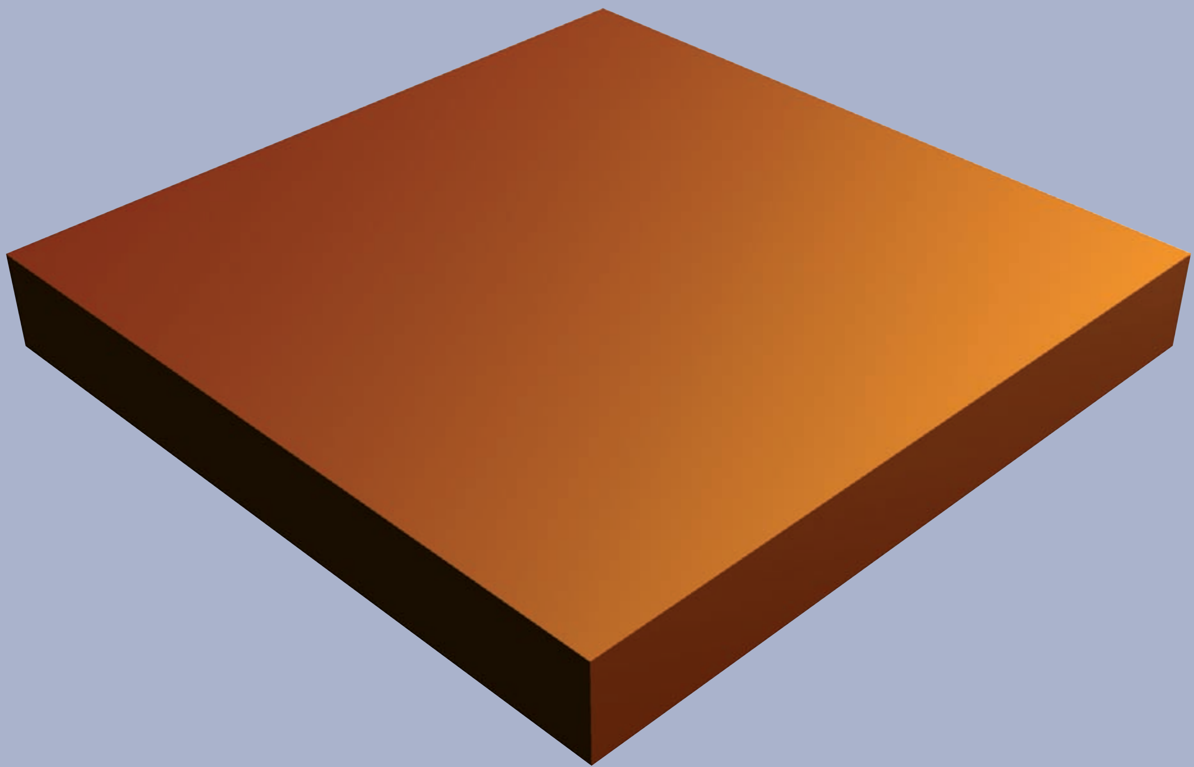
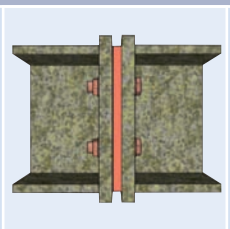
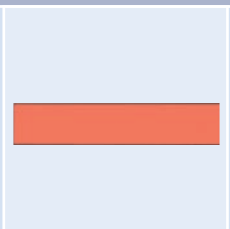
CALENBERG INGENIEURE

COMPACT CORE BEARING







Unreinforced heavy-duty elastomeric bearing

Thermal separation in structural steelwork

Bearing design formulae

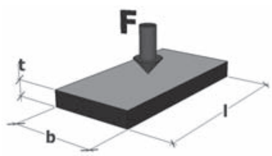
Contents

Product description

The Calenberg Compact Core Bearing is an unreinforced heavy-duty elastomeric bearing with a smooth surface. The red-brown colour of the material clearly identifies the product.

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

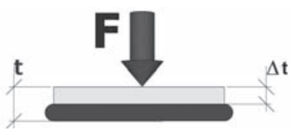
Allow. mean compressive stress



$$\text{Allow. } \sigma_m = \frac{S^2 + S + 1}{0{,}70} \leq 30 \text{ N/mm}^2$$

Refer to design tables 1 and 2

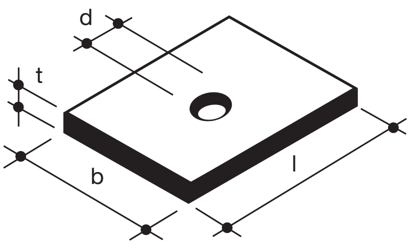
Bearing elastic deformation



See pages 4 and 5

Material data

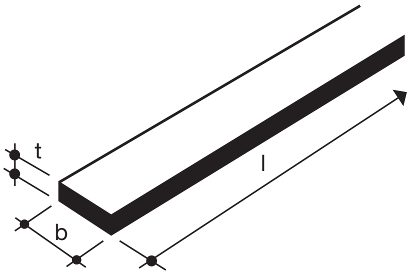
Material hardness	40 ± 5 [Shore-D]; t = 5, 10, 15 mm 60 ± 5 [Shore-D]; t = 20 mm
Thermal conductivity λ	0,2 [W/m · K]
Temperature range	−20 to +70°C
Surface resistivity in accordance with DIN EN 20284	$7.5 \cdot 10^{10}$ Ω
Volume resistivity in accordance with DIN IEC 93	$2.1 \cdot 10^{12}$ Ω cm



