About Simpson Strong-Tie®

For more than 50 years Simpson Strong-Tie® has focused on creating structural products that help build safer and stronger homes and buildings. A leader in structural systems research and technology, we have become one of the largest suppliers of structural building products in the World.

Developed in conjunction with Napier University and approved by Trada Technology, Strong-Portal™ is the latest in a long line of innovative products developed to overcome design challenges and meet legislation changes facing the timber frame industry.

Technical Support

We have covered most eventualities in this brochure, however our technical support team is also on hand to provide advice and guidance in the use of Steel Strong-Wall™ and Strong-Portal™:

Telephone: 01827 255600
Fax: 01827 255616
Visit: strongportal.co.uk

See Strong-Portal™ in action: YouTube /strongtieuk
Introduction

Overcome the challenge of racking resistance with large openings...

Typically, a timber frame building is subjected to wind loads which result in racking, overturning and sliding forces being exerted against it.

For engineers and designers working with timber frame structures it is becoming increasingly difficult to provide sufficient racking resistance, particularly in buildings with large openings and very little wall in the front and rear elevations.

Strong-Portal™ and Steel Strong-Wall™ from Simpson Strong-Tie® have been developed to provide improved resistance to racking forces and to help overcome the design challenges presented in such cases.

These new systems can be used in external or internal walls depending on the racking requirement and available wall space.
Design Guidelines

Applications
The racking solutions described in this document can be used in the following situations within a building to resist racking loads.

- Around openings such as garages, patio doors and bay windows.
- Narrow piers.
- Internal walls.
- External walls

Wall Thickness
The Steel Strong-Wall™ panel can be used in conjunction with either 89mm or 140mm deep stud walls (and any thickness in between).

The Strong-Portal™ can only be used in walls with a minimum thickness of 149mm (140mm stud and 9mm OSB).

Racking Resistance
The graph opposite which shows the performance values for the complete range of products.

Item Codes Explained
The item codes shown opposite follow a convention indicating dimensions and (in the case of Strong-Portal™) vertical load capacity. Example shown SP300/2400-8.3:

SP 300 / 2400 - 8.3

1. Product Type: SP for Strong-Portal™ or SSWT for Steel Strong-Wall™.
2. Column width ‘C’: 300mm or 450mm.
3. Height ‘H’ in mm.
4. Applied vertical load (kN/m). (Does not apply to the Steel Strong-Wall™).
# Racking Resistance Performance Values

For use in conjunction with BS5268-2 design methods.

## Strong-Portal™

<table>
<thead>
<tr>
<th>Vertical Load (kN/m)</th>
<th>Span W (mm)</th>
<th>Height H (mm)</th>
<th>Column Width C (mm)</th>
<th>Racking Resistance $R_b$ (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1500-3000</td>
<td>1900-2455</td>
<td>450</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2456-2700</td>
<td>450</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>3000-3600</td>
<td>1900-2455</td>
<td>450</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2456-2700</td>
<td>450</td>
<td>4.5</td>
</tr>
</tbody>
</table>

## Steel Strong-Wall™

<table>
<thead>
<tr>
<th>Vertical Load (kN/m)</th>
<th>Span W (mm)</th>
<th>Height H (mm)</th>
<th>Column Width C (mm)</th>
<th>Racking Resistance $R_b$ (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>2172</td>
<td>610</td>
<td>10.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>305</td>
<td></td>
<td>1.75</td>
</tr>
</tbody>
</table>

Please Note

Several products can be used together to give increased performance. For example:

2 x SSWT305/2172 = 2 x 1.75 = 3.5kN
2 x SP450/2700-8.3 = 2 x 8.00 = 16kN

For further information, please contact Simpson Strong-Tie® technical support on 01827 255600.
Developed to offer enhanced racking resistance in timber structures, Strong-Portal™ is available in a range of heights and widths to suit various sizes of opening and can be delivered directly to site or to the timber frame manufacturer’s facility.

**Key Benefits**

- Easily integrated with existing timber frame designs.
- Secured directly to foundation and adjacent timber frame panels.
- Sustainable product (mainly comprising timber and OSB).
- Easy to handle - no need for cranes or mechanical handling equipment.
- Pre-insulated with pre-determined ‘U-Values’.
- No additional framework required - simple connection to adjacent elements.
- All fixings and adhesives required for installation provided.

