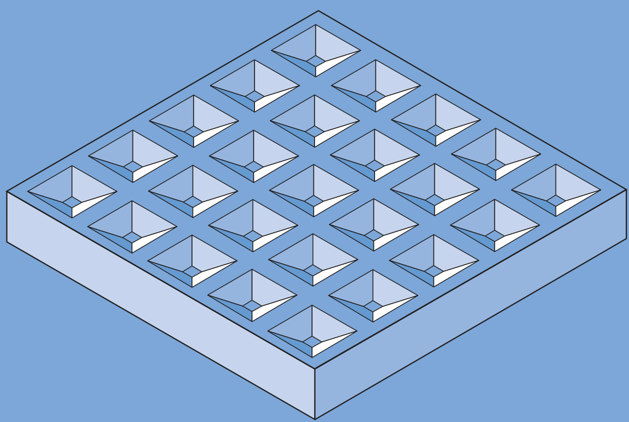
CALENBERG INGENIEURE
Planmäßig elastisch lagern

Product Information

CALENBERG
COMPACT BEARING CR 2000

High Performance unreinforced Elastomer Bearing loadable up to 20 N/mm²

High Quality CR-Material



Approved in Practice

Less Stress and Strain for adjoining Components by special Design of Surface

Contents

Product Description

Calenberg Compact Bearing CR 2000 is a modification of the CR-Compact Bearing H, the first bearing pad with an engineer-like calculation concept, which has been approved for decades. It is made of a chloroprene material with a hardness of 70 ± 5 Shore A. The wafer-like bearing surface is leading to a stress-poor compensation of pressure during the initial loading phase. Cross and splitting tensile forces caused in adjoining components will be reduced in comparison to bearing pads with smooth surfaces.

Hint: The calculation formulae are based on results of research carried out by Dr. Flohrer. The high compressive stress affecting the bearing requires an exact calculation and arrangement of transverse and tensile splitting reinforcement in adjoining components (see example page 7–11).

Calculation Formulae

Calenberg Compact Bearing CR 2000

Calculation for bearing class 2 according to DIN 4141 part 3

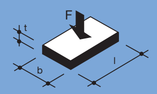
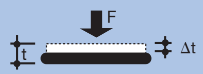
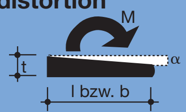
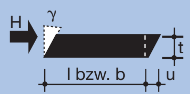
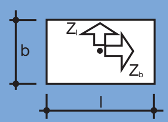
Permissible mean load  	**perm. σ_m = $(S^2 + S + 1) / 0{,}70 \le 20$ N/mm²** requirement: $l \ge b \ge 5 \times t$ S = shape factor (page 3) see also calculation tables page 4 and 5
Actual elastic deformation  	**act. Δt = act. $\sigma_m \cdot t / E_D$ [mm]** E_D = compression modulus (see page 6) **max. Δt** ⋗ see picture 3 on page 6
Permissible angle of distortion  	**perm. α = 200 · t / l bzw. b [‰];** rectangular bearing **perm. α = 226 · t / D [‰];** circular bearing
Permissible horizontal shear deformation  	**perm. u = 0,6 · (t – 3) [mm]** **perm. H = $C_s \cdot u \cdot A_E$ / 19000 [kN]** C_s-values and requirements see page 11
Cross tensile force  	**act. Z_m = $m_1 \cdot S \cdot t \cdot c$ [N]** (m_1: see picture 5) Concrete contact surfaces made with: – wood shuttering: c = 1,00 – plastic/grp shuttering: c = 0,66 – steel shuttering: c = 0,50
Splitting tensile force	act. Z_{Sp} [N] calculation according to picture 8
b, l, t, D in mm; A_E in mm²; H in kN; E_D in N/mm²; m_1 in N/mm; Z_m, Z_{Sp} in N; S and c without measuring unit	

Table 1

How to Specify

Deliver Calenberg Compact Bearing CR 2000, unreinforced homogeneous elastomer bearing according to DIN 4141 part 3, bearing class 2, format dependant loadable up to a mean load of 20 N/mm², Official Certificate No. 850.0425.

