Steel-reinforced elastomeric and sliding bearing with dimensionally stable sliding plane, loadable up to 25 N/mm²
Bearing types

Contents

Bearing types  2
General  3
Edge distances  3
Perforated™ Bearing, Type Z  4
  – Design formulae  4
  – Text of tender documents  5
  – Design table  5
Perforated™ Sliding Bearing, Type Z  6
  – Design formulae  6
  – Text of tender documents  7
  – Design table  7
Transverse and splitting tensile stress reinforcement  8
Load/deflection graphs  10
Shear modulus  11
Friction values  11
Delivery forms, dimensions  12
Installation  12
Fire behaviour  12
Test certificates  12

Figure 1: Standard cut-outs

a: Round hole  
b: Corner notch  
c: Slit notch  
d: Rectangular notch  
e: Slot  
f: Rectangular hole  
g: Corner chamfer

Figure 2: Perforated™ Bearing, Type Z

Figure 3: Perforated™ Sliding Bearing, Type Z

l = Length of the elastomer  
b = Width of the elastomer
General

The Perforated™ Bearing, Type Z is a heavy-duty bearing that can be used in situations where large forces have to be transferred over relatively small areas. It consists of an elastomer based on synthetic rubber chloroprene (CR) with a hardness of 65±5 Shore A in accordance with DIN 4141 Part 14/15.

The grid of circular holes allows the bearing to compensate very well for inaccuracies arising from installation and manufacture of the adjoining structural elements. This helps to avoid stress concentrations. Transverse and splitting tensile stresses are reduced compared with homogeneous elastomeric bearings.

Figures 2 and 3 show various bearing features and constructions. The following criteria need to be considered in the choice of bearing type:
- Load
- Rotational deformation
- Horizontal displacement

Figure 4: Maximum plan dimensions of an elastomer in compliance with the edge distances in accordance with Book 600, German Committee for Reinforced Concrete (DAfStb). The edge distance to the outer edge of the structural element shall be at least 10 mm in structural steelwork.
**Product description**

**Perforated™ Bearing, Type Z**

The steel-reinforced Perforated™ bearing, Type Z consists of several elastomer layers of thickness $t = 6$ mm and intermediate layers of weather-resistant steel grade WTSt 52-3 of thickness $t_s = 3$ mm (transverse tensile plate).

By suitable selection of the bearing thickness, the bearing can accommodate large vertical forces as well as large rotational deformations.

The splitting tensile stresses are calculated taking the provisions of DIN 4141, Part 14 Section 5.2 in accordance with Book 339, DAfStb.

Design using characteristic values in acc. with DIN 4141, Part 3 (BC 2)

<table>
<thead>
<tr>
<th>Load type</th>
<th>Symbol</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>All. mean compressive stress, loading perpendicular to the bearing axis</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td>See design table 1</td>
</tr>
<tr>
<td>Deflection $\Delta h$</td>
<td><img src="image2.png" alt="Diagram" /></td>
<td>See Fig. 10</td>
</tr>
<tr>
<td>All. shear deformation, loading parallel to the bearing axis</td>
<td><img src="image3.png" alt="Diagram" /></td>
<td>All. $u = 0.5 \cdot T$ [mm]</td>
</tr>
<tr>
<td>Restoring forces arising from shear deformation</td>
<td><img src="image4.png" alt="Diagram" /></td>
<td>Act. $H_R = k_s \cdot Act. \ u$ [kN]</td>
</tr>
<tr>
<td>shear modulus $G$</td>
<td><img src="image5.png" alt="Diagram" /></td>
<td>See Fig. 12</td>
</tr>
<tr>
<td>shear stiffness $k_s$</td>
<td><img src="image6.png" alt="Diagram" /></td>
<td>$k_s = \frac{G \cdot A_E}{T} \cdot 10^{-3}$ [kN/mm]</td>
</tr>
<tr>
<td>Allowable rotation</td>
<td><img src="image7.png" alt="Diagram" /></td>
<td>All. $\alpha = \frac{200 \cdot T}{l \ or \ b} \leq 40$ [%]</td>
</tr>
<tr>
<td></td>
<td><img src="image8.png" alt="Diagram" /></td>
<td>$Z_{q,l} = 0.75 \cdot F_{ED} \cdot t \cdot b \cdot 10^{-6}$ [kN]</td>
</tr>
<tr>
<td></td>
<td><img src="image9.png" alt="Diagram" /></td>
<td>$Z_{q,b} = 0.75 \cdot F_{ED} \cdot t \cdot l \cdot 10^{-5}$ [kN]</td>
</tr>
</tbody>
</table>