Without hole: $S = \frac{l \cdot b}{2 \cdot t\,(l + b)}$

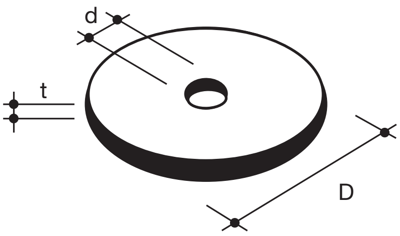
With hole: $S = \frac{4 \cdot l \cdot b - \pi \cdot d^2}{4 \cdot t\,(2 \cdot l + 2 \cdot b + \pi \cdot d)}$

Shape factor for rectangular bearing pad



$S = \frac{b}{2 \cdot t}$

Shape factor for bearing strip



Without hole: $S = \frac{D}{4 \cdot t}$

With hole: $S = \frac{D - d}{4 \cdot t}$

Shape factor for circular bearing pad

How to specify

Supply Calenberg Compact Core Bearing, unreinforced homogeneous elastomeric bearing in accordance with DIN 4141 Part 3, bearing class 2, through-coloured red-brown with smooth surface, loadable depending on format up to an average compressive stress of 30 N/mm², National Technical Approval No. P-852.0448.

a) Standard Installation

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

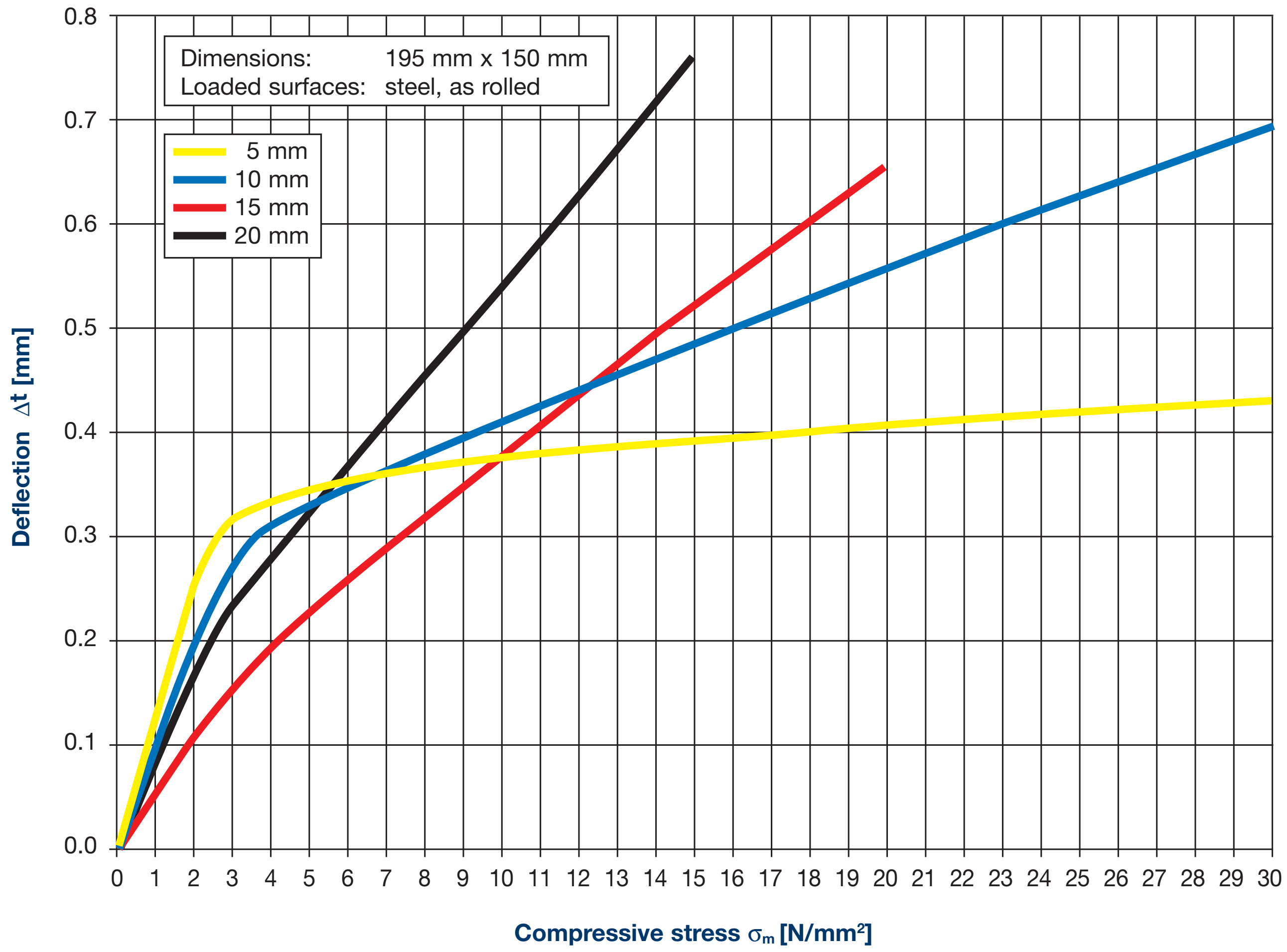
b) Embedded in polystyrene or Ciflamon fire-proofing plate

