1-1, Section 4. The principles are specified in Section 5.7 of this manual. |
5 DETAIL DESIGN

5.1 Design stages and parties

Anstar’s anchor plates are products whose final use must be designed by the civil engineers of the concrete structures. For detail design of the anchor plates, we have prepared this user manual as well as the ASTEEL software, version 2.0.

The detail design of anchor plates is performed according to this user manual when the forces on the connection, the materials and the placement of the parts correspond to this manual. In deviating structures, load combinations and connection placements, the plates are designed using the ASTEEL software. The software calculates the connection piece resistances with the selected dimensions of the base concrete and the concrete strength as well as the calculation forces and profile specified. The software checks that the calculation forces of the connection pieces are transferred to the concrete and reinforcement in accordance with the European standards. Instructions for using the software and anchor plates are available from Anstar’s technical design department.

Use of the software is described in more detail in the ASTEEL User Manual. The anchor plates are designed using connection 7. The software can be downloaded from our website at www.anstar.fi.

5.2 ASTEEL software

1. Main window of the software

![Main window of the ASTEEL software with connection 7.](image)

Figure 12. Main window of the ASTEEL software with connection 7.

2. Utilisation rate indicator lights and acceptance

<table>
<thead>
<tr>
<th>1. General</th>
<th>- The bottom bar of the window includes indicator lights showing the utilisation rates of various calculation quantities.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- The colours of the calculation quantities have the following meanings:</td>
</tr>
<tr>
<td>2. Meaning</td>
<td>- The designing quantity of each indicator light is displayed below the light bar when you point the mouse at the light.</td>
</tr>
</tbody>
</table>
3. Utilisation rate
- When you click a light, the output window for the quantity in question is opened, showing the most dominant load case and calculation quantity.
- The light bar shows the utilisation rates of the connection's calculation quantities.

4. Acceptance
- When all the lights are green, yellow or grey, the connection has been accepted.
- A red light means that the utilisation rate of the calculation quantity has been exceeded.
- The final acceptance is the responsibility of the person performing the calculation.

5.3 Initial data for the software

5.3.1 Project folder and calculation standard of software

1. Project folder

1. General
- Start the calculation by creating a project folder in which the calculation standard and files are saved.
- The ASTEEL user manual provides a more detailed description of the software's initial data for calculation and calculation methods as well as the calculation theory and results.
- This user manual only provides connection-specific information.

2. Calculation standard selection
- Start by creating a project folder in the File/Project folder menu.
- The software prompts you to select the country-specific calculation standard to be copied to the folder and used for calculating the file in the folder. The standard is selected once for each new folder. (The calculation standard for bonds is selected in the connection selection window.)
- The calculation will use the standard selected in this folder.
- You can change the standard by creating a new folder and selecting another standard for it.

3. Project information
- In these fields, you provide general information about the project in the folder.
- This will be output at the beginning of the calculation file.

2. Calculation standard of software

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFS-EN 1002-1-1:2005+NA</td>
<td>Finnish Eurocode + NA</td>
</tr>
</tbody>
</table>

5.3.2 Connection type

1. Connection type
- Select an anchor plate connection by choosing Connection selection from the initial data menu.
- The menu shown in Figure 13 opens in the window, showing the connection types available in the software.
- Anchor plates are calculated using connection type 7.
- Connection type 8 is only available to Anstar Oy.
- Connection types 3–6 are coming soon. The connection type is selected first. The selection adjusts the software's main window and other windows according to the connection selected.

2. Calculation code of joint
- Select the calculation standard for the anchor plate from the window.
- The default standard is EN 1992-4:2018, and the calculation can also be performed using the older CEN/TS 1992-4-2 standard, which provides slightly more conservative calculation results.
5.3.3 Dimension and material data

0. General

1. **Menu**
   - The dimensions of the connection are specified in the *Dimension and material data* menu, which has six tabs.

2. **Data**
   - Enter the initial data in the numerical order of the tabs, either by changing the values or accepting the default values. Some of the standard values are visible, but the field is grey, meaning that they cannot be changed.

3. **Acceptance**
   - When you click *Accept*, the main window is updated according to the dimensions of the selected connection type.

1. **Calculation ID**
   The identifying information output in the calculations is entered in the fields.

2. **Profile and material strengths**

4. **Profile type**
   - This activates the necessary databases. The profile is selected on Tab 3.

5. **Base concrete splitting and bonding state**
   - Use split concrete as the default, unless the plate and bonds are in non-splitting concrete.
   - The bonding condition is selected according to the casting state of the base as instructed in EN 1992-1-1.

6. **Using supplementary reinforcement for the bolt/bond**
   - The use of reinforcement for connection 7 is selected on a case-specific basis for both tension and/or shear.
   - By default, reinforcement is used.

7. **Slab, material strengths**
   - Specify the concrete strength of the plate’s base.
   - The default concrete strength is C25/30.

8. **Steel strengths**
   - Material strengths for calculating the profile to be connected and its weld.

Figure 13. ASTEEL software connection menu

Figure 14. Tab 2. Material strengths, concrete splitting state and reinforcement.
3. Dimensions of the structure

1. Profile shape and dimensions
   - The dimensions of rolled profiles are provided in the profile tables.
   - The most common standard profiles are available.
   - The dimensions of welded profiles are entered profile-specifically.

2. Profile weld on plate
   - The profile’s fillet or butt weld is selected separately.
   - The weld goes around the profile.
   - The maximum butt weld size is the material thickness/2 for open profiles and the material thickness for hollow sections.
   - The fillet weld size is not limited.

Figure 15. Tab 3. Dimension and material data of the profile to be connected

4. Anchor plate dimensions

1. Anchor plate dimensions
   - The anchor plate type is selected from the upper menu.
   - The anchor plate is selected from the lower menu.
   - The window shows the dimensions of the selected plate.

2. Anchor plate rotation
   - The plate can be rotated 90 degrees. The profile cannot be rotated.
   - Rotation is possible after selecting.

3. Profile eccentricity on plate
   - The profile can be placed on the surface of the plate using two different methods:

4. Upper profile centrically
   - The profile is placed centrically on the origin of the plate in the main window graphics.
   - Axial force and bending moment resistance are then calculated centrically.
   - Shear force is calculated centrically or can be provided with basic eccentricity (= 10% of the plate side length or a maximum of 20 mm).

Use this method when the profile is centred on the plate and you want to ensure an eccentric installation tolerance for shear force.

5. Upper profile eccentrically
   - The profile is placed eccentrically on the plate. The actual location is specified as displacement distances. The displacement distance is from the origin to the middle of the profile.
   - The profile can be placed anywhere on the plate. The tensile and shear resistances are calculated with this eccentric placement.
   - If you want to ensure installation eccentricity, add another 10% of the side length or a maximum of 20 mm in the direction that gives the dominant effect.
   - The software does not add these eccentricities automatically in this selection.

Figure 16. Tab 4. Anchor plate selection and eccentricity of the connected profile’s location
5. Dimensions of the lower structures

3. Base dimensions

- Distances from the centre of the plate to the nearest edge in the X and Y directions. (±X-axis, ±Y-axis). Select the minimum from three options:
  - Distance from the centre of the plate to the edge of the structure in the direction of the coordinate axis.
  - Distance from the centre of the plate to the nearest hole whose width is ≥ plate side length/3. Smaller holes need not be taken into account.
  - Distance from the centre of the plate to halfway between this and the adjacent anchor plate. Or another point load on the slab.
- The plate can be placed such that it touches the edge of the structure. Resistances are always calculated with the placement specified.
- The resistance calculation is influenced by the selection of reinforcement on Tab 2.

4. Base depth
The calculation of bonds is influenced by the base depth, i.e. the thickness of the structure. Specify the actual depth.

5. Corner bevel
The dimension can be used when the plate is located in the corner of an element, at the end of a column. This only influences the graphics in the main window.

6. Supplementary reinforcement

1. Supplementary reinforcement
- The calculation size of the anchor plate’s reinforcement can be selected on Tab 6.
- The window shows the reinforcing units available for each connection type.
- The reinforcement principle drawing can be opened by clicking the Ast code.
- The software calculates the amount of supplementary reinforcement with the selected rebar size.
- The default rebar size selected is output to the calculation file.

7. Accepting the initial data

1. Acceptance
- All calculation data that has been selected/modified must be accepted by clicking the Accept button.
- The button accepts all the tabs of the Initial data window at the same time.

2. Changes
- The dimensions and materials can be changed and tried out quickly between calculations.

5.3.4 Forces on the connection

1. Forces on the connection and combinations

1. Specifying the calculation forces
- The forces on the anchor plate are calculated using a separate statistics application.
- These are used to form the combinations of forces, the most dominant of which is provided.
- The forces already include the partial safety factors of loads in accordance with the calculation standard as well as the factor of the consequence class.
- The forces are specified by load combination, where the tensile force...
and/or bending moment usually forms the most dominant combination.  
- All the forces acting at the same time must be provided for the same case. Changing moment and shear directions must be analysed.