$t$ = thickness of an elastomer layer; $T = \Sigma$ of the elastomer layer thicknesses; $A_E$ = area of bearing in mm²; $l$, $b$, $T$, $h$ in mm; $u$ in ‰; $M_R$, $H_R$ in kNm; $F_{ED}$ in kN; $Z_{q,l}$, $Z_{q,b}$ in kN; $k_s$ in kN/mm; $G$ in N/mm²
**Text of tender documents**

Supply Calenberg Perforated™ Bearing, Type Z, steel-reinforced elastomeric bearing with a regular grid of circular holes, in accordance with DIN 4141 Part 3, bearing class 2, loadable independent of format up to a mean compressive stress of 25 N/mm², National Technical Approval Certificate No. P-2011.0913-2.

**a) Standard installation**

Length: ................................... mm  
Width: .................................... mm  
Thickness: ................................ mm  
Quantity: ................................... piece  
Price: ...................................... €/piece

**b) Embedded in polystyrene or Ciflamon fire protection board**

Overall length: ......................... mm  
Overall width: ............................ mm  
Bearing length: ............................ mm  
Bearing width: ............................ mm  
Thickness: ................................. mm  
Quantity: ................................. piece  
Price: ...................................... €/piece

**Supplier:**

Calenberg Ingenieure GmbH  
Am Knübel 2-4  
D-31020 Salzhemmendorf/Germany  
Phone +49(0)5153/9400-0  
Fax +49(0)5153/9400-49
Design formulae 2

Product description
Perforated™ Sliding Bearing Type Z

The Perforated™ Sliding Bearing, Type Z consists of a bearing module and a sliding plate. The total thickness is made up of a number of elastomer layers of thickness \( t = 6 \) mm, the transverse tensile stress plate of weather-resistant steel grade WTSt 52-3 of thickness \( t_s = 3 \) mm, the PTFE coating on the top transverse tensile stress plate, and the associated sliding plate of thickness \( t_g = 5 \) mm. The sliding plate can be any size to suit the sliding distances (translations).

The splitting tensile stresses are calculated taking the provisions of DIN 4141, Part 14 Section 5.2 in accordance with Book 339, DAfStb.

<table>
<thead>
<tr>
<th>Load type</th>
<th>Symbol</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>All. mean compressive stress, loading perpendicular to the bearing axis</td>
<td>( \Delta )h</td>
<td>See design table 2</td>
</tr>
<tr>
<td>Deflection ( \Delta h )</td>
<td></td>
<td>See Fig. 11</td>
</tr>
<tr>
<td>Allowable rotation</td>
<td></td>
<td>All. ( \alpha = \frac{200 \cdot T}{l \text{ or } b} \leq 40 % )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Z_{q,l} = 0.75 \cdot F_{ED} \cdot t \cdot b \cdot 10^{-5} \ [kN] )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Z_{q,b} = 0.75 \cdot F_{ED} \cdot t \cdot l \cdot 10^{-5} \ [kN] )</td>
</tr>
</tbody>
</table>

\( t = \) thickness of an elastomer layer; \( T = \Sigma \) of the elastomer-layer thicknesses;
\( l, b, t, T \) in mm; \( \alpha \) in \%; \( M, F, Z_{q,l}, Z_{q,b} \) in kNm
### Text of tender documents

Supply Calenberg Perforated™ Sliding Bearing, Type Z, steel-reinforced elastomeric bearing with a regular grid of circular holes, in accordance with DIN 4141 Part 3, bearing class 2, loadable independent of format up to a mean compressive stress of 25 N/mm², National Technical Approval Certificate No. P-2011.0913-1.

**a) Standard installation**

l₁ / b₁ x 2 x 6 mm x t = 

Quantity: ................................ piece

Price: .................................... €/piece

**b) Embedded in polystyrene or Ciflamon fire protection board**

Overall length: ......................... mm

Overall width: ......................... mm

Bearing length: ......................... mm

Bearing width: ......................... mm

Length of sliding plate: ............ mm

Width of sliding plate: ............. mm

Thickness: ......................... mm

Quantity: ................................. piece

Price: ...................................... €/piece

### Supplier:

Calenberg Ingenieure GmbH
Am Knübel 2-4
D-31020 Salzhemmendorf/Germany
Phone +49(0)5153/9400-0
Fax +49(0)5153/9400-49