Overall width:	.... mm
Elastomer width:	.... mm
Thickness:	.... mm
Quantity:	.... m
Price:	.... €/m

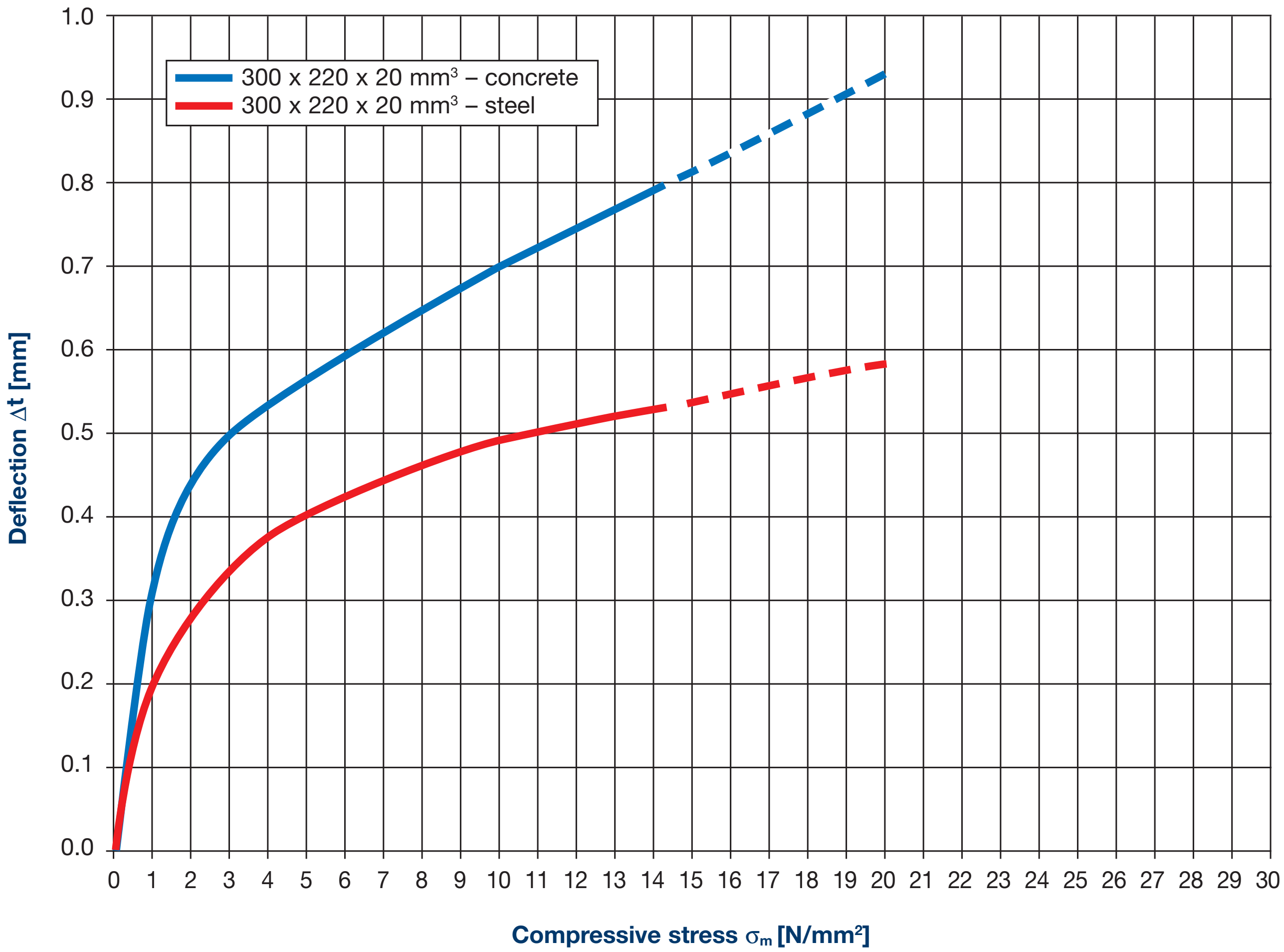
Supplier:
Calenberg Ingenieure GmbH
Am Knübel 2-4
31020 Salzhemmendorf, Germany
Phone +49 (0) 51 53 / 94 00-0
Fax +49 (0) 51 53 / 94 00-49