### 2. Accidental limit state
- The accident limit state (ALS) is specified as specific loads or what is to be calculated.  
- The software does not add partial safety factors for loads to the calculation.

### 3. Acceptance
- All forces that have been specified or modified must be accepted by clicking the Accept button.

### 4. Axial force $N_d$
- The connected profile’s Axial force is specified for the connection.  
- The most dominant case of the profile’s compressive force must be calculated. The force is usually transferred to the concrete through the plate, in which case the compressive stress of the concrete under the plate may become dominant. The compressive force is distributed between the bonds according to the rigidity of the plate. Thereby, the bond transfers some of the compression.  
- The software does not calculate the punching resistance of the structure.

### 5. Bending moments $M_{xd}, M_{yd}$
- The profile’s bending moments are specified for the connection.  
- In an eccentric profile, the furthest bond in tension becomes the determining one.  
- For moments with the same value, the (+, −) directions need to be calculated.  
- The anchor plate is also calculated in the skew bending direction.

### 6. Shear force $Q_{xd}, Q_{yd}$
- Shear forces are calculated in the directions of the main axes.  
- The most dominant shear force comes towards the nearest edge of the structure.  
- The highest shear force is also calculated, even though its direction is away from the edge.  
- The steel shear resistance of the bond is analysed in the direction of the shear resultant for both shear and torsion.

### 7. Torsional moment $T_d$
- The profile’s torsional moment and its sign are specified.  
- The torsion is combined with the shear force components.

### 8. Proportion of permanent loads $G_k$
- The relative proportion of permanent loads $G_k$ of the total load. The value is used for calculating the reinforcement stress state with the specific loads. Refer to Section 5.7, Serviceability limit state design. The default value can be changed.

Figure 19. Anchor plate calculation forces and coordinate system

### 5.3.5 Anchor plate calculation

1. **Selecting the calculation method for the anchor plate**

   To calculate the anchor plate, select Calculate, which will open the Resistance calculation window.  

   The calculation is performed for the following anchor plate structures:  
   - Calculating the plate’s stress state/deformed geometry using the FEM method.  
   - Calculating the concrete’s stress/deformation state under the plate.  
   - Calculating the anchors for axial force and shear criteria in accordance with EN 1992-4.  
   - Calculating the anchor plate reinforcement for tensile and shear forces.
1. **Case to be calculated**
   
   This selection performs the calculation in the following calculation states:
   - **Ultimate limit state (ULS)**
   - **Accident limit state (ALS)**
   - When you want to output both calculations, you must first output the ultimate limit state to a file.
   - If the accident limit state loads have not been specified, the state cannot be calculated.

2. **Base plate connection calculation method**
   
   Here, you select the calculation method for the plate.
   - **Rigid joint (elastic)**
   - **Semi rigid joint (elastic-plastic)**

### Semi rigid joint. Elastic-plastic calculation.
- Plane deformations are allowed for the surface plate.
- Plasticisation is allowed in calculating the plate. The designer specifies the acceptable degree of plasticisation.
- Torsion occurs in the surface plate.
- The calculation time is longer (approx. 5–10 min).

### Rigid joint. Elastic calculation.
- The surface plate acts as a rigid plate.
- No out-of-plane deformations are allowed for the plate.
- The plate is calculated as elastic, and plasticisation is not allowed in the plate.
- The surface plate is rigid and non-torsional.
- The calculation time is relatively short.

#### New method:

This is the new calculation method recommended for anchor plates, since it takes into account the resistance of the surface plate according to the actual location and stress state of the profile and bonds.

The deformations of the surface plate are used to calculate the actual forces on the bonds, making it possible to take into account the prying effect of the bond on the forces acting on the anchor plate’s anchors as required by the European standard.

#### Old method:

This corresponds to the conventional anchor plate calculation method, in which the surface plate was assumed rigid in manual calculation. This led to significant under-design of the plate resistance and forces on the bonds, since the surface plate starts to be plasticised regardless of the initial assumption.

In the calculation method, the plate’s stresses are kept in the elastic area. Plasticisation of the plate must not be allowed in the calculation. The method results in a non-torsional, rigid joint.

### 5.4 Surface plate and profile calculation results

#### 1. Surface plate stress state and utilisation rates

The second tab of Window 2/1 shows the surface plate’s utilisation rate and stress state outputs as illustrative 3D images by load case.

<table>
<thead>
<tr>
<th><strong>3D image</strong></th>
<th>Graphical 3D surface of the utilisation rate and von Mises stress state.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong></td>
<td>The X-axis shows the plate dimensions and the Y-axis the scaled value of the calculation quantity.</td>
</tr>
<tr>
<td><strong>1.</strong></td>
<td>The colour palette on the side has been calculated with the calculation strength of the material.</td>
</tr>
<tr>
<td><strong>1.</strong></td>
<td>The image can be viewed and rotated with the left mouse button.</td>
</tr>
<tr>
<td><strong>1.</strong></td>
<td>The level and scope of each quantity’s utilisation rate can be found in the pattern.</td>
</tr>
<tr>
<td><strong>1.</strong></td>
<td>The yellow colour means that the utilisation rate/calculation stress has been exceeded.</td>
</tr>
</tbody>
</table>

| **Failure state representation** | The stress surface has been cut with a horizontal plane in the calculation elements where the calculation value exceeds the calculation value of the |
material’s breaking strength (= \( f_u / Y_M2 \)).

**Semi rigid joint**
- The peaks of the surface have been cut, so the pattern shows, in an even area, the elements whose stress exceeds the calculation value of the yield strength = \( f_u / Y_M2 \).
- Using the yield area must be considered separately.

**Rigid joint**
- The peaks have not been cut, so the pattern shows the entire stress area.
- Using the yield area is not allowed.

### 3. Acceptance of results

**Semi rigid joint**
- The graph for the utilisation rate of the main element’s reference stress \( N_{\text{vert}} \) is used.
- Formula 6.1 of Eurocode 3 provides the dominant designing criterion.
- Using the yellow yield area of von Mises stress \( \delta_{\text{vert}} \) is allowed for semi rigid joints and static loads. Approved by the designer.
- Using the yellow horizontal failure area is possible if it is concentrated in the area of a few elements only.
- Using the yield area significantly reduces the surface plate’s fatigue strength.

**Rigid joint**
- The graph for the utilisation rate of the main element’s reference stress \( N_{\text{vert}} \) is used.
- Formula 6.1 of Eurocode 3 provides the dominant designing criterion.
- Using the yellow yield area of von Mises stress \( \delta_{\text{vert}} \) is not allowed for rigid joints.

---

**Figure 20.** Ultimate limit state. Surface plate’s von Mises stress state, 3D surface
2. **Surface plate deflection**

The third tab of Window 2/1 shows the deflection of the surface plate by load case.

<table>
<thead>
<tr>
<th>1. <strong>3D image</strong></th>
<th><strong>Surface plate deflection.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- The shape of the deflection surface corresponds to the plate’s displacement in the Z-axis direction, and the vertical axis shows the numerical value of the displacement.</td>
</tr>
<tr>
<td></td>
<td>- The displacement colour palette has been scaled to the maximum displacement in relation to the zero level.</td>
</tr>
<tr>
<td></td>
<td>- The zero level represents an unloaded surface level where the stress state of the base concrete is zero.</td>
</tr>
<tr>
<td></td>
<td>- With a rigid plate, the deflection surface is a straight plane whose inclination changes according to the load state. Torsion does not occur.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. <strong>Separation of the plate from the base</strong></th>
<th><strong>Displacement in relation to the zero level.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Above the zero level, the plate has come loose from the base.</td>
</tr>
<tr>
<td></td>
<td>- Below the zero level, elastic compression occurs in the concrete.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. <strong>Acceptance of results</strong></th>
<th><strong>No utilisation rate is specified for plate deflection.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Deformations of the plate determine the rigidity of the joint, which can be used to assess the additions to the deformed geometry of the connected profile in relation to a fully rigid joint.</td>
</tr>
<tr>
<td></td>
<td>- Water enters the connection in the plate’s separation area.</td>
</tr>
<tr>
<td></td>
<td>- With compressed plates, it must be ensured that the stress of the base concrete remains elastic.</td>
</tr>
<tr>
<td></td>
<td>- The stress state of the base concrete is shown on the third tab of Window 3/1. Figure 24.</td>
</tr>
</tbody>
</table>

Figure 21. Ultimate limit state. Surface plate’s 3D deflection in relation to the zero level.

3. **Connection profile’s weld for the base plate**

The weld type and dimensions are specified for the connection profile.

- The resistance of the connection profile welds on the surface plate is shown in Window 2/2.
- The calculation is performed using the profile’s weld dimensions.
- The welded connection’s resistance in relation to the profile’s resistance graph is shown on the first tab of Window 3/1.
Calculation strengths of the profile welds.