### Design table 2

<table>
<thead>
<tr>
<th>h</th>
<th>15</th>
<th>25</th>
<th>34</th>
<th>42</th>
<th>51</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>1 x 6 mm</td>
<td>2 x 6 mm</td>
<td>3 x 6 mm</td>
<td>4 x 6 mm</td>
<td>5 x 6 mm</td>
</tr>
<tr>
<td>b</td>
<td>σ₀</td>
<td>α</td>
<td>σ₀</td>
<td>α</td>
<td>σ₀</td>
</tr>
<tr>
<td>50</td>
<td>15.0</td>
<td>24.0</td>
<td>15.0</td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>15.0</td>
<td>20.0</td>
<td>15.0</td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>20.0</td>
<td>17.1</td>
<td>20.0</td>
<td>34.3</td>
<td>15.0</td>
</tr>
<tr>
<td>80</td>
<td>20.0</td>
<td>15.0</td>
<td>20.0</td>
<td>30.0</td>
<td>20.0</td>
</tr>
<tr>
<td>90</td>
<td>25.0</td>
<td>13.3</td>
<td>25.0</td>
<td>26.7</td>
<td>20.0</td>
</tr>
<tr>
<td>100</td>
<td>25.0</td>
<td>12.0</td>
<td>25.0</td>
<td>24.0</td>
<td>25.0</td>
</tr>
<tr>
<td>110</td>
<td>25.0</td>
<td>10.9</td>
<td>25.0</td>
<td>21.8</td>
<td>25.0</td>
</tr>
<tr>
<td>120</td>
<td>25.0</td>
<td>10.0</td>
<td>25.0</td>
<td>20.0</td>
<td>25.0</td>
</tr>
<tr>
<td>130</td>
<td>25.0</td>
<td>9.2</td>
<td>25.0</td>
<td>18.5</td>
<td>25.0</td>
</tr>
<tr>
<td>140</td>
<td>25.0</td>
<td>8.6</td>
<td>25.0</td>
<td>17.1</td>
<td>25.0</td>
</tr>
<tr>
<td>150</td>
<td>25.0</td>
<td>8.0</td>
<td>25.0</td>
<td>16.0</td>
<td>25.0</td>
</tr>
<tr>
<td>160</td>
<td>25.0</td>
<td>7.5</td>
<td>25.0</td>
<td>15.0</td>
<td>25.0</td>
</tr>
<tr>
<td>170</td>
<td>25.0</td>
<td>7.1</td>
<td>25.0</td>
<td>14.1</td>
<td>25.0</td>
</tr>
<tr>
<td>180</td>
<td>25.0</td>
<td>6.7</td>
<td>25.0</td>
<td>13.3</td>
<td>25.0</td>
</tr>
<tr>
<td>190</td>
<td>25.0</td>
<td>6.3</td>
<td>25.0</td>
<td>12.6</td>
<td>25.0</td>
</tr>
<tr>
<td>200</td>
<td>25.0</td>
<td>6.0</td>
<td>25.0</td>
<td>12.0</td>
<td>25.0</td>
</tr>
<tr>
<td>250</td>
<td>25.0</td>
<td>4.8</td>
<td>25.0</td>
<td>9.6</td>
<td>25.0</td>
</tr>
<tr>
<td>300</td>
<td>25.0</td>
<td>4.0</td>
<td>25.0</td>
<td>8.0</td>
<td>25.0</td>
</tr>
<tr>
<td>350</td>
<td>25.0</td>
<td>3.4</td>
<td>25.0</td>
<td>6.9</td>
<td>25.0</td>
</tr>
<tr>
<td>400</td>
<td>25.0</td>
<td>3.0</td>
<td>25.0</td>
<td>6.0</td>
<td>25.0</td>
</tr>
<tr>
<td>450</td>
<td>25.0</td>
<td>2.7</td>
<td>25.0</td>
<td>5.3</td>
<td>25.0</td>
</tr>
<tr>
<td>500</td>
<td>25.0</td>
<td>2.4</td>
<td>25.0</td>
<td>4.8</td>
<td>25.0</td>
</tr>
<tr>
<td>550</td>
<td>25.0</td>
<td>2.2</td>
<td>25.0</td>
<td>4.4</td>
<td>25.0</td>
</tr>
<tr>
<td>600</td>
<td>25.0</td>
<td>2.0</td>
<td>25.0</td>
<td>4.0</td>
<td>25.0</td>
</tr>
</tbody>
</table>
Transverse and splitting tensile stress reinforcement

Arrangement of the transverse and splitting tensile stress reinforcement for elastomeric bearings installed at column-beam supports

Transmission of force by direct contact between the longitudinal reinforcement and the bearing surface must be eliminated by suitable measures (e.g. plastic sleeves that prevent the transfer of end bearing loads, see Fig. 7).

The longitudinal reinforcement must be enclosed by continuous external reinforcement. The design of the laps in this reinforcement should be such that the lap cannot fail, i.e. stirrups cannot open.