Shape factor

Deflection 1



CALENBERG
INGENIEURE



Deflection 2

Design table 1

Compact core bearing, **5 and 10 mm** thick

Bearing-thickness t [mm]	Bearing-width b [mm]	Compressive stress, allowable σ_m [N/mm²]																	
		Bearing length l [mm]																	
		50	**60**	**70**	**80**	**90**	**100**	**120**	**130**	**150**	**170**	**180**	**200**	**250**	**300**	**350**	**400**	**450**	**500**
5	**50**	13.9	16.0	17.7	19.3	20.8	22.1	24.3	25.2	26.9	28.3	28.9							
	60	16.0	18.6	21.0	23.1	25.1	26.9												
	70	17.7	21.0	23.9	26.7	29.2													
	80	19.3	23.1	26.7															
	90	20.8	25.1	29.2															
	100	22.1	26.9																
	110	23.2	28.5																
	120	24.3																	
	130	25.2																	
	140	26.1																	
	150	26.9															**30.0**		
	160	27.6																	
	170	28.3																	
	180	28.9																	
	200																		
10	**50**	5.4	6.0	6.6	7.0	7.4	7.8	8.4	8.7	9.1	9.5	9.7	10.0	10.6	11.0	11.4	11.7	11.9	12.1
	60	6.0	6.8	7.5	8.1	8.6	9.1	10.0	10.4	11.0	11.6	11.9	12.3	13.2	13.9	14.5	14.9	15.2	15.5
	70	6.6	7.5	8.3	9.1	9.8	10.4	11.6	12.1	13.0	13.8	14.1	14.7	16.0	17.0	17.7	18.4	18.9	19.3
	80	7.0	8.1	9.1	10.0	10.9	11.7	13.1	13.7	14.9	15.9	16.3	17.2	18.9	20.2	21.2	22.1	22.8	23.3
	90	7.4	8.6	9.8	10.9	11.9	12.8	14.5	15.3	16.7	18.0	18.6	19.6	21.8	23.5	24.8	26.0	26.9	27.7
	100	7.8	9.1	10.4	11.7	12.8	13.9	16.0	16.9	18.6	20.1	20.8	22.1	24.8	26.9	28.6			
	150	9.1	11.0	13.0	14.9	16.7	18.6	22.1	23.7	26.9	29.8								
	200	10.0	12.3	14.7	17.2	19.6	22.1	26.9	29.2										
	250	10.6	13.2	16.0	18.9	21.8	24.8												
	300	11.0	13.9	17.0	20.2	23.5	26.9												
	350	11.4	14.5	17.7	21.2	24.8	28.6												
	400	11.7	14.9	18.4	22.1	26.0											**30.0**		
	450	11.9	15.2	18.9	22.8	26.9													
	500	12.1	15.5	19.3	23.3	27.7													
	600	12.3	16.0	19.9	24.3	28.9													