**Materials**

- Timber: C24 graded, preservative treated
- Sheathing: 11mm OSB/3
- Metalwork: Galvanised mild steel - Z275
- Insulation: Rigid insulation: \( \lambda = 0.023 \text{ W/mK} \)
- AT-HP Adhesive: Styrene free, methacrylate resin
- Threaded Rods: Grade 8.8 carbon steel, zinc plated
- Nuts and Washers: Carbon steel, zinc plated

**Thermal Performance**

The thermal performance of Strong-Portal™ has been independently assessed by TRADA Technology Ltd. The thermal performance of the columns and lintel can be accounted for in the area weighted U-value of the whole wall by including within the appropriate timber fraction.
## Product Range & Performance Values for use with BS 5268-2 Design Methods

<table>
<thead>
<tr>
<th>Portal Width Range (W) mm</th>
<th>Height Range (H) mm</th>
<th>Column Width (C) mm</th>
<th>Header Depth (D) mm</th>
<th>Permissible Racking Load - $R_b$ (kN)</th>
<th>Maximum Total Vertical Load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 kN/m</td>
<td>8.3 kN/m</td>
</tr>
<tr>
<td>1500-3000</td>
<td>1900-2455</td>
<td>300</td>
<td>200</td>
<td>5.00</td>
<td>6.00</td>
</tr>
<tr>
<td>3000-3600</td>
<td>2456-2700</td>
<td></td>
<td>300</td>
<td>4.50</td>
<td>5.50</td>
</tr>
<tr>
<td>1500-3000</td>
<td>1900-2455</td>
<td>450</td>
<td>200</td>
<td>4.00</td>
<td>5.00</td>
</tr>
<tr>
<td>3000-3600</td>
<td>2456-2700</td>
<td></td>
<td>300</td>
<td>3.50</td>
<td>4.50</td>
</tr>
<tr>
<td>1500-3000</td>
<td>1900-2455</td>
<td></td>
<td>450</td>
<td>9.50</td>
<td>12.50</td>
</tr>
<tr>
<td>3000-3600</td>
<td>2456-2700</td>
<td></td>
<td>300</td>
<td>8.50</td>
<td>11.50</td>
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<tr>
<td>1500-3000</td>
<td>1900-2455</td>
<td></td>
<td>200</td>
<td>7.00</td>
<td>9.00</td>
</tr>
<tr>
<td>3000-3600</td>
<td>2456-2700</td>
<td></td>
<td>300</td>
<td>6.00</td>
<td>8.00</td>
</tr>
</tbody>
</table>

1. Fasteners and anchors are supplied with Strong-Portal™.
2. $R_b$ is the racking resistance determined from tests carried out in accordance to BS EN 594:2011
3. It is the responsibility of the building engineer/designer to ensure the foundation and hold down anchors can take the applied tension and compression loads.

Generic foundation details are provided in the following pages.
Strip Foundations with Ground Supported Floor Slab
(again applicable to Steel Strong-Wall™)

- Strong-Portal™ column (could also be Steel Strong-Wall™)
- Floor (designed by others)
- Brick and block work as per the engineering details.
- Concrete Pier, cast to the required floor height and reinforced/connected to the strip foundation (designed by engineer responsible for the foundations).

Strip Foundations with Suspended Floor Slab

- Strong-Portal™ column (could also be Steel Strong-Wall™)
- Floor (designed by others)
- Brick and block work as per the engineering details.
- Concrete Pier, cast to the required floor height and reinforced/connected to the trench fill foundation for fixed base design. No reinforcement/connection is required for pinned base design (designed by engineer responsible for the foundations).
Trench Fill Foundations with Ground Supported Floor Slab

Strong-Portal™ column (could also be Steel Strong-Wall™)

Floor (designed by others)

Brick and block work as per the engineering details.

Concrete Pier, cast to the required floor height and reinforced/connected to the trench fill foundation for fixed base design. No reinforcement/connection is required for pinned base design (designed by engineer responsible for the foundations).

Raft Foundations and Floor Slab

Strong-Portal™ column (could also be Steel Strong-Wall™)

Floor (designed by others)

Brick and block work as per the engineering details.

Concrete Pier, cast to the required floor height and reinforced/connected to the trench fill foundation for fixed base design. No reinforcement/connection is required for pinned base design (designed by engineer responsible for the foundations).
Strip or Trench Fill Foundations with Precast Concrete Beam and Block Floor

Strong-Portal column (could also be Steel Strong-Wall™)

Beam and Block Floor (designed by others)

Brick and block work as per the engineering details.