**Butt weld calculation strength**
- \( F_{W,Rd} = \frac{f_u}{\gamma_{M2}} \)
- \( f_u = \min; f_u \) (plate, profile, weld metal)
- \( \gamma_{M2} = 1.25 \)

**Fillet weld calculation strength**
- \( F_{W,Rd} = \frac{f_u}{(\sqrt{3} \times \beta_w \times \gamma_{M2})} \)
- \( f_u = \min; f_u \) (plate, profile, weld metal)
- \( \gamma_{M2} = 1.25 \)

The calculation stress \( F_{W,Ed} \) of the welds has been calculated using a more accurate component method.

**Acceptance**
The weld is acceptable when the utilisation rates are \( \leq 1.00 \).

Figure 22. Ultimate limit state. Calculation stress and utilisation rate of the profile weld.

## 5.5 Anchor plate calculation results

### 5.5.1 Combined effect graphs of the connection

1. **Combined effect graphs**
   
   - **1. Specifying the graphs**
     - Window 3/1 shows the resistance graphs and loading points of the various structures of the anchor plate. Figure 23.
     - The axial force resistance graphs are output in the bending directions of the X- and Y-axes as well as the skew bending direction.
   
   - **2. Acceptance**
     - The ultimate and accident limit state loading points, C1–C8 (blue), must be located inside all the graphs and the red dashed line.
     - The red, green and blue graph may locally intersect each other.
     - In addition to this, it is also necessary to check the local resistance of the surface plate stress state and bonds.

Figure 23. Ultimate limit state. Resistance graphs and loading points. X-axis direction.
## 2. Resistance graphs of the anchor plate connection

<table>
<thead>
<tr>
<th>Graph color</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Green** graph | Anchor plate resistance  
- The graph is calculated for an area of concrete the size of the surface plate with the steel tensile resistance of the bonds and the calculation strength of the base concrete.  
- The effect of shear force is not included here.  
- The graph does not take into account the edge distances of the base.  
- The eccentricity of the profile location is indicated next to the loading point by a green circle, which depicts the eccentricity moment coming from the profile location. |
| **Blue** graph | Resistance of the connected profile  
- The graph shows the axial force and bending moment resistance of the connected profile.  
- The cross-section class of the profile's plate parts has not been taken into account in the graph; it represents the cross-section's resistance in cross-section classes 1 and 2.  
- The strength of the profile has been calculated for the value \( f_y/\gamma_m \).  
  Coefficient \( \gamma_m = 1.0 \).  
- The blue graph may intersect the green graph or be located inside it. |
| **Red** graph | Profile weld resistance on the plate  
- The graph shows the resistance of the profile welds on the plate.  
- If the red is outside the blue, the profile determines the connection.  
- If the red is inside the blue, the profile weld determines the connection.  
- A balanced welded connection can be specified for the profile in the calculation. |
| **Red dashed line** | The acceptable area is between the dashed lines  
- The loading points must not be located in the area of the graphs outside the red dashed line. EN 1990, Section 2.2(3) (= attaining the limit state) |

## 3. Stress state of the surface plate base concrete

<table>
<thead>
<tr>
<th>Presentation of results</th>
<th>The stress state of the surface plate base concrete is shown on the second and third tab of window 3/1.</th>
</tr>
</thead>
</table>
| **Element data** | - In the 2D window, the stress state and utilisation rates of an individual concrete calculation element can be checked with the mouse.  
  - The force and stress state of the bonds is shown in the window.  
  - The 3D graph for the concrete shows the distribution of the stresses under the plate, the maximum value calculated as well as the calculation strength and utilisation rate of the concrete.  
  - In the area shown in grey, the stress level is zero or the plate has come loose from the concrete.  
  - The colour palette represents the utilisation rates of compressive stresses. |
| **Acceptance of results** | - The compressive stress of the concrete must not exceed the calculation strength \( f_{cd} \).  
  - The surface plate is allowed to come loose from the concrete if this is acceptable in terms of corrosion. |
5.5.2 **Anchor plate axial force resistance**

<table>
<thead>
<tr>
<th><strong>Anchor plate’s designing in concrete</strong></th>
<th>The software calculates the resistances of the anchor plate and individual bonds in the base concrete according to the location and edge distances of the bonds.</th>
</tr>
</thead>
</table>
| **1. Presentation of the resistances** | The resistances are presented in windows 3/3, 3/4 and 3/5 as follows:  
- The force quantities, resistances and utilisation rates of the anchor plate are shown on the first row of the table.  
- The anchor plate resistance cannot be calculated for certain failure criteria.  
- The force quantities, resistances and utilisation rates of each bond are shown on table rows 2–n.  
- The bonds are numbered in the main window. |
| **2. Designing for axial force** | Axial force resistance of the plate and bonds.  
- Steel resistance  
- Blow-out and pull-out resistance  
- Concrete cone resistance  
- Supplementary reinforcement resistance |
| **3. Designing for shear force** | Shear resistance of the plate and bonds.  
- Steel resistance  
- Pry-out resistance  
- Concrete edge resistance  
- Supplementary reinforcement resistance |
| **4. Axial and shear force combination** | The Axial and shear force combination in the directions of the main axes is calculated for the anchor plate and all the bonds.  
The steel resistance of the shear force and torsion are calculated in the direction of the force resultant.  
The software finds the most dominant combinations of these and outputs them. |
| **5. Acceptance of results** | **Acceptance of the results.**  
- The resistance is acceptable when the main window indicator lights 3/3, 3/4 and 3/5 are green, yellow or grey.  
**Acceptance criteria:**  
- The plate is acceptable when the light is green or yellow.  
A green utilisation rate is in the range of 0–0.95 and yellow 0.951–1.0. |

Figure 24. Ultimate limit state. Stress state of the surface plate base concrete, 3D image.
- Grey means that the quantity in question is not calculated for the plate.
- A red light means that the utilisation rate has been exceeded for a calculation quantity.
- The designing quantity value is a dash (-).
- The failure criterion or quantity has no significance for designing or cannot be calculated for the load case in question. (No actions.)
- The designing quantity value is zero (0.0).
- When you click a light with the mouse, a window opens and shows the load case which has the maximum utilisation rate or in which the exceeding occurred.

2. **Design value for axial force resistance**

<table>
<thead>
<tr>
<th>1. <strong>General</strong></th>
<th>Tab 1 of Window 3/3 shows the most dominant axial force resistance of the anchor plate and bonds from tabs 2, 3 and 4 as well as the utilisation rate by load case.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. $N_{Ed}$</td>
<td>Calculated tensile force of the plate or bond by load case. When the plate only has bending moment, the force is zero.</td>
</tr>
<tr>
<td>3. $N_{Rd,s}$</td>
<td>Steel tensile resistance of the plate or bond arm.</td>
</tr>
</tbody>
</table>
| 4. $N_{Rd,c}$ | Design axial force failure criterion resistance of the plate or bond. The design value is calculated from the condition:
- $N_{Rd,c} = \min(N_{Rd,s}; N_{Rd,c}; N_{Rd,p}; N_{Rd,cb})$ Without tensile reinforcement.
- $N_{Rd,c} = \min(N_{Rd,s}; N_{Rd,re}; N_{Rd,p}; N_{Rd,cb})$ With tensile reinforcement. |
| 5. **Utilisation rate** | Designing axial force utilisation rate of the plate or bond. Calculated from the most dominant failure criterion in item 3. |
| 6. **Criterion** | The description can be used to review which failure criterion became dominant for each bond and plate. Criterion = the minimum of cases 1–5. The designing criterion is assessed as follows:
1. $N_{Rd,s}$ The steel tensile resistance of the bond is determining. The plate is so far from the edge that the steel resistance is determining. If exceeded, change the plate.
2. $N_{Rd,c}$ The edge distance (concrete) restricts the bond’s tensile resistance. The plate is at the edge of the structure and a concrete failure criterion is determining. If exceeded, add supplementary reinforcement or change the plate.
3. $N_{Rd,p}$ Pull-out restricts the bond’s tensile resistance. This failure criterion determines the bond and plate. If exceeded, change the plate.
4. $N_{Rd,cp}$ Blow-out restricts the bond’s tensile resistance. The plate is so close to the edge of the structure that blow-out is determining. If exceeded, change the plate, modify the structure.
5. $N_{Rd, re}$ Supplementary reinforcement determines the tensile resistance of the bond/plate. If exceeded, the plate will not withstand even with reinforcement; change the plate. |
| 7. **Acceptance** | The light at the end of a row depicts the acceptance utilisation rate and limit for the bond or plate in question. The limits are presented in item 5 of the previous table. |
Figure 25. Ultimate limit state. Tensile resistance and utilisation rate of the anchor plate.