a) In general

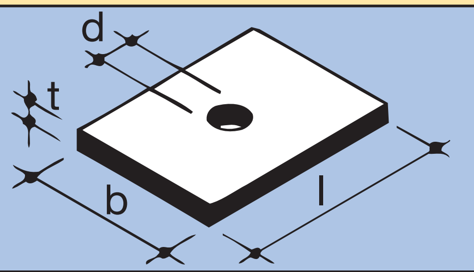
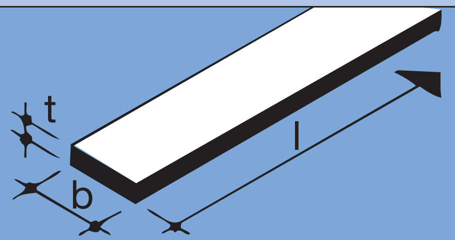
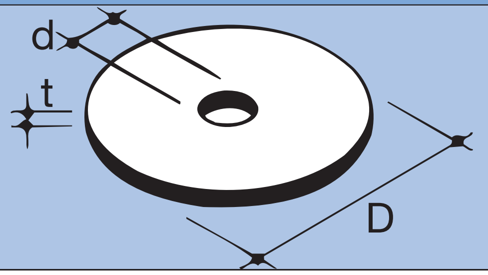
Length: ...... mm
Width: ...... mm
Thickness: ...... mm
Quantity: ...... piece
Price: ...... Euro/piece

b) Embedded in Polystyrene or Ciflamon

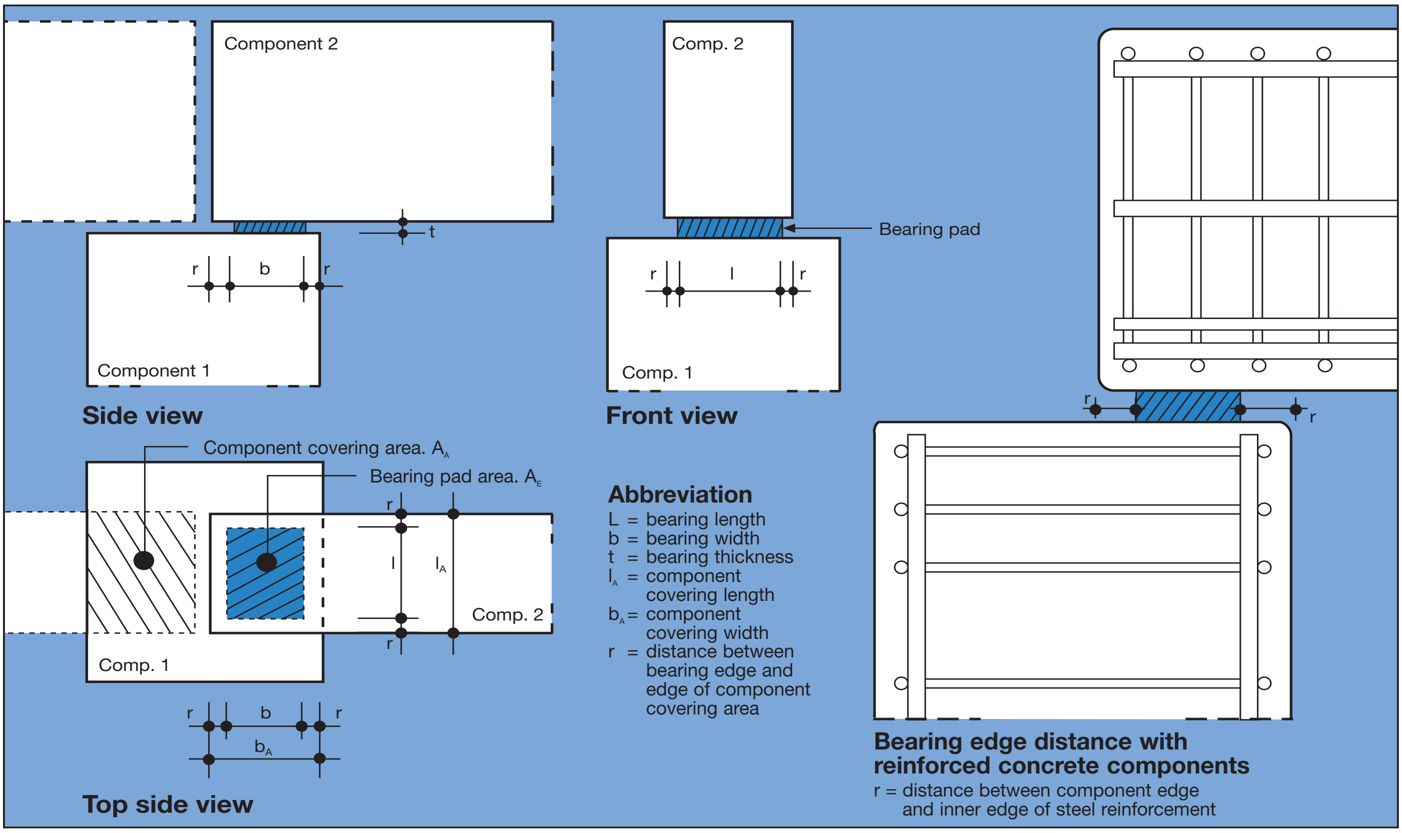
Total width: ...... mm
Width of bearing pad: ...... mm
Thickness: ...... mm
Quantity: ...... m
Price: ...... Euro/m