Concrete Pier, cast to the required floor height and reinforced/connected to the trench fill foundation for fixed base design. No reinforcement/connection is required for pinned base design (designed by engineer responsible for the foundations).
Racking Solutions for Timber Framed Buildings

**Strong-Portal™ Installation**

**General Information**
- The Strong-Portal™ column should be fixed directly to the concrete foundation. DO NOT sit the Strong-Portal™ on a timber sole plate.
- A DPC is required between the Steel Strong-Wall™ column and the concrete foundation.
- The concrete foundation should be designed by the engineer responsible for the structure to accommodate the hold down anchors and resist the applied loads.

**Equipment Required for Installation**
- 1 off 18mm masonry drill, minimum 300mm long.
- 1 off Dust Brush (item code BR17/30).*
- 1 off Dust Pump (item code PUMP).*
- 1 off Resin Dispensing Gun (item code DT380).*
- 1 off 24mm A/F, Long Length Socket
- 1 off Torque Wrench (minimum capacity 80Nm.

* Available from Simpson Strong-Tie, call 01827 255600 for prices.

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**Strong-Portal™ Installation Step 1**

1a - Position the drilling template (supplied) on top of the foundation in the required position, ensuring the correct orientation of the template. The drilling template is the same size as the bottom plate of the Strong-Portal™.

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**Strong-Portal™ Installation Step 2**

2a - Drill vertically through the drilling template in the positions marked.

2b - Drill holes to the stated diameter and depth (see drilling template for details).

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**Strong-Portal™ Installation Step 3**

3a - Ensure the holes are cleaned thoroughly (refer to page 19).

3b - Install the anchor bolts supplied: AT-HP resin with Grade 8.8 LMAS M16X230 threaded rod.

Refer to page 19 for anchor details.
**Strong-Portal™ Installation Step 4**

4a - Position the columns over the anchor bolts ensuring the correct orientation as shown below. Level by using Simpson Strong-Tie® TFLS steel shims and structural grout if required.

Plumb and where necessary, provide temporary bracing which can be the adjacent timber frame panels if already installed.

4b - Install M16 nuts and washers and tighten by hand.

**Strong-Portal™ Installation Step 5**

5a - Place the header between the left hand (LH) and right hand (RH) columns, ensuring the flush face (OSB and LVL) is at the bottom (refer to product label).

5b - Connect the column to the header using 6.0X70mm screws provided. Ensure that the angle between the header and column is 90° (fig. 5b1) and that there is no gap between the bottom of the header and the top view of the column (view ‘A’: fig. 5b2)

149mm overall thickness to suit use with 140mm studs and 9mm OSB in standard timber frame panels.
Racking Solutions for Timber Framed Buildings

Strong-Portal™ Installation

**Strong-Portal™ Installation Step 6**

6a - Once the assembly is in its final position the securing nuts on the anchors can be tightened to the recommended torque (80 Nm using torque wrench with 24mm Socket). Do not over tighten the anchor bolt nuts as this will lead to premature failure. Base connections are to be considered as “pinned-joints” when designing the foundations.

6b - Install the ‘access panel assembly’ using 22 no. CNA4,0x60 nails (provided). The assembly of the Strong-Portal™ is now complete and the adjacent elements can be installed (if not already in place).

![Image of Strong-Portal™ Installation Step 6](image)

**Strong-Portal™ Installation Step 7**

7a - The Strong-Portal™ frame can be secured to adjacent timber frame panels using SDW22300 screws installed from the timber frame side shown in fig.7a. Spacing is to be determined by the engineer responsible for the design structure.

![Lateral Capacity of SDW22300 Screw](image)

Alternate fastening specification shall be in accordance with engineers instructions.

7b - Ensure that the adjacent frames are aligned correctly by checking that the OSB panels are flush as shown in fig.7b.

7c - Install the head binder continuously over the timber frame and Strong-Portal™, connecting to both.

Floor joists are supported by the Strong-Portal™ by sitting them on top of the head binder and frame as shown in fig. 7c.
The Steel Strong-Wall™ is a corrugated steel panel which is designed to be fixed directly to the concrete foundations of a the building, within either the external or internal wall sections, via a bolted connection.

Being relatively small in width the Steel Strong-Wall™ can be used in areas where only small sections of wall are available, offering significantly higher racking resistance than the equivalent sized standard timber frame wall panel.