3. Blow-out and Pull-out resistance

1. General
   Tab 2 of Window 3/3 shows the pull-out and blow-out resistance of the plate and bonds.

2. $N_{Ed}$
   Calculated tensile force of the plate or bond by load case.

3. $N_{Rd,s}$
   Steel tensile resistance of the plate or bond arm.

4. $N_{Rd,p}$, $N_{Rd,cp}$
   Pull-out and blow-out resistance of the plate or bond.

5. Utilisation rate $n_1$, $n_2$
   Plate or bond utilisation rate for these failure criteria.

6. Acceptance
   The acceptance rate of the pull-out and blow-out failure criteria is at the end of the row.

Figure 26. Ultimate limit state. Pull-out and Blow-out resistance of the anchor plate.
4. **Concrete cone resistance and supplementary reinforcement**

1. **General**
   
   Tab 3 of Window 3/3 shows the steel resistance, concrete cone and supplementary reinforcement resistance of the plate and individual bonds.

2. $N_{Ed}$
   
   Calculated tensile force of the plate or bond by load case.
   If the plate’s $N_{Ed} = 0.0$, the forces are generated by the bending moments.

3. $N_{Rd,s}$
   
   Steel tensile resistance of the plate or bond arm.

4. $N_{Rd,c}$
   
   Concrete tensile resistance of the plate or bond. Minimum value from the concrete cone resistance.

5. $N_{Rd,re}$
   
   Tensile resistance of the plate or bond reinforcement. Criterion $N_{Rd,re} > N_{Rd,c}$.
The value is calculated for the selected tensile reinforcement in Window 3/6, Tab 1. If there is no reinforcement, this value is zero.

6. **Utilisation rate $n$**
   
   Plate or bond utilisation rate for the dominant tensile force failure criteria.

7. **Acceptance**
   
   Acceptance rate for the minimum failure criteria determines the axial force and bending moments at the end of the row.

---

**Figure 27.** Ultimate limit state. Concrete cone resistance of the anchor plate and bond.

5.5.3 **Anchor plate shear resistance**

1. **Shear resistance design value**

   1. **General**
      
      Tab 1 of Window 3/4 shows the most dominant shear resistance of the anchor plate and bonds from Tab 2 as well as the utilisation rate by load case in the directions of the main axes.

   2. $V_{Exd}, V_{Eyd}, V_{Exyd}$
      
      Calculation value of the anchor plate’s or bond’s shear force by load case in the directions of the main axes and shear resultant.
The external shear force and torsional moment as well as the torsion caused by the profile location’s eccentricity and basic eccentricity are calculated in the shear force value.

   3. $V_{Rd,cx}, V_{Rd,cx}, V_{Rd,cxy}$
      
      Shear resistance of the plate or bond.
The values are output according to whether shear reinforcement has been selected for use.
   - Minimum shear resistance of the bond/plate without shear reinforcement:
     $V_{Rd,cx}, V_{Rd,cy} = \min(V_{Rd,s}, V_{Rd,cp}, V_{Rd,c1}, V_{Rd,cy})$
Minimum shear resistance of the bond/plate with shear reinforcement:
\[ V_{Rd,ox}, V_{Rd,oy} = \min(V_{Rd,s} ; V_{Rd,cp} ; V_{Rd,ox1} ; V_{Rd,oy1}) \]

Minimum shear resistance of the plate/bond in the direction of the resultant:
\[ V_{Rd,ox} = \min(V_{Rd,rs} \text{ resultant}) \]

Anchor plate shear resistance:
\[ V_{Rd,ox}, V_{Rd,oy} = n \times \min(\Sigma V_{Rd,ox1}, \Sigma V_{Rd,oy1}), \text{ where } n = \text{ number of bonds on the plate.} \]

The shear resistance of the plate is determined by the shear resistance of the bond closest to the edge. This minimum value is entered for the other bonds when specifying the resistance of the anchor plate.

4. Utilisation rate \(n_1, n_2, n_3\)
Anchor plate or bond utilisation rate for the design failure criteria.

5. Criterion
The description can be used to review which failure criterion became dominant for each bond and plate. Criterion = the minimum of cases 1–6.
1. Shear reinforcement is not needed. The plate/bond withstands in the concrete without shear reinforcement.
2. Bond-specific shear stirrups are needed. The plate must be provided with shear reinforcement for shear force. If the resistance is exceeded, the plate will not withstand even with shear reinforcement.
3. Pry-out resistance is dominant. Change the plate.
4. The steel shear resistance of the bond is dominant. The plate is so far from the concrete edge that the bond’s steel shear resistance is determining. If this is exceeded, change the plate.
5. The bond is too close to the concrete edge for shear force. The plate/bond resistance is exceeded. Add shear reinforcement. If the message was received with shear reinforcement, the plate will not withstand, and the structure must be changed.

6. Acceptance
The acceptance rate for the minimum failure criteria determining the shear force and torsion in the directions of the main axes and resultant is shown at the end of the row.

Figure 28. Ultimate limit state. Shear and torsional resistance of anchor plate and bond.
2. Shear resistances, pry-out, concrete edge and steel shear

1. General

Tab 2 of Window 3/4 shows the failure criterion shear resistances of the plate and bonds.

2. \( V_{Rdx,c1} \) \( V_{Rdy,c1} \)

Bond’s concrete edge shear resistance without reinforcement.
The resistances are output in the +,- directions of both axes.
- The first number is the bond’s shear resistance in the directions of the +X- and +Y-axis without reinforcement.
- The second number is the bond’s shear resistance in the directions of the −X- and −Y-axis without reinforcement.
- The plate’s shear resistance by direction is \( \min (V_{Rdx,c1}) ; \min (V_{Rdy,c1}) \).
If this is exceeded, the plate must be provided with shear reinforcement.

3. \( V_{Rdx,c3} \) \( V_{Rdy,c3} \)

Bond’s concrete edge shear resistance with supplementary reinforcement.
- The first number is the bond’s shear resistance in the directions of the +X- and +Y-axis with supplementary reinforcement.
- The second number is the bond’s shear resistance in the directions of the −X- and −Y-axis with supplementary reinforcement.
- The plate’s shear resistance by direction is \( \min (V_{Rdx,c3}) ; \min (V_{Rdy,c3}) \).
If this is exceeded, change the plate or modify the structure.

4. \( V_{Rd,cp} \)

Pry-out failure criterion resistance of the plate and bond.
If exceeded, change the plate.

5. \( V_{Rd,s} \)

Steel shear resistance of the plate and bond.
If exceeded, change the plate.

Figure 29. Ultimate limit state. Bond’s concrete shear resistance with reinforcement.

5.5.4 Axial and shear force combination

1. General

Window 3/5 shows the combination of the bonds’ axial and shear force resistances in the directions of the main axes and in the skew bending direction.

2. \( N_{Ed} \), \( V_{Exd} \), \( V_{Eyld} \), \( V_{Eyd} \)

Calculation value of the bond’s axial and shear force by load case in the directions of the main axes and shear resultant.

3. \( N_{Ed}, N_{Rd,i}, \beta_N \)

Bond’s axial force calculation value, resistance and utilisation rate.

4. \( V_{Exd} \), \( V_{Eyd} \), \( V_{Eyd} \)

Bond’s shear force calculation value, resistance and utilisation rate in the directions of the X- and Y-axes.
Bond’s skew direction shear resultant, steel shear resistance and utilisation rate.

5. Utilisation rate \( n_x, n_y, n_{xy} \)

Utilisation rate of the bond’s axial force and shear combination in the directions of the X- and Y-axes and skew resultant.

6. Criterion

The description can be used to review which combination criterion became dominant for each bond. Combination formulas EN 1992-4:2018, Section 7.2.3.1
Criterion = min (from cases 1–4).
1. The bond’s steel resistance is determining. Tension + shear. Formula EN 1992-4:2018 (7.54)

2. The bond’s concrete resistance is determining. Tension + shear. Either only concrete resistance or both tensile and shear supplementary reinforcement are used. Formula EN 1992-4:2018 (7.55)

3. The bond’s concrete resistance is determining. Tension + shear. Either only concrete resistance or both tensile and shear supplementary reinforcement are used. Formula EN 1992-4:2018 (7.56)

4. The bond’s concrete resistance is determining. Tension + shear. Either concrete resistance or only tensile or shear supplementary reinforcement is used. Formula EN 1992-4:2018 (7.57)

7. Acceptance
If the bond acceptance rate in this window is green or yellow, the anchor plate is also accepted.
For the surface plate, the stress state in Window 2/1 must also be accepted.
Thereby, the highest individual bond utilisation rate also represents the anchor plate utilisation rate, and the bond’s Criterion shows which criterion will become dominant for the anchor plate.

Figure 30. Ultimate limit state. Combining the bond’s axial force and shear resistance.