Supplier: Calenberg Ingenieure GmbH
Am Knübel 2–4
D-31020 Salzhemmendorf
Tel. +49 51 53 / 94 00-0
Fax +49 51 53 / 94 00-49

Shape Factors

Bearing Format	Shape Factor
	**Rectangular bearing pad** ● without hole: $S = \frac{l \cdot b}{2 \cdot t\,(l + b)}$ ● with round hole: $S = \frac{4 \cdot l \cdot b - \pi \cdot d^2}{4 \cdot t\,(2 \cdot l + 2 \cdot b + \pi \cdot d)}$
	**Rectangular bearing strip** $S \approx \frac{b}{2 \cdot t}$
	**Circular bearing pad** ● without hole: $S = \frac{D}{4 \cdot t}$ ● with round hole: $S = \frac{D - d}{4 \cdot t}$

Picture 1: Shape factors for different formats



Picture 2: Maximum ground area of elastomer bearing pad in reinforced concrete construction (edge distance). With wood or steel components the edge distance of the bearing pad should be at least 1 cm resp. 1,5 times of the bearing thickness.

Calculation Table 1: Compact Bearing CR 2000, **11 mm** thick

Bearing Thickness (mm)	perm. angular Distortion α (‰)	Bearing Width (mm)	Load, perm. σ_m (N/mm²) Bearing Length l (mm)																	
			50	60	70	80	90	100	125	150	175	200	225	250	275	300	350	400	450	500
11	44.0	50	4.9	5.4	5.8	6.2	6.6	6.9	7.5	8.0	8.4	8.7	9.0	9.3	9.5	9.6	9.9	10.1	10.3	10.5
	36.7	60	5.4	6.0	6.6	7.1	7.6	8.0	8.9	9.6	10.2	10.7	11.1	11.5	11.8	12.1	12.5	12.9	13.1	13.4
	31.4	70	5.8	6.6	7.3	8.0	8.6	9.1	10.3	11.3	12.1	12.7	13.3	13.8	14.2	14.6	15.3	15.8	16.2	16.5
	27.5	80	6.2	7.1	8.0	8.7	9.5	10.1	11.6	12.9	13.9	14.8	15.5	16.2	16.8	17.3	18.2	18.9	19.5	19.9
	24.4	90	6.6	7.6	8.6	9.5	10.3	11.1	12.9	14.4	15.7	16.8	17.8	18.7	19.4					
	22.0	100	6.9	8.0	9.1	10.1	11.1	12.1	14.1	16.0	17.5	18.9								
	20.0	110	7.1	8.4	9.6	10.8	11.9	12.9	15.3	17.4	19.3									
	18.3	120	7.4	8.7	10.1	11.3	12.6	13.8	16.5	18.9										
	16.9	130	7.6	9.1	10.5	11.9	13.2	14.5	17.6											
	15.7	140	7.8	9.4	10.9	12.4	13.8	15.3	18.6											
	14.7	150	8.0	9.6	11.3	12.9	14.4	16.0	19.6											
	13.8	160	8.2	9.9	11.6	13.3	15.0	16.6												