**Key Benefits**

- Available in two widths: 305mm and 610mm.
- Standard height available: 2172mm.
- At only 89mm wide, it can be fitted into standard 89mm and 140mm deep stud walls.
- Supplied with timber studs attached.
- All fixings and adhesives required for installation are included.

**Materials**

Steel Strong-Wall™: Galvanised mild steel
Timber Studs: 38 x 89mm. C16 graded Preservative treated
SDS Screws: Hot dip galvanised, carbon steel
AT-HP Adhesive: Styrene free, methacrylate resin
Threaded Rods: Grade 5.8 carbon steel, zinc plated
Nuts and Washers: Carbon steel, zinc plated

**Product Range & Performance Values for use in BS Design Methodology**

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Overall Panel Dimensions (mm)</th>
<th>Foundation Anchors</th>
<th>Fasteners to Top Rail ((R_b)) (kN)</th>
<th>Permissable Loads (kN)</th>
<th>Anchor Loads at Max Permissable Racking Load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Depth ((D))</td>
<td>Width ((W))</td>
<td>Height ((H))</td>
<td>Qty</td>
<td>Diameter ((\text{mm}))</td>
</tr>
<tr>
<td>SSWT305/2172</td>
<td>89</td>
<td>305</td>
<td>2172</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>SSWT610/2172</td>
<td>89</td>
<td>610</td>
<td>2172</td>
<td>2</td>
<td>24</td>
</tr>
</tbody>
</table>

1. Fasteners are supplied with the Steel Strong-Wall™ panel.
2. \(R_b\) is the test racking resistance determined from tests carried out in accordance to BS EN 594:2011.
3. It is the responsibility of the building engineer/designer to ensure the foundation and hold down anchors can take the applied “tension” and “compression” loads. Please see previous section for generic foundation detail examples.
Thermal Performance

The thermal performance of Steel Strong-Wall™ has been independently assessed by TRADA Technology Ltd for the stated insulation options shown in fig. 1. Typical construction detail as per table below.

<table>
<thead>
<tr>
<th>Insulation Description and Position</th>
<th>Overall Insulation Thickness (mm)</th>
<th>Insulation Lambda (W/mK)</th>
<th>Wall U-Value (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celotex GA300 on outside face of Steel Strong-Wall™</td>
<td>50</td>
<td>0.023</td>
<td>0.36</td>
</tr>
<tr>
<td>Kingspan TW55 on outside face Steel Strong-Wall™</td>
<td>50</td>
<td>0.023</td>
<td>0.36</td>
</tr>
<tr>
<td>Steico Flex on outside face of Steel Strong-Wall™</td>
<td>50</td>
<td>0.038</td>
<td>0.42</td>
</tr>
<tr>
<td>Knauf Earthwool on outside face of Steel Strong-Wall™</td>
<td>50</td>
<td>0.032</td>
<td>0.40</td>
</tr>
<tr>
<td>Celotex GA300 on outside face of Steel Strong-Wall™ + cavity fill</td>
<td>100</td>
<td>0.023</td>
<td>0.23</td>
</tr>
<tr>
<td>Kingspan TW55 on outside face Steel Strong-Wall™ + cavity fill</td>
<td>100</td>
<td>0.023</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Racking Solutions for Timber Framed Buildings

Steel Strong-Wall™

General Information

- The Steel Strong-Wall™ panel should be fixed directly to the concrete foundation. **DO NOT** sit the Steel Strong-Wall on a timber sole plate.
- A DPC is required between the Strong-Wall™ panel and the concrete foundation.
- The concrete foundation should be designed by the engineer responsible for the structure to accommodate the hold down anchors and resist the applied loads.

Equipment Required for Installation

- 1 off 22/28mm (SSWT305/SSWT610) masonry drill, minimum 300mm long.
- 1 off Dust Brush (item code BR17/30).
- 1 off Dust Pump (item code PUMP).
- 1 off Resin Dispensing Gun (item code DT380)*
- 1 off 30/36mm (SSWT305/SSWT610) A/F, Long Length Socket
- 1 off Torque Wrench (minimum capacity 150Nm (SSWT305) or 200Nm (SSWT610).
- 1 off SDS1/4 Hex Drive (SDS3/8-RB).*

* Available from Simpson Strong-Tie®, call 01827 255600 for prices.