5.6 Anchor plate reinforcement

1. Anchor plate reinforcement principle

1. Principle of using reinforcement

Option 1: Calculation
- The anchor plate can be calculated without reinforcement if the distance of the centre of the plate from the edge of the structure is ≥ s/2+1.5\*\(h_{el}\). S = distance between bonds
In this case, reinforcements are not output in Window 3/6.
- The anchor plate can also be calculated with tensile and/or shear reinforcement.
Window 3/6 shows the reinforcement calculated for the forces specified.
- The plate can be reinforced with the minimum reinforcements shown in Window 3/6.

Option 2: Tables
- The plate’s resistances must always be checked for several forces using the software.
- The plate does not require reinforcement if this is allowed by the
resistances and edge distances > (X2, Y2) in Design tables 8–15.
- The maximum reinforcements in tables 16–19 can always be used for the plate.
- Tables 19–22 are a conservative choice in terms of reinforcement.
- The reinforcement is also sufficient for punching and edge failure of the base structure.

2. Tensile reinforcement of the anchor plate failure cone $A_{st5}$

<table>
<thead>
<tr>
<th>AKL plate</th>
<th>Tensile reinforcement</th>
<th>Splitting reinforcement on the top surface of the base</th>
<th>Shear reinforcement/ bond X direction</th>
<th>Shear reinforcement/ bond Y direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKL 100/100</td>
<td>303 * 2&quot;T12</td>
<td>110 T8 K100 B300</td>
<td>50 T18</td>
<td>50 T18</td>
</tr>
<tr>
<td>AKL 100/150</td>
<td>375 * 2&quot;T8</td>
<td>128 T8 K100 B300</td>
<td>53 T18</td>
<td>49 T18</td>
</tr>
<tr>
<td>AKL 150/150</td>
<td>431 2&quot;T10</td>
<td>161 T8 K100 B400</td>
<td>57 T18</td>
<td>57 T18</td>
</tr>
<tr>
<td>AKL 100/200</td>
<td>430 2&quot;T10</td>
<td>141 T8 K100 B300</td>
<td>52 T18</td>
<td>47 T18</td>
</tr>
<tr>
<td>AKL 100/300</td>
<td>726 2&quot;T12</td>
<td>217 T8 K100 B500</td>
<td>50 T18</td>
<td>50 T18</td>
</tr>
<tr>
<td>AKL 200/200</td>
<td>712 2&quot;T12</td>
<td>258 T8 K100 B500</td>
<td>86 T18</td>
<td>86 T18</td>
</tr>
<tr>
<td>AKL 250/250</td>
<td>720 2&quot;T12</td>
<td>268 T8 K100 B500</td>
<td>84 T18</td>
<td>84 T18</td>
</tr>
<tr>
<td>AKL 200/300</td>
<td>706 2&quot;T12</td>
<td>262 T8 K100 B500</td>
<td>84 T18</td>
<td>84 T18</td>
</tr>
<tr>
<td>AKL 300/300</td>
<td>738 2&quot;T12</td>
<td>273 T8 K100 B500</td>
<td>89 T18</td>
<td>89 T18</td>
</tr>
</tbody>
</table>

Failure cone reinforcement for the anchor plate’s tensile force
- Stirrup reinforcement $A_{st5}$ is placed in the area of the anchor plate bonds.
- The stirrups are positioned symmetrically around the bonds.
- The necessary stirrups are presented in tables 19–22 and figures 31–32.
- $A_{st5}$ is the total area of the stirrups. The marking 2*2T10 means two T10 U-stirrups at both bond rows.
- The reinforcement selected is a double-legged stirrup.

3. Splitting reinforcement $A_{st8}$ of the top surface of the base

Splitting reinforcement is placed on the top surface of the base, in the area of the plate’s tensile failure cone, strengthening the failure cone’s functioning.
- The connection can be reinforced using mesh $A_{st8}$, which corresponds to the connection’s maximum tensile resistance as indicated in tables 19–22. The area is in the direction of the mesh.
- Another option is to use the number calculated by the software on the basis of the calculation loads provided.
- The calculated reinforcement area $A_{st8}$ is placed as a mesh on both sides of the anchor plate’s centre, in the distribution area indicated in the table.
- Other reinforcement in the structure can be used for this purpose if the application of the mesh allows this.

4. Shear reinforcement $A_{st11}$ of the anchor plate’s bond

Edge failure cone reinforcement for the anchor plate’s shear force
- Stirrup reinforcement $A_{st11}$ is placed around each of the anchor plate’s bonds.
- The stirrups are placed symmetrically such that they touch the bonds.
- Tables 19–22 and Figure 33 present the shear U-stirrup of the most heavily loaded bond corresponding to the maximum shear resistance.
- $A_{st11}$ is the required total area of the U-stirrup, and T is the stirrup size selected for it.

5. AKLP and AKLJ reinforcement

- The bond’s tensile reinforcement presented in Table 22 is set for each pair of bonds in the plate’s narrower direction.
- Surface reinforcement has been specified for a group of two pairs of bonds, and reinforcement is placed evenly across the entire area of the plate.
- Shear reinforcement is placed for each of the plate’s bonds.

2. Reinforcement tables for the anchor plate’s maximum resistance

Table 19. AKL anchor plate reinforcement
### Table 20. KL anchor plate reinforcement

<table>
<thead>
<tr>
<th>KL anchor plate</th>
<th>Tensile reinforcement</th>
<th>Splitting reinforcement on the top surface of the base</th>
<th>Shear reinforcement/ bond X direction</th>
<th>Shear reinforcement/ bond Y direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$A_{ss5}$ mm²</td>
<td>$A_{ss5}$ T</td>
<td>$A_{st8}$ mm²</td>
<td>$A_{st8}$ T</td>
</tr>
<tr>
<td>KL 100/100</td>
<td>196 2*1T8</td>
<td>91 T8 K180 B360</td>
<td>52 1T8</td>
<td>52 1T8</td>
</tr>
<tr>
<td>KL 100/150</td>
<td>190 2*1T8</td>
<td>86 T8 K180 B360</td>
<td>52 1T8</td>
<td>50 1T8</td>
</tr>
<tr>
<td>KL 150/150</td>
<td>256 2*1T10</td>
<td>131 T8 K140 B420</td>
<td>96 1T8</td>
<td>96 1T8</td>
</tr>
<tr>
<td>KL 100/200</td>
<td>259 2*1T10</td>
<td>106 T8 K140 B420</td>
<td>108 1T10</td>
<td>88 1T10</td>
</tr>
<tr>
<td>KL 100/300</td>
<td>457 2*2T12</td>
<td>171 T8 K170 B680</td>
<td>149 1T12</td>
<td>152 1T12</td>
</tr>
<tr>
<td>KL 200/200</td>
<td>456 2*2T12</td>
<td>171 T8 K170 B680</td>
<td>149 1T12</td>
<td>149 1T12</td>
</tr>
<tr>
<td>KL 250/250</td>
<td>463 2*2T12</td>
<td>173 T8 K170 B680</td>
<td>137 1T12</td>
<td>137 1T12</td>
</tr>
<tr>
<td>KL 200/300</td>
<td>465 2*2T12</td>
<td>173 T8 K170 B680</td>
<td>138 1T12</td>
<td>136 1T12</td>
</tr>
<tr>
<td>KL 300/300</td>
<td>465 2*2T12</td>
<td>176 T8 K170 B680</td>
<td>134 1T12</td>
<td>134 1T12</td>
</tr>
</tbody>
</table>

### Table 21. JAL anchor plate reinforcement

<table>
<thead>
<tr>
<th>JAL anchor plate</th>
<th>Tensile reinforcement</th>
<th>Splitting reinforcement on the top surface of the base</th>
<th>Shear reinforcement/ bond X direction</th>
<th>Shear reinforcement/ bond Y direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$A_{ss5}$ mm²</td>
<td>$A_{ss5}$ T</td>
<td>$A_{st8}$ mm²</td>
<td>$A_{st8}$ T</td>
</tr>
<tr>
<td>JAL 150/150</td>
<td>735 2*2T12</td>
<td>275 T10 K125 B500</td>
<td>85 1T8</td>
<td>85 1T8</td>
</tr>
<tr>
<td>JAL 150/200</td>
<td>1065 2*3T12</td>
<td>387 T10 K116 B580</td>
<td>157 1T10</td>
<td>148 1T10</td>
</tr>
<tr>
<td>JAL 150/250</td>
<td>1075 2*3T12</td>
<td>355 T10 K112 B560</td>
<td>146 1T10</td>
<td>130 1T10</td>
</tr>
<tr>
<td>JAL 200/200</td>
<td>1104 2*3T12</td>
<td>409 T10 K110 B660</td>
<td>140 1T10</td>
<td>140 1T10</td>
</tr>
<tr>
<td>JAL 200/250</td>
<td>1029 2*3T12</td>
<td>379 T10 K128 B640</td>
<td>137 1T10</td>
<td>133 1T10</td>
</tr>
<tr>
<td>JAL 250/250</td>
<td>1002 2*3T12</td>
<td>370 T10 K132 B660</td>
<td>130 1T10</td>
<td>130 1T10</td>
</tr>
<tr>
<td>JAL 200/300</td>
<td>1607 2*4T12</td>
<td>533 T10 K109 B760</td>
<td>222 1T12</td>
<td>209 1T12</td>
</tr>
<tr>
<td>JAL 300/300</td>
<td>1683 2*4T12</td>
<td>627 T12 K140 B840</td>
<td>208 1T12</td>
<td>208 1T12</td>
</tr>
<tr>
<td>JAL 400/400</td>
<td>1676 2*4T12</td>
<td>600 T12 K143 B855</td>
<td>203 1T12</td>
<td>203 1T12</td>
</tr>
<tr>
<td>JAL 500/500</td>
<td>1634 2*4T12</td>
<td>604 T12 K143 B855</td>
<td>208 1T12</td>
<td>208 1T12</td>
</tr>
<tr>
<td>JAL 600/600</td>
<td>1634 2*4T12</td>
<td>604 T12 K143 B855</td>
<td>208 1T12</td>
<td>208 1T12</td>
</tr>
</tbody>
</table>