	12.9	170	8.3	10.1	11.9	13.7	15.5	17.2												
	12.2	180	8.5	10.3	12.2	14.1	16.0	17.8												
	11.6	190	8.6	10.5	12.5	14.4	16.4	18.4												
	11.0	200	8.7	10.7	12.7	14.8	16.8	18.9												
	10.5	210	8.9	10.9	13.0	15.1	17.2	19.4												
	10.0	220	9.0	11.0	13.2	15.4	17.6	19.8												
	9.6	230	9.1	11.2	13.4	15.7	18.0													
	9.2	240	9.2	11.3	13.6	16.0	18.3													
	8.8	250	9.3	11.5	13.8	16.2	18.7													
	8.5	260	9.3	11.6	14.0	16.4	19.0													
	8.1	270	9.4	11.7	14.2	16.7	19.3													
	7.9	280	9.5	11.8	14.3	16.9	19.5													
	7.6	290	9.6	12.0	14.5	17.1	19.8													
	7.3	300	9.6	12.1	14.6	17.3														
	7.1	310	9.7	12.2	14.8	17.5														
	6.9	320	9.8	12.2	14.9	17.7														
	6.7	330	9.8	12.3	15.0	17.8														
	6.5	340	9.9	12.4	15.1	18.0														
	6.3	350	9.9	12.5	15.3	18.2														
	6.1	360	10.0	12.6	15.4	18.3														
	5.9	370	10.0	12.6	15.5	18.5														
	5.8	380	10.1	12.7	15.6	18.6														
	5.6	390	10.1	12.8	15.7	18.7														
	5.5	400	10.1	12.9	15.8	18.9														
	5.4	410	10.2	12.9	15.9	19.0														
	5.2	420	10.2	13.0	16.0	19.1														
	5.1	430	10.3	13.0	16.0	19.2														
	5.0	440	10.3	13.1	16.1	19.3														
	4.9	450	10.3	13.1	16.2	19.5														
	4.8	460	10.4	13.2	16.3	19.6														
	4.7	470	10.4	13.2	16.3	19.7														
	4.6	480	10.4	13.3	16.4	19.8														
	4.5	490	10.5	13.3	16.5	19.9														
	4.4	500	10.5	13.4	16.5	19.9														
	4.3	510	10.5	13.4	16.6															
	4.2	520	10.5	13.5	16.7															
	4.2	530	10.6	13.5	16.7															
	4.1	540	10.6	13.5	16.8															
	4.0	550	10.6	13.6	16.8															
	3.9	560	10.6	13.6	16.9															
	3.9	570	10.7	13.7	16.9															
	3.8	580	10.7	13.7	17.0															
	3.7	590	10.7	13.7	17.0															
	3.7	600	10.7	13.8	17.1															
	3.6	610	10.7	13.8	17.1															
	3.5	620	10.8	13.8	17.2															