Steel Strong-Wall® Installation Step 1

1a - Position the drilling template (provided) on top of the foundations in the required position, ensuring the correct orientation of the template. The drilling template is the same size as the bottom plate of the Steel Strong-Wall™.

1b - Drill vertically through the drilling template in the positions marked. Drill holes to the stated diameter and depth (see drilling templates provided).

1c - Ensure the holes are cleaned thoroughly (refer to page 19).

1d - Install the anchor bolts supplied: AT-HP resin with M20X245 threaded rod for SSWT305 and M24X310 threaded rod for SSWT610.

Refer to page 19 for anchor details.

Steel Strong-Wall® Installation Step 2

2a - Position the Steel Strong-Wall™ over the anchor bolt rods and level by using the Simpson Strong-Tie® TFLS steel shims and structural grout if required. Plumb and where necessary provide temporary bracing, which can be adjacent timber frame panels if already installed.

2b - Install nuts and washers and tighten by hand. Once the AT-HP resin has cured (see cartridge label for cure times) tighten the nut to the recommended torque (M20: 150 Nm torque, using torque wrench with a 30mm socket. M24: 200 Nm torque, 36mm socket). Do not over-tighten nuts as this may lead to premature failure.

WARNING: DO NOT USE AN IMPACT WRENCH TO TIGHTEN NUTS.
Steel Strong-Wall® Installation Step 3

3a - The Steel Strong-Wall™ can be secured to the adjacent timber frame wall panels using SDW22300 screws, installed from the timber frame side as shown in fig. 3a. The spacing of the SDW screws is to be determined by the engineer responsible for the design structure.

**Lateral Capacity of SDW22300 Screw:**
BS 5268: **0.9kN** (short term)
Based on 38mm thick C16 timber frame and 38mm thick Steel Strong-Wall™ stud.

Alternate fastening specification shall be in accordance to engineers instructions.

Steel Strong-Wall™ Installation Step 4

4a - Connect the top of the Steel Strong-Wall™ to the timber frame structure through the pre-drilled holes in the top plate with the SDS screws provided. If required, as a height make-up piece, a single solid timber packer (typically LVL) should be inserted between the top of the Steel Strong-Wall™ and the timber frame structure.

4b - Install the head binder over timber frame and the Steel Strong-Wall™.

4c - Install insulation on the outer face of the Steel Strong-Wall™ panel and close off the panel by installing sheathing to the face of the timber studs - thus maintaining continuity in the timber frame construction.

Sheathing to be installed with fasteners in accordance with engineers instructions.
AT-HP™ is a styrene free methacrylate resin suitable for high performance fixing applications of threaded rod into concrete. Easy to dispense and fast curing, specially designed for structural fixings and technical construction sites. Applicable for use with metallic racking or work reinforced concrete.

**Benefits**
- Fast curing.
- Low Odour.
- Non-flammable.

**Chemical Anchor AT-HP™**

**Steel Strong-Wall® Installation**

**Step 3**

1. The permissible loads have been calculated using the partial safety factors for resistances stated in the ETA approvals and a partial safety factor of $\gamma_F = 1.4$. The permissible loads are valid for unreinforced concrete with a rebar spacing $s \geq 15\text{cm}$ and reinforced concrete with a rebar spacing $s \geq 10\text{cm}$ if the rebar is 10mm or smaller.

2. The permissible shear loads are based on a single anchor without influencing concrete edges. For shear loads applied close to an edge ($c \leq 10h_{ef}$ and $60d$) concrete edge failure must be checked per ETAG001, Annex C, design method A.

3. Concrete is considered non-cracked when tensile stress within the concrete is $\sigma_c = 3N/mm^2$ can be assumed (L equals the tensile stress within the concrete as a result of external loads, forces on anchors included).

4. If spacings or edge distances become smaller than the characteristic values, a calculation per ETAG001, Annex C, design method A must be performed.

**Chemical Anchor AT-HP™** is a styrene free methacrylate resin suitable for high performance fixing applications of threaded rod into concrete. Easy to dispense and fast curing, specially designed for structural fixings and technical construction sites. Applicable for use with metallic racking or work reinforced concrete.