### Table 22. AKL and AKLJ anchor plate reinforcement. Profile spacing ≥ 400 mm.

<table>
<thead>
<tr>
<th>AKLP</th>
<th>Tensile reinforcement</th>
<th>Splitting reinforcement on the top surface of the base</th>
<th>Shear reinforcement/ bond X direction</th>
<th>Shear reinforcement/ bond Y direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKLP</td>
<td>$A_{ss5}$ mm²</td>
<td>$A_{ss5}$ T</td>
<td>$A_{st8}$ mm²</td>
<td>$A_{st8}$ T</td>
</tr>
<tr>
<td>AKLP 100/L</td>
<td>279 2*1T10</td>
<td>104 T8 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AKLP 150/L</td>
<td>267 2*1T10</td>
<td>100 T8 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AKLP 200/L</td>
<td>313 2*1T10</td>
<td>116 T8 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AKLP 300/L</td>
<td>314 2*1T10</td>
<td>116 T8 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AKLP 400/L</td>
<td>314 2*1T10</td>
<td>117 T8 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AKLJ 300/L</td>
<td>486 2*2T12</td>
<td>181 T8 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AKLJ 400/L</td>
<td>496 2*2T12</td>
<td>185 T8 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AKLJ 500/L</td>
<td>1086 2*3T12</td>
<td>206 T10 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AKLJ 600/L</td>
<td>1532 2*3T12</td>
<td>260 T10 K100 B200</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

### 3. Anchor plate reinforcement calculation and output according to the forces

**1. Calculation principle**

Reinforcements calculated by the software are used instead of tables 16–19.
- The software only calculates reinforcements for the forces that require them.
- Supplementary reinforcement must be enabled in the software.
- If reinforcement is not output, it is not needed.
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2. Tensile reinforcement $A_{st5}$</strong></td>
<td>The anchor plate’s tensile reinforcement is output in Window 3/6, Tab 1. - According to EN 1992-4:2018 (7.2.1.2), all the bonds of the anchor plate must be reinforced for the tensile force on the plate’s most heavily loaded bond. - The reinforcement area calculated bond-specifically is shown in the Required column. - The reinforcement area according to the selected rebar is shown in the Selected column. The Foundations total column shows the plate’s reinforcement selected according to the most heavily loaded bond as well as the total area of the reinforcement $A_{st5}$.</td>
</tr>
<tr>
<td><strong>3. Surface reinforcement $A_{st8}$</strong></td>
<td>The anchor plate’s surface reinforcement is output in Window 3/6, Tab 2. - The reinforcement is a mesh whose area and placement width are shown in the window. - The placement width is $3h_{ef}$, where $h_{ef} =$ the plate’s height in the structure. - The mesh rebar anchoring length $l_{bd}$ begins from the edge of the placement area. - At the edge, the mesh rebar must be anchored to the bottom surface with links. - The mesh rebar can be used at the corners of $A_{st5}$ U-stirrups. - Surface reinforcement can be replaced with other reinforcement if it is in the area of the anchor plate and is suitable for use.</td>
</tr>
<tr>
<td><strong>4. Reinforcement principle drawing</strong></td>
<td>Figure 33 presents the reinforcement principle for tensile force. - U-links are placed next to the bonds and symmetrically on the plate. - The U-links must be located in the plate’s tensile failure cone area = $3h_{ef}$. - The U-link’s anchoring length $l_{bd}$ starts at the bottom end of the bond and extends outside the failure cone. - At the corners of the U-link, there are steels on the top surface and also on the bottom surface, if necessary. Reinforcement $A_{st8}$ can be used for this. - The distance of the U-links and mesh from the surface of the structure is $c_{nom}$. - The designer specifies the reinforcement according to these principles.</td>
</tr>
<tr>
<td><strong>5. Rebar for determining the reinforcement</strong></td>
<td>On Tab 6 of the software’s initial data window, you can select the desired rebar for outputting the reinforcement. - The default values can only be changed specifically for each calculation. - The software uses this rebar for calculating the reinforcements. - $A_{st5}$ = Tensile failure cone U-stirrups - $A_{st8}$ = Surface reinforcement mesh on the top surface - $A_{st11}$ = U-stirrups for the bond’s shear reinforcement</td>
</tr>
</tbody>
</table>
4. **Anchor plate is reinforced for tensile force according to the principles of Figure 31.**

1. **Tensile reinforcement $A_{ast5}$ in the middle of the structure:**
   - The reinforcement is a U-stirrup around the bonds.
   - The U-stirrup is anchored outside the failure cone.
   - Corner steels are used at the corners of the stirrup.
   - If the reinforcement is an element, it can be spread such that the plate can be pushed inside the reinforcement.

2. **Tensile reinforcement $A_{ast5}$ at the edge of the structure:**
   - The reinforcement is a U-stirrup placed like above.
   - The U-stirrup is anchored outside the failure cone.
   - Corner steels are used at the corners of the stirrup.
   - The reinforcement is connected to the surface reinforcement shown in Figure 32.

   ![Figure 31](image)

   **Figure 31. Anchor plate reinforcement principle. U-stirrups for tensile force.**

5. **Surface reinforcement of anchor plate is made according to principles of Figure 32.**

3. **Surface reinforcement $A_{ast8}$ in the middle of the structure:**
   - The width of the mesh placement area is $S/2+3h_{ref}$.
   - The rebar is anchored outside the area.
   - Other mesh on the structure can be used for the reinforcement.
   - The mesh rebar can also be used at the corners of $A_{ast5}$.

4. **Surface reinforcement $A_{ast8}$ at the edge of the structure:**
   - The width of the mesh placement area is $S/2+3h_{ref}$.
   - The rebar is anchored outside the area.
   - At the edge of the structure, the mesh is anchored to the bottom surface of the structure.

   ![Figure 32](image)

   **Figure 32. Anchor plate reinforcement principle. Surface mesh.**

6. **Anchor plate shear reinforcement calculation and placement according to the forces**

<table>
<thead>
<tr>
<th>Calculation principle</th>
<th>Shear reinforcements calculated by the software can be used instead of tables 16–19.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The software only calculates reinforcements for the forces that require them.</td>
</tr>
<tr>
<td></td>
<td>When the distance of the centre of the plate from the edge of the structure is $\leq s/2+1.5h_{ref}$, the anchor plate is reinforced for shear force with a check for edge failure.</td>
</tr>
</tbody>
</table>
- The distance of the stirrup and mesh from the surface of the structure is $c_{nom}$.

2. Shear reinforcement $A_{st11}$

The anchor plate's shear reinforcement is output in Window 3/6, Tab 3.

- According to EN 1992-4:2018 (7.2.2.2), all the bonds of the anchor plate must be reinforced for the shear force on the plate's most heavily loaded bond.

- The U-stirrup in X- and Y-direction columns show the minimum reinforcement area calculated for each bond and the U-stirrup selected. If the reinforcement is shown in red, its resistance is exceeded, and the plate cannot be reinforced.

- The Foundations total column shows the U-stirrups thus selected and the minimum total area $A_{st11}$.

3. Reinforcement principle drawings

Figure 33 presents the anchor plate's reinforcement principle for shear force.

- U-links are placed around the bonds.

- The U-links are anchored such that anchoring length $l_{bd}$ starts at the bond and extends outside the failure cone.

The designer specifies the reinforcement according to these principles.

4. Stress state of the characteristic value of loads.

The $\delta_{ch}$ column shows the stress state of the selected reinforcement with the characteristic value of loads. The value can be used for the plate's serviceability limit state design in Section 5.7.

7. Anchor plate is reinforced for shear force according to the principles of Figure 33.

1. Shear reinforcement $A_{st11}$ around the bond

- The reinforcement is a U-stirrup placed such that it touches the bond in the direction of the shear force.