Compact core bearing, **15 and 20 mm** thick

Bearing-thickness t [mm]	Bearing-width b [mm]	Compressive stress, allowable σ_m [N/mm²]																	
		Bearing length l [mm]																	
		50	**60**	**70**	**80**	**90**	**100**	**120**	**130**	**150**	**170**	**180**	**200**	**250**	**300**	**350**	**400**	**450**	**500**
15	**100**	4.8	5.4	6.1	6.7	7.2	7.8	8.7	9.2	10.0	10.7	11.0	11.7	12.9	13.9	14.7	15.4	16.0	16.4
	110	4.9	5.7	6.4	7.0	7.7	8.3	9.4	9.9	10.8	11.7	12.1	12.8	14.3	15.5	16.5	17.4	18.0	18.6
	120	5.1	5.9	6.6	7.4	8.1	8.7	10.0	10.6	11.7	12.6	13.1	13.9	15.7	17.2	18.4	19.3	20.2	20.9
	130	5.2	6.1	6.9	7.7	8.5	9.2	10.6	11.2	12.4	13.6	14.1	15.0	17.1	18.8	20.2	21.4	22.4	23.2
	140	5.3	6.2	7.1	8.0	8.8	9.6	11.1	11.9	13.2	14.4	15.0	16.1	18.5	20.4	22.1	23.4	24.6	25.6
	150	5.4	6.4	7.3	8.2	9.1	10.0	11.7	12.4	13.9	15.3	16.0	17.2	19.8	22.1	23.9	25.5	26.9	28.1
	200	5.9	7.0	8.2	9.3	10.5	11.7	13.9	15.0	17.2	19.2	20.2	22.1	26.3					
	250	6.2	7.4	8.8	10.1	11.5	12.9	15.7	17.1	19.8	22.5	23.8	26.3						
	300	6.4	7.8	9.2	10.8	12.3	13.9	17.2	18.8	22.1	25.3	26.9							
	350	6.6	8.0	9.6	11.3	13.0	14.7	18.4	20.2	23.9	27.7	29.5							
	400	6.7	8.2	9.9	11.7	13.5	15.4	19.3	21.4	25.5	29.7								
	450	6.8	8.4	10.1	12.0	13.9	16.0	20.2	22.4	26.9							**30.0**		
	500	6.9	8.5	10.3	12.3	14.3	16.4	20.9	23.2	28.1									
	550	6.9	8.7	10.5	12.5	14.6	16.8	21.5	24.0	29.1									
	600	7.0	8.7	10.7	12.7	14.9	17.2	22.1	24.6										
20	**100**	3.6	4.0	4.4	4.8	5.1	5.4	6.0	6.3	6.8	7.2	7.4	7.8	8.5	9.1	9.6	10.0	10.3	10.6
	110	3.7	4.2	4.6	5.0	5.4	5.7	6.4	6.7	7.3	7.8	8.0	8.5	9.4	10.1	10.7	11.2	11.6	11.9
	120	3.8	4.3	4.8	5.2	5.6	6.0	6.8	7.1	7.8	8.4	8.6	9.1	10.2	11.0	11.7	12.3	12.8	13.2
	130	3.9	4.4	4.9	5.4	5.9	6.3	7.1	7.5	8.2	8.9	9.2	9.8	11.0	12.0	12.8	13.5	14.1	14.6
	140	4.0	4.5	5.0	5.6	6.1	6.6	7.5	7.9	8.7	9.4	9.8	10.4	11.8	13.0	13.9	14.7	15.4	16.0
	150	4.0	4.6	5.2	5.7	6.3	6.8	7.8	8.2	9.1	9.9	10.3	11.0	12.6	13.9	15.0	16.0	16.7	17.4
	200	4.3	5.0	5.7	6.4	7.1	7.8	9.1	9.8	11.0	12.2	12.8	13.9	16.4	18.6	20.4	22.1	23.5	24.8
	250	4.5	5.2	6.1	6.9	7.7	8.5	10.2	11.0	12.6	14.2	14.9	16.4	19.8	22.9	25.6	28.1		
	300	4.6	5.4	6.3	7.2	8.2	9.1	11.0	12.0	13.9	15.8	16.7	18.6	22.9	26.9				
	350	4.7	5.6	6.6	7.5	8.6	9.6	11.7	12.8	15.0	17.2	18.3	20.4	25.6					
	400	4.8	5.7	6.7	7.8	8.9	10.0	12.3	13.5	16.0	18.4	19.6	22.1	28.1					
	450	4.8	5.8	6.9	8.0	9.1	10.3	12.8	14.1	16.7	19.4	20.8	23.5				**30.0**		
	500	4.9	5.9	7.0	8.1	9.3	10.6	13.2	14.6	17.4	20.3	21.8	24.8						
	550	4.9	6.0	7.1	8.3	9.5	10.8	13.6	15.1	18.0	21.1	22.7	25.9						
	600	5.0	6.0	7.2	8.4	9.7	11.0	13.9	15.4	18.6	21.8	23.5	26.9						