Figure 8 shows the shapes and arrangements of reinforcement stirrups proven to be particularly suitable in numerous tests. In the splitting tensile stress reinforcement zone, the spacing of the transverse bars should not exceed 300 mm, in the transverse tensile stress reinforcement zone 100 mm.

Figure 5: Method A: The transverse tensile forces are carried by the reinforcement directly where they are created.
- a) Ties-transverse stress reinforcement: horizontal closed links and additional stirrups
- b) Verticals-transverse tensile stress reinforcement: vertical closed links and additional stirrups, fixed at right angles to each other

Figure 6: Method B: The transverse tensile forces are carried by continuous reinforcement enclosing the area of the bearing
The stirrup spacing in the longitudinal direction of the column should not exceed 100 mm (splitting tension) and 50 mm (transverse tension) in order to prevent outward buckling of the longitudinal reinforcement under large bearing rotational deformations.

Figures 8 and 9 show the reinforcement arrangement in accordance with Book 339 DAfStb, while Figures 5 and 6 show suggestions from Dr.-Ing. M. Flohrer and Dipl.-Ing. E. Stephan.

Further literature:
1) H. R. Sasse; F. Müller; U. Thormählen; German Committee for Reinforced Concrete; Column-column joints in precast RC construction with unreinforced elastomeric bearings; Book 339; 1982 (in German)
2) M. Flohrer; E. Stephan; Design Charts for transverse tensile forces at elastomeric bearings; Die Bautechnik, Vol. 9 and 12, 1975 (in German)
Deflection

Figure 10: Deflection of the Perforated™ Bearing, Type Z shown in relation to compressive stress

Figure 11: Deflection of the Perforated™ Sliding Bearing, Type Z shown in relation to compressive stress
Figure 12: Shear modulus shown in relation to compressive stress

Figure 13: Static friction shown in relation to the number of load cycles

Figure 14: Sliding friction value shown in relation to sliding distance

Friction value
**Test certificates**


- Fire safety assessment no. 3799/7357-AR; assessment of Calenberg elastomeric bearings regarding classification into the fire resistance class F 90 or F 120 according to DIN 4102 part 2 (issued 9/1977); Accredited Material Testing Authority for Civil Engineering at the Institute for Construction Materials, Reinforced Concrete Construction and Fire Protection, Technical University, Braunschweig; March 2005

**Installation**

In precast construction, all types of Perforated™ Bearings are placed centrally on the bearing support surface and no special constructional measures are required. This applies whether the bearing module is below or on top. In in-situ concrete construction, the edge distance to the outside edge of the structural element must be at least 40 mm and the plan area of the bearing must be enclosed by reinforcement. Any chamfers on the edges of structural elements must be taken into account in determining the edge distance. (Figure 5)

Attention should be paid to the following:

- **The sliding direction of the bearing must align with the movement direction of the structural element.**

- **In in-situ construction, the sliding gap must not be concreted over.**

- **The bearing must always be able to slide.**

- **In steel and timber construction, the edge distance must be at least 40 mm.**

**Delivery forms, Dimensions**

Perforated™ Bearings, Type Z are specially manufactured for each structure.

For use in in-situ concrete construction, Perforated™ Bearings, Type Z can be supplied to order embedded in polystyrene or Ciflamon fire protection board so that no wet concrete can penetrate the bearing joint. Otherwise the spring effect of the bearing, which must be preserved at all times, would be lost.

**Fire behaviour**

Fire Safety Report No. 3799/7357-AR by the Technical University (TU) of Braunschweig shall be determinant for elastomeric bearings installed in situations where fire safety has to be taken into account. The report describes minimum dimensions and other measures that fulfil the requirements of DIN 4102-2: Fire Behaviour of Building Materials and Building Components, 1977-09.

The contents of the publication in the result of many years of research an experience gained in application technology. All information is given in good faith; it does not represent a guarantee with respect to characteristics an does not exempt the user from testing the suitability of products and from ascertaining that the industrial property rights of third parties are not violated. No liability whatsoever will be accepted for damage – regardless of its nature and its legal basis – arising from advice given in this publication. This does not apply in the event that we or our legal representatives or our management are found guilty of having acted with intent or gross negligence. The exclusion of liability applies also to the personal liability of or legal representatives and employed in performing our obligations.

**Calenberg Ingenieure GmbH**
Am Krübel 2-4
D-31020 Salzhemmendorf, Germany
Phone +49 (0) 5153/94 00-0
Fax +49 (0) 5153/94 00-49
info@calenberg-ingenieure.de
www.calenberg-ingenieure.de