- The anchoring length begins at the outer bond.

2. Edge failure reinforcement $A_{s88}$ at the edge of the structure

- The tensile reinforcement surface mesh $A_{s88}$ is used as the reinforcement and shaped to the edge of the structure.

- Anchoring length $l_{bd}$ begins at the outer bond.

Figure 33. Anchor plate reinforcement principle for shear force. U-stirrups and edge failure.
8. **Punching and edge failure designing of the anchor plate**

<table>
<thead>
<tr>
<th>1. Punching and edge failure of the anchor plate’s base concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>These situations are always analysed regardless of whether tensile and shear force reinforcement is used on the plate. The software does not calculate these situations.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Axial force punching failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The compressive forces on the anchor plate must be subjected to base structure punching analysis according to EN 1992-1-1, Section 6.5.</td>
</tr>
<tr>
<td>- Punching failure is calculated when the plate is subjected to significant compressive load and the base structure is thin.</td>
</tr>
<tr>
<td>- Punching failure is calculated when the plate is in split concrete and its axial force resistance is limited by the edge distance.</td>
</tr>
<tr>
<td>- The base structure must be provided with punching reinforcement according to the analysis.</td>
</tr>
<tr>
<td>- The other reinforcement of the base and the reinforcement calculated for the anchor plate can be utilised when specifying the punching failure.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Shear force edge failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Edge failure and concrete splitting analysis must be performed for the anchor plate when the distance of the centre of the plate from the edge of the structure is ≤ s/2+1.5*htef.</td>
</tr>
<tr>
<td>- Edge failure is always analysed, regardless of whether the plate’s bonds are provided with shear reinforcement.</td>
</tr>
<tr>
<td>- Shear reinforcement Ast11 cannot replace edge failure reinforcement.</td>
</tr>
<tr>
<td>- Edge failure reinforcement can be created using the plate’s surface reinforcement Ast8 by turning the rebar down at the edge of the structure.</td>
</tr>
<tr>
<td>- The area and stress level of the mesh must be adjusted to the required crack width.</td>
</tr>
<tr>
<td>- The edge failure reinforcement principle is presented in Figure 33.</td>
</tr>
</tbody>
</table>

5.7 **Serviceability limit state design of the anchor plate**

1. **Splitting analysis of the anchor plate’s base concrete with the specific loads.**

<table>
<thead>
<tr>
<th>1. Concrete and supplementary reinforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>The following analysis is performed on the splitting of the anchor plate’s base concrete:</td>
</tr>
<tr>
<td>- Tab 1 of Window 3/6 shows the stress state of the tensile reinforcement calculated for the anchor plate with specific loads δt,nom.</td>
</tr>
<tr>
<td>- Tab 3 of Window 3/6 shows the stress state of the shear reinforcement calculated for the anchor plate with specific loads δs,nom.</td>
</tr>
<tr>
<td>- The specific load has been determined by dividing the calculation load by a factor specified with the load ratio factor Gk in the Loads window.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Splitting design</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Splitting design is performed for the anchor plate’s base concrete at the edge of the structure by using these stress states as the basis for the calculation along with the structure’s dimensions and other loads.</td>
</tr>
<tr>
<td>- The splitting design is performed by applying the instructions in EN 1992-1-1,[6] Section 7.3.</td>
</tr>
</tbody>
</table>

2. **Surface plate and profile analysis**

<table>
<thead>
<tr>
<th>1. Surface plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Separation of the surface plate from the concrete must be taken into account in the plate’s serviceability limit state design, since moisture may then get under plate. This must be structurally prevented.</td>
</tr>
<tr>
<td>- The protection of the side edge of the surface plate must also be taken into account in the analysis.</td>
</tr>
<tr>
<td>- The alkaline protection of concrete is sufficient for the bottom surface of the plate.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Profile and its weld</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The plate’s top surface and connection profile are painted on the site according to the EN 12944-2[12] standard.</td>
</tr>
</tbody>
</table>
The atmospheric corrosivity category according to EN 12944-2 and its requirements are taken into account in the surface treatment of the visible plate and connection profile. The treatment is determined by the designer.

3. **Recommended concrete covers and surface treatments**

1. **Connection piece cast in concrete**
   - Table 23 shows the nominal value $C_{nom}$ required for the concrete cover of the anchor plate’s bonds by exposure class according to the minimum value in EN 1992-1-1.
   - The required concrete cover is also taken into account for the edge of the plate.

2. **Surface plate, profile and its weld**
   - Table 23 presents the recommended surface treatments for the plate, profile and weld. The treatment has been applied in accordance with the concrete exposure classes.

3. **Hot-dip galvanisation**
   - The anchor plates cannot be hot-dip galvanised, since welding the connection to a galvanised structure would cause an occupational safety problem.
   - A hot-dip galvanised anchor plate can be achieved by welding a connection profile to the plate before use, with a connection plate and screw holes for mounting.
   - After this, the connection piece can be hot-dip galvanised before casting.
   - This special structure can be supplied for anchor plates if necessary.

### Table 23. Required nominal concrete cover and surface treatment.

<table>
<thead>
<tr>
<th>Exposure class EN 1992-1-1</th>
<th>50-year service life $C_{nom}$ mm</th>
<th>100-year service life $C_{nom}$ mm</th>
<th>Anchor plate bonds</th>
<th>Surface plate and connection profile protection method</th>
</tr>
</thead>
<tbody>
<tr>
<td>X0</td>
<td>20</td>
<td>35</td>
<td>Sufficient concrete cover</td>
<td>Painting</td>
</tr>
<tr>
<td>XC1</td>
<td>25</td>
<td>40</td>
<td>Sufficient concrete cover</td>
<td>Painting</td>
</tr>
<tr>
<td>XC3</td>
<td>35</td>
<td>45</td>
<td>Sufficient concrete cover</td>
<td>Painting</td>
</tr>
<tr>
<td>XC2, XC4</td>
<td>40</td>
<td>50</td>
<td>Sufficient concrete cover</td>
<td>Austenitic plate</td>
</tr>
<tr>
<td>XS1–XD1</td>
<td>45</td>
<td>55</td>
<td>Sufficient concrete cover</td>
<td>Austenitic plate</td>
</tr>
<tr>
<td>XD2</td>
<td>50</td>
<td>60</td>
<td>Sufficient concrete cover</td>
<td>Austenitic plate</td>
</tr>
<tr>
<td>XD3</td>
<td>55</td>
<td>65</td>
<td>Sufficient concrete cover</td>
<td>Austenitic plate</td>
</tr>
<tr>
<td>XS2–XS3</td>
<td>—</td>
<td>—</td>
<td>The connections can be used on the basis of site-specific special analyses. The surface plate material, surface treatment and concrete cover are specified according to the site requirements.</td>
<td></td>
</tr>
<tr>
<td>XA1–XA3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XF1–XF4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The connections can be used on the basis of site-specific special analyses. The surface plate material, surface treatment and concrete cover are specified according to the site requirements.
6 ANCHOR PLATE ERECTION

6.1 Anchor plate delivery, storage and identification

The anchor plates are delivered shrink-wrapped on a pallet. Longer-term storage protected from rain. The pallet is equipped with identifying information and each connection piece has a colour code.

6.2 Anchor plate erection in formwork

| 1. Assembling a connection group | - The anchor plates are ready for installation in formwork as they are.  
- Two adjacent anchor plates can be welded together with a piece of flat steel behind the surface plate. |
| 2. Connection piece installation and fastening | - Place the anchor plate’s surface plate against the side surface or bottom of the formwork.  
- Fasten the anchor plate to the formwork by nailing through the holes.  
- Use another suitable fastening method according to the application.  
- The anchor plate must be fastened to the formwork such that it cannot move during casting. |
| 3. Supplementary reinforcement | - Ensure that the supplementary reinforcement of the anchor plate has been installed.  
- Ensure that the structure has been reinforced according to the plans in the anchor plate area. |

Anchor plate erection tolerances in the formwork:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anchor plate displacement on the surface of the structure.</td>
</tr>
<tr>
<td>2</td>
<td>Anchor plate installation on the top surface of the casting. Deviation from the theoretical level.</td>
</tr>
<tr>
<td>3</td>
<td>Anchor plate installation against the surface of the formwork. Maximum allowable clearance.</td>
</tr>
<tr>
<td>4</td>
<td>Anchor plate torsion/inclination in relation to the base. Allowable deviation.</td>
</tr>
</tbody>
</table>