Design table 2

Design example

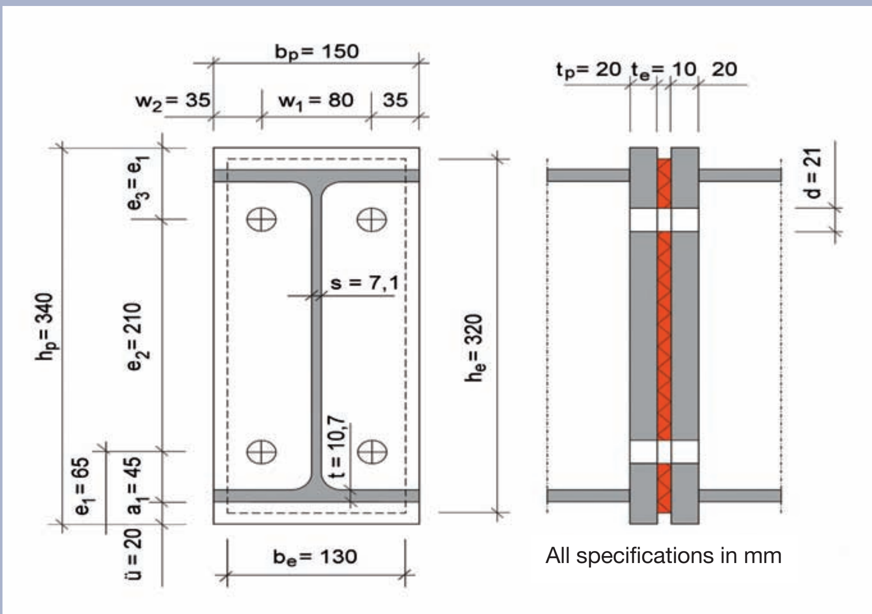


Fig. 1: Dimensions of the end plate butt joint design example

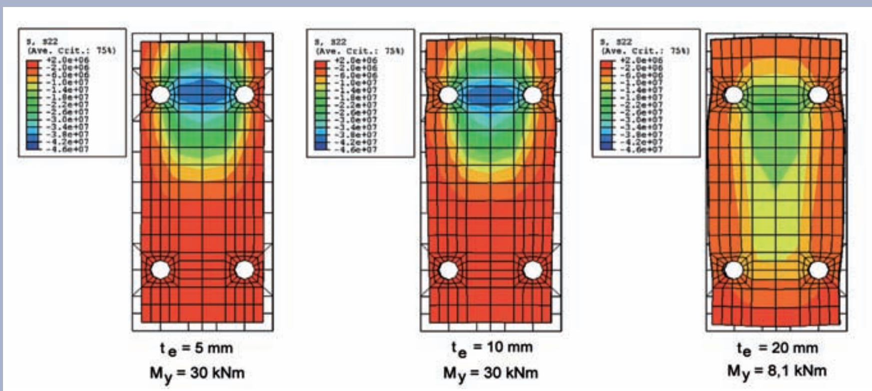


Fig. 2: Influence of elastomer thickness on structural behaviour, determined using finite element analysis

Design of end plate connection with intermediate elastomeric bearing

(after: Dr.-Ing. L. Nasdala;
Dr.-Ing. B. Hohn, R. Rühl
Institute for Structural Analysis
University of Hanover,
Faculty for Construction Engineering and Geodetics in “Der Bauingenieur” – 11/2005)

Cold bridges are created in buildings when steel beams penetrate the building envelope. In addition to the associated heat loss, this frequently leads to the formation of mould due to condensation forming on the indoor wall surfaces. If thermal insulation cannot be attached to the external steelwork components, e.g. for architectural reasons, then thermal separation of the internal and external structure is required. Thermal separation can be provided by elastomeric bearings with a thermal conductivity of $\lambda \approx 0.2$ W/(mK), which, although five to ten times higher than conventional insulation materials such as glass wool or polystyrene, is more than two hundred times lower than structural steel. The most important advantage over traditional insulation materials is the bearing‘s higher load-bearing capacity.
Figure 1 shows the traditional end plate butt joint. The details of the example design are given on the following pages.

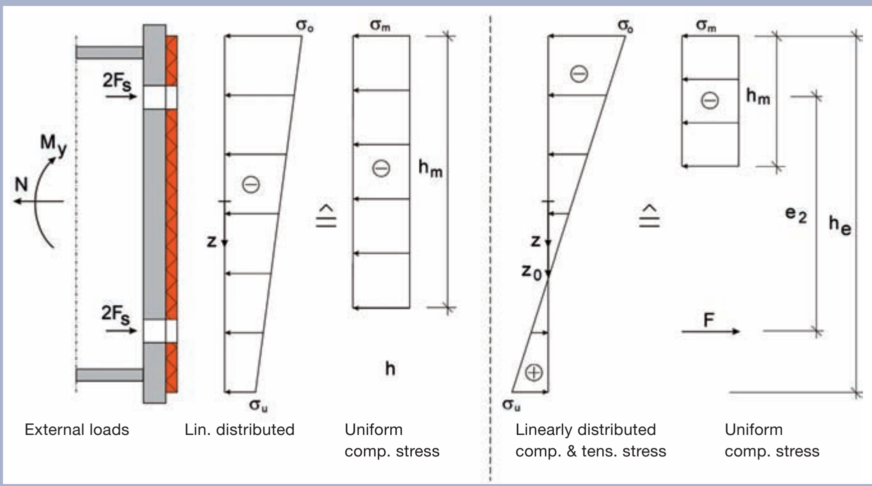


Fig. 3: Determination of the compressive stress in the elastomer

The end plates of the IPE 300 beam butt joint are made from S 235 steel. A height of h_e = 320 mm, a width of b_e = 130 mm and a thickness of t_e = 10 mm were selected for the elastomer. The fasteners are 4 x M20 bolts strength class 10.9 with a 1 mm tolerance.

The design of the joint without the intermediate elastomer layer in accordance with EC 3 will not be discussed any further here.