**ETA Approvals**

- ETA-11-0151

**Curing Schedule (let anchor fully cure without disturbance)**

<table>
<thead>
<tr>
<th>Temperature of Anchorage Base</th>
<th>Working Time $\tau_{gel}$</th>
<th>Curing Time $\tau_{cure}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5°C</td>
<td>45 min</td>
<td>9 h</td>
</tr>
<tr>
<td>0°C</td>
<td>15 min</td>
<td>4 h</td>
</tr>
<tr>
<td>+5°C</td>
<td>12 min</td>
<td>1 h 30 min</td>
</tr>
<tr>
<td>+10°C</td>
<td>9 min</td>
<td>60 min</td>
</tr>
<tr>
<td>+20°C</td>
<td>4 min</td>
<td>30 min</td>
</tr>
<tr>
<td>+30°C</td>
<td>1 min</td>
<td>20 min</td>
</tr>
</tbody>
</table>

Note: Temperature of the resin is ≥ 5°C.

**Product Summary**

<table>
<thead>
<tr>
<th>Product Family</th>
<th>Anchor Ø</th>
<th>Anchor Length</th>
<th>Drill Hole Ø</th>
<th>Drill Hole Depth</th>
<th>Clearance Hole Ø</th>
<th>Width Across Flats</th>
<th>Installation Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP300</td>
<td>M16</td>
<td>230</td>
<td>18</td>
<td>128</td>
<td>18</td>
<td>24</td>
<td>80</td>
</tr>
<tr>
<td>SP450</td>
<td>M16</td>
<td>230</td>
<td>18</td>
<td>128</td>
<td>18</td>
<td>24</td>
<td>80</td>
</tr>
<tr>
<td>SSWT305</td>
<td>M20</td>
<td>245</td>
<td>22</td>
<td>200</td>
<td>22</td>
<td>30</td>
<td>150</td>
</tr>
<tr>
<td>SSWT610</td>
<td>M24</td>
<td>310</td>
<td>28</td>
<td>240</td>
<td>26</td>
<td>36</td>
<td>200</td>
</tr>
</tbody>
</table>

**Spacings, Edge Distances and Member Thickness (mm)**

<table>
<thead>
<tr>
<th>Thread Diameter</th>
<th>Product</th>
<th>SP300</th>
<th>SP450</th>
<th>SSWT305</th>
<th>SSWT610</th>
</tr>
</thead>
<tbody>
<tr>
<td>M16</td>
<td>Effective Embedment Depth ($h_{ef}$)</td>
<td>128</td>
<td>128</td>
<td>200</td>
<td>240</td>
</tr>
<tr>
<td>M16</td>
<td>Minimum Spacing ($S_{min}$)</td>
<td>88</td>
<td>238</td>
<td>173</td>
<td>464</td>
</tr>
<tr>
<td>M20</td>
<td>Minimum Edge Distance ($C_{min}$)</td>
<td>106</td>
<td>106</td>
<td>145</td>
<td>250</td>
</tr>
<tr>
<td>M24</td>
<td>Minimum Member Thickness ($h_{min}$)</td>
<td>160</td>
<td>160</td>
<td>240</td>
<td>450</td>
</tr>
</tbody>
</table>

**Recommended Values for Resistance to Tension and Shear Loads in Non-Cracked Concrete (C20/25)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>M16</th>
<th>M20</th>
<th>M24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension Loads $^2$</td>
<td>28.5</td>
<td>50.37</td>
<td>54.7</td>
</tr>
<tr>
<td>Shear Loads $^{1,2}$</td>
<td>19.4</td>
<td>30.3</td>
<td>30.3</td>
</tr>
<tr>
<td>Bending Moments $^2$</td>
<td>63.4</td>
<td>160.5</td>
<td>160.5</td>
</tr>
</tbody>
</table>

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1. The permissible loads have been calculated using the partial safety factors for resistances stated in the ETA approvals and a partial safety factor of $F = 1.4$. The permissible loads are valid for unreinforced concrete with a rebar spacing $s \geq 15\text{cm}$ and reinforced concrete with a rebar spacing $s \geq 10\text{cm}$ if the rebar is 10mm or smaller.

2. The permissible shear loads are based on a single anchor without influencing concrete edges. For shear loads applied close to an edge ($c \leq 10h_{ef}$ and $60d$) concrete edge failure must be checked per ETAG001, Annex C, design method A.

3. Concrete is considered non-cracked when tensile stress within the concrete is $\sigma_c = 3N/mm^2$ can be assumed (L equals the tensile stress within the concrete as a result of external loads, forces on anchors included).

4. If spacings or edge distances become smaller than the characteristic values, a calculation per ETAG001, Annex C, design method A must be performed.
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