6.3 Corrective measures allowed for anchor plates

The structures of the anchor plate must not be modified without the manufacturer’s permission. Non-conformity reports must be prepared for any modifications. Corrective measures allowed for the connection pieces are:

| 1. Allowable corrective measure | - Two anchor plates can be assembled into an installation group by spot welding a piece of flat steel behind the surface plate.  
- However, the weld must not reach the area of the bonds’ weld.  
- Reinforcements may be welded behind the surface plate, if spot welds are used and the purpose is to fasten the anchor plate to the formwork during the installation.  
- Brackets may be spot welded to the top surface of the surface plate for the purpose of fastening it to the formwork. |
| 2. Non-allowable corrective measure | - The anchor plate’s surface plate must not be modified by cutting or welding.  
- The anchor plate’s bonds must not be removed, shortened or bent.  
- Brackets must not be welded to the anchor plate’s bonds even for the duration of the installation.  
- No other force transfer structures may be welded to the anchor plate’s surface plate during construction. |

The following corrective measures are not allowed. These changes require a separate non-conformity plan and the connection manufacturer’s approval.
6.4 Manufacture quality control

Manufacture quality control for anchor plate connections is carried out in accordance with the prefabrication factory’s quality system and/or any separate element quality control plan prepared for the project. The structural and dimensional inspections specified in the quality system/inspection plan are performed on the connection pieces. The quality control measures to be performed for anchor plates include:

| Measures before casting | - Check that the anchor plate is the correct one and has not been damaged.  
|                         | - Ensure that the anchor plate is correctly located in the formwork.   
|                         | - Ensure that the anchor plate has been securely fastened.             
|                         | - Ensure that the supplementary reinforcement of the anchor plate has been installed. |
| Measures after casting  | - Measure the location of the anchor plate to correspond to the required tolerances.  
|                         | - Check that the casting has been successful around the plate.         |

6.5 Final documentation of manufacture quality control

When the job has been accepted, the builder is required to provide the client with the inspection and quality control documentation created during manufacture. In addition, the delivery must include any as-built documentation and non-conformity reports made during manufacture.

7 WELDING THE CONNECTION PROFILE ON THE SITE

7.1 Standards and plans to be followed during welding

The following instructions and project plans are to be followed when welding the connection profile.

| Standards Implementation breakdown Quality plan | - Installation plan prepared by the frame installer.   
|                                                | - Concrete structure implementation breakdown prepared for the project and site.  
|                                                | - Steel structure implementation breakdown prepared for the project and site.   
|                                                | - Welding procedures prepared for the project (WPS)     
|                                                | - Quality inspection plan prepared for the project and site.  
|                                                | - EN 13670 Execution of concrete structures [17]       
| Drawings                                      | - Installation drawings prepared by the frame designer.  
|                                                | - Installation details prepared by the frame designer.   |
| Installation instructions                     | - Anchor plates. User manual, whose sections 7, 8 and 9 apply to installing a connection profile on the site. [21] |

7.2 Welding the connected profile

| As-built measurements | - Perform as-built measurement of the location of the anchor plate.   
|                       | - Ensure that the anchor plate’s tolerance deviations are within the area allowed by the installation tolerances.  
|                       | - The as-built measurements are checked/approved by the person installing the connected profile. |
| Working conditions    | - Welding must be carried out under protection from rain, moisture and wind.  
|                       | - At temperatures below +5 °C, preheating is used according to the welding procedure specifications. The surface plate must not be overheated. Only enough to remove moisture and make the plate... |
temperature acceptable for welding.
- The plate is cleaned with a wire brush.
- The primer applied at the machine shop need not be removed.

3. **Welding**
- Welding is carried out according to the welding procedure specifications prepared for the project.
- The WPS and filler materials are selected according to the material and material thickness of the anchor plate and connected profile.
- Large welds must be made using several welding beads in order to minimise heat transfer through the surface plate to the concrete.
- For austenitic plates and profiles, the surface is post-processed according to the project breakdown.
- After welding, the surface plate and profile weld area are to be painted.

4. **Safety requirements**
- See the installation plan for the installation order and time.
- Find out about other safety and stability requirements for the installation.

5. **Inspections**
- 100% visual inspection must be performed on the welds. Other inspection methods are used according to the project breakdown.

### 7.3 Installation tolerances for the connected profile

The installation tolerances for the connected profile are in accordance with EN 1090-2:2018 [2]. The profile to be welded to the anchor plate and its location are specified in the structural plans. The following location tolerances can be allowed for the profile.

<table>
<thead>
<tr>
<th></th>
<th>Location of the profile centre line in relation to the anchor plate centre line:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The tolerance is followed if no stricter location requirements have been specified in the structural plans. Location tolerances looser than this can be specified in the structural plans; for example, the allowable welding area for the profile.</td>
</tr>
<tr>
<td>2</td>
<td>Profile torsion on the plate, unless otherwise specified:</td>
</tr>
<tr>
<td>3</td>
<td>Profile head clearance from the surface of the plate:</td>
</tr>
<tr>
<td>4</td>
<td>The other profile installation tolerances follow the EN 1090-2:2018 standard or the instructions in the structural plan.</td>
</tr>
</tbody>
</table>

### 7.4 Fire protection of the anchor plate

The anchor plate is fire-protected as follows:

<table>
<thead>
<tr>
<th></th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- See the structural plans for the planned fire protection method for structures connected to the anchor plate.</td>
</tr>
<tr>
<td></td>
<td>- The anchor plate and the structures must meet the same protection requirement.</td>
</tr>
<tr>
<td></td>
<td>- An unprotected anchor plate connection meets the R15 requirement.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Protecting a connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>- The connected profile and surface plate must be protected to the required class with external fire protection.</td>
</tr>
<tr>
<td></td>
<td>- Connection pieces inside the concrete structure are protected by concrete.</td>
</tr>
<tr>
<td></td>
<td>- In other cases, follow the instructions in the structural plans.</td>
</tr>
</tbody>
</table>
8 SAFETY MEASURES

8.1 Information for preparing work safety instructions for the site

Appointed by the developer, the project’s work safety coordinator is responsible for ensuring work safety during the building work. When preparing work safety instructions for the project, the following must be taken into account in the installation of the connected structures.

| 1. Installation | - Structures are installed by following the working order in the contractor’s installation plan and the requirement for stability during erection determined by the designer.  
- The anchor plate must not be loaded in ways and with forces deviating from the plan. |
| 2. Stability     | - The stability of the structures under exceptional natural forces must be ensured at the end of the shift, particularly if the installation work is not completed. |
| 3. Structure     | - The time at which the anchor plate can be loaded must be specified in the installation plan. |

8.2 Commissioning a connection during construction

The anchor plate has not been specifically designed for the erection state. The anchor plate will work for final state loads when the concrete has reached the design strength and the connection profile has been welded. However, when installing the connected structure, it must be ensured that partially installed structures work according to the plans, so that the anchor plate is not loaded incorrectly during the erection state.

9 INSTALLATION QUALITY CONTROL

9.1 Instructions for monitoring connection installations

Installation quality control for the anchor plates is carried out in accordance with the quality control plan prepared for the project and site. The instructions to be followed are in EN 13670 [17] for the requirements for concrete structures and in EN 1090-2:2018 for steel structures. An inspection report is prepared for the element frame’s quality control and dimensional inspections and saved in the project’s quality documentation. The inspection measures for anchor plates are:

| 1. Before anchor plate installation | - Ensure that the anchor plate has not been damaged.  
- Ensure that the anchor plates used are in accordance with the plans.  
- Installation plan for welding the connection profiles to the anchor plate.  
- Need for supporting the structures during installation.  
- Checking the location tolerances of the anchor plate. |
| 2. After connection profile installation | - Check that the connected profiles have been installed according to the plans.  
- Ensure that the materials used are in accordance with the plans.  
- The connection profile welds have been inspected. |
| 3. Deviations | If the installer deviates from the approved plans and documents in any of the following tasks:  
  - quality control  
  - installation work, lifting and transfers and the materials used  
  - structural tolerances and dimensional and other inspections of the structure  
the installer is obliged to start documenting the non-conformity upon observing the deviation from the plan and to have the client approve the resulting measures. Non-conformity reports are saved in the project’s quality documentation. |
9.2 Final documentation of installation quality control

The contractor delivers the inspection and quality control documentation created during the installation work.

<table>
<thead>
<tr>
<th>1. Readiness inspection records</th>
<th>- Anchor plate inspection record.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Commissioning inspection of the anchor plates after the connection profiles.</td>
</tr>
<tr>
<td>2. Non-conformity reports</td>
<td>- Any non-conformity reports prepared during the installation of the anchor plates are handed over.</td>
</tr>
<tr>
<td>3. Product approval as-built</td>
<td>- CE marking certificates or corresponding product approval information for materials purchased for the site.</td>
</tr>
<tr>
<td></td>
<td>- As-built documentation for changes made to the structure.</td>
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Anstar Oy is a Finnish family business specialising in the sales and manufacture of concrete structure connections and composite beams. We are an international operator, and one of the pioneers in the field. Anstar will help you with all your questions relating to concrete connections. Anstar’s specialists may also develop solutions to customer-specific connection problems.