As elastomers are almost incompressible, they bulge out at the sides under load. Therefore – for the same material properties – thick elastomer plates cannot carry as much load as thin ones. Using the Shape Factor S, and taking into account the elastomer dimensions and the number and diameter of the bolts, the allowable average compressive stress can be determined. It is defined as the ratio of effective structural bearing surface A_m to the associated side area A_s.

$$S = \frac{A_m}{A_s} \quad [1]$$

As the accurate distribution of the compressive stress is unknown, a linear stress distribution is assumed initially for the bearing design. As shown in Figure 3, the stress distribution is converted using the equilibrium of normal forces and moments into an average stress σ_m and an effective height h_m. The number of bolt holes to be taken into account depends on the value of this height h_m.

For a rectangular bearing plate with 2 or 4 holes, the Shape Factor is:

$$S = \frac{h_m \cdot b_e - \pi\, d^2/2}{2 \cdot t_e \cdot (h_m + b_e + \pi\, d)} \quad \text{if} \quad h_m \leq \frac{2}{3} h_e \quad [2]$$

$$S = \frac{h_m \cdot b_e - \pi\, d^2}{2 \cdot t_e \cdot (h_m + b_e + 2\,\pi\, d)} \quad \text{if} \quad h_m > \frac{2}{3} h_e \quad [3]$$

The allowable average compressive stress in the elastomer of the Core Compact Bearing is calculated using:

$$\text{allw. } \sigma_m = \frac{S^2 + S + 1}{0{,}70} \leq 30 \text{ N/mm}^2 \quad [4]$$

Linear stress distribution

If the holes are disregarded and a linear distribution assumed, the stresses are calculated according to the equation:

$$\sigma_{(z)} = \frac{N - 4\,Fs}{b_e\;h_e} + \frac{12\,my}{b_e\;h_e^3}\;z \quad [5]$$

with edge stresses $\sigma_o = \sigma\,(-h_e/2)$ and $\sigma_u = \sigma\,(+h_e/2)$

If computer analyses indicate that tensile stresses occur, they result in a bolt tensile force F.

Design example

Design example

At point

$$z_o = \frac{4\,F_s - N}{12\,M_y}\,h_e^2 \in \left[-\frac{h_e}{2};\,+\frac{h_e}{2}\right] \qquad [6]$$

a large moment My results in a sign change, $\sigma(z_o) = 0$.

Compressive stress only

For

$$z_o \in \left[-\frac{h_e}{2};\,+\frac{h_e}{2}\right] \text{ and } 4\,F_s > N \text{ it follows:}$$

$$h_m = h_e + \frac{2\,M_y}{N - 4\,F_s} \text{ and} \qquad [7]$$

$$\sigma_m = \frac{(N - 4\,F_s)^2}{b_e\,[h_e\,(N - 4\,F_s) + 2\,M_y]} \qquad [8]$$

Compressive & tensile stresses

For

$$z_o \in \left[-\frac{h_e}{2};\,+\frac{h_e}{2}\right] \text{ and } M_y > 0 \text{ the bolt}$$

tensile forces are calculated as:

$$F = \frac{N - 4\,F_s}{h_e}\left(\frac{h_e}{2} - z_o\right) + \frac{6\,M_y}{h_e^3}\left(\frac{h_e^2}{4} - z_o^2\right) \qquad [9]$$

and the following apply

$$h_m = h_e + \frac{2\,M_y - F\,e_2}{N - 4\,F_s - F} \text{ and} \qquad [10]$$

$$\sigma_m = \frac{(N - 4\,F_s - F)^2}{b_e\,[h_e\,(N - 4\,F_s - F) + 2\,M_y - F \cdot e_2]} \qquad [11]$$

Example calculation:

Bending moment	$M_y = 30$ kNm
Normal force	$N = -20$ kN
Bolt prestress force	$F_s = 80$ kN/bolt

$$z_o = \frac{4 \cdot 80 - (-20)}{12 \cdot 30} \cdot 0{,}32^2 = 0{,}097\,\text{m using } [6]$$

As $M_y > 0$ the bolt tensile force is calculated using **[9]**

$$F = \frac{(-20) - 4 \cdot 80}{0{,}32}\left(\frac{0{,}32}{2} - 0{,}097\right) + \frac{6 \cdot 30}{0{,}32^3}\left(\frac{0{,}32^2}{4} - 0{,}097^2\right)$$

F = 22 kN

and an effective height h_m using **[10]**

$$h_m = 0{,}32 + \frac{2 \cdot 30 - 22 \cdot 0{,}21}{-20 - 4 \cdot 80 - 22} = 0{,}167\text{ m}$$

The average compressive stress using **[11]**

$$\sigma_m = \frac{(-20 - 4 \cdot 80 - 22)^2}{10^3 \cdot 0{,}13\,[0{,}32\,(-20 - 4 \cdot 80 - 22) + 2 \cdot 30 - 22 \cdot 0{,}21]}$$

$\sigma_m = 16{,}67$ N/mm²

From $h_m = 0{,}167\text{ m} < \frac{2}{3}\,0{,}32 = 0{,}21$ m

the shape factor is calculated using **[2]**

$$S = \frac{167 \cdot 130 - \pi \cdot 21/2}{2 \cdot 10 \cdot (167 + 130 + \pi \cdot 21)} = 2{,}9$$

The allowable bearing load in accordance with **[4]** is

$$\text{allow. } \sigma_m = \frac{2{,}9^2 + 2{,}9 + 1}{0{,}70} = 17{,}58\text{ N/mm}^2 \le 30\text{ N/mm}^2$$

With the following result

Actual $\sigma_m = 16{,}67$ N/mm² $\le$ Allow. $\sigma_m = 17{,}58$ N/mm²

compliance with the requirements is confirmed.

CALENBERG INGENIEURE

Characteristics

Due to its high material hardness, the Compact Core Bearing – in contrast to ordinary, softer elastomeric bearings – deforms very little under load. In practice this means:

- The high stiffness of the bearing means it is not suitable for accommodating shear deformations and rotations.
- Transverse deformation is extremely low thanks to the bearing's excellent shape stability.
- Moments are transferred without large deformations.
- Due to its low deformation and high thermal resistivity, the bearing is particularly suitable for use as a thermal separation layer in end plate butt joints in structural steelwork.

Use and areas of application

Compact Core Bearings are used in all fields of metal construction to provide thermal separation, such as in the installation of building facades, solar energy equipment on roofs or the connection of balconies and canopies to the main loadbearing structure.

Material

Elastomeric material based on butadiene-acrylonitrile rubber, colour red-brown (common short name: NBR (nitrile rubber)

Compact Core Bearings are resistant to oil, grease and fuel; they are also resistant to abrasion and wear.

Delivery forms

Calenberg Compact Core Bearings are supplied ready-made in the shape and dimensions required for each project. (Figure 4)
Holes, cut-outs, slots etc. can be provided to allow bolts or dowels to pass through the bearings.

Dimensions

- Bearing thicknesses:
  5, 10, 15, 20 mm
- Maximum cut dimensions:
  1200 mm x 1200 mm

Characteristics

Test certificate

Test certificate, proof of suitability

- National Technical Approval No. P-852.0448 Compression, shear and creep tests on building bearing hard spring plate "NBR Compact Core Bearing"; Testing Institute for Mechanical Engineering Materials and Plastics, Technical University of Hanover, 2003
- 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.

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

Standard cut-outs

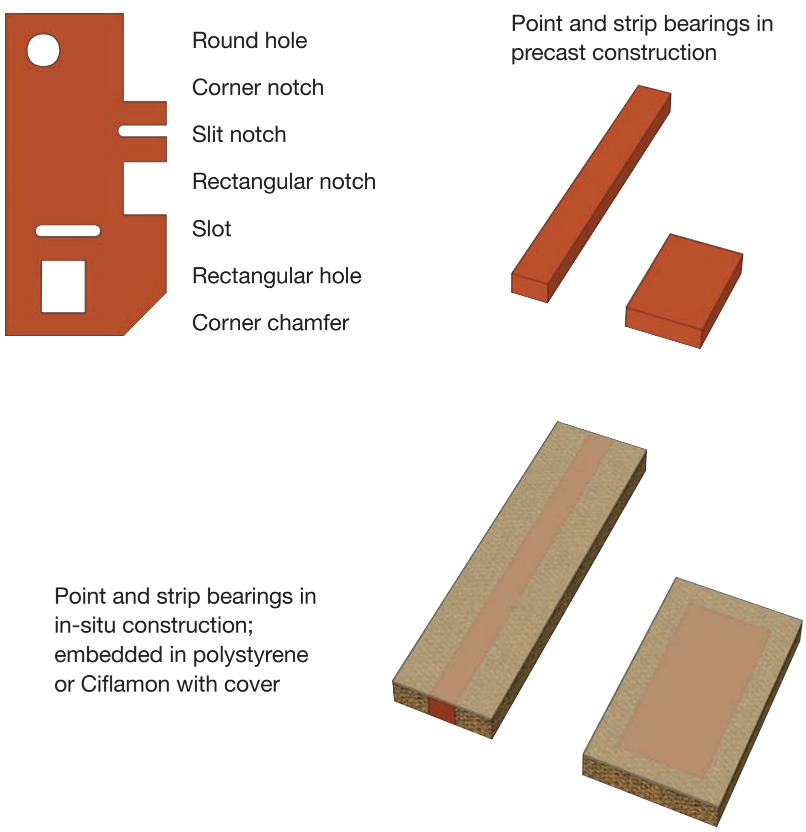


Fig. 4: Calenberg Compact Core Bearings, standard cut-outs and delivery forms

Calenberg Ingenieure GmbH
Am Knübel 2-4
D-31020 Salzhemmendorf, Germany
Phone +49 (0) 51 53/94 00-0
Fax +49 (0) 51 53/94 00-49
info@calenberg-ingenieure.de
www.calenberg-ingenieure.de