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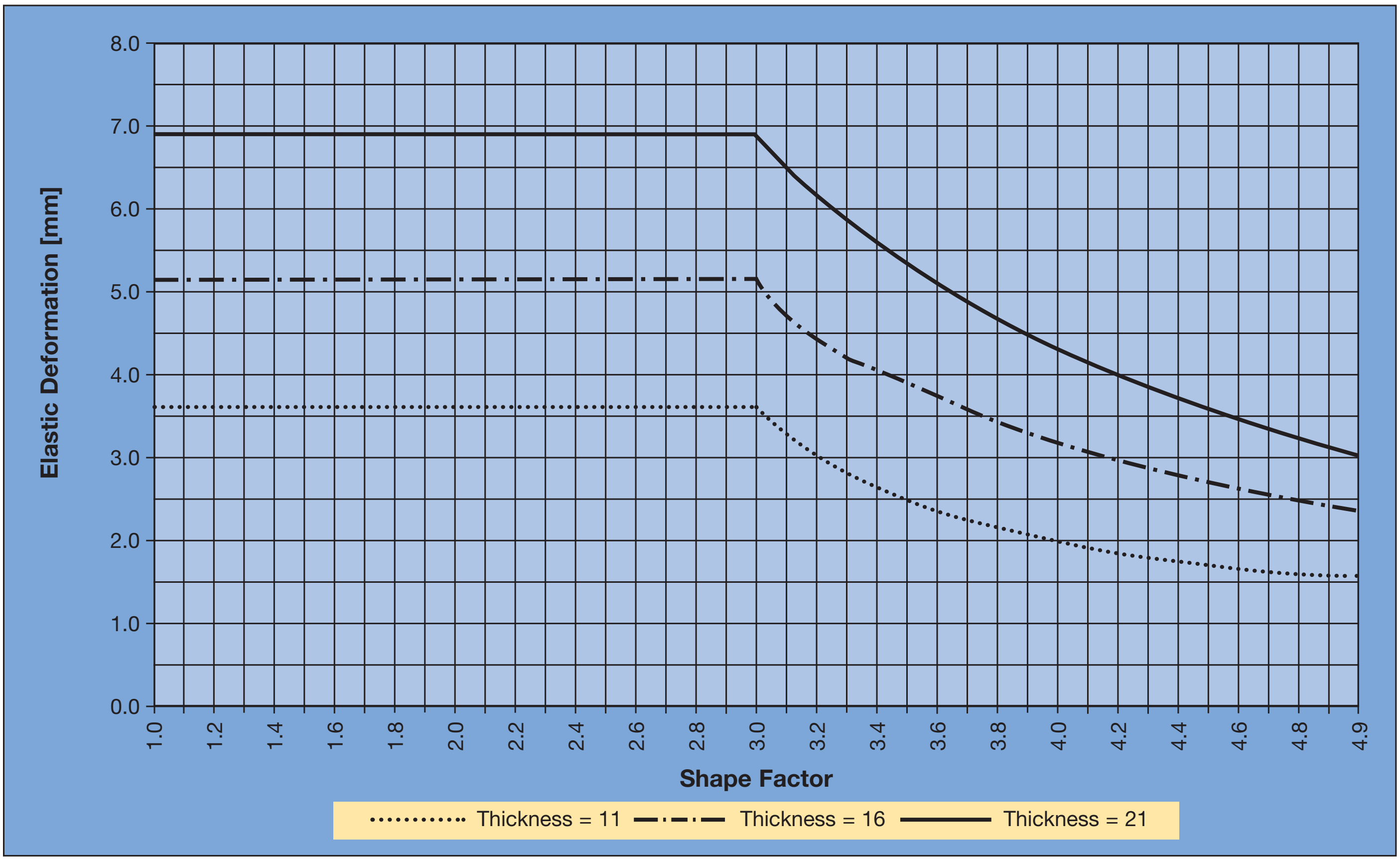
Calculation Table 2: Compact Bearing CR 2000, **16, 21 mm** thick

Bearing Thickness (mm)	perm. angular Distortion α (‰)	Bearing Width (mm)	**Load, perm. σ_m (N/mm²)**																	
			Bearing Length l (mm)																	
			50	60	70	80	90	100	125	150	175	200	225	250	275	300	350	400	450	500
16	40.0	80	4.1	4.6	5.0	5.4	5.8	6.2	6.9	7.6	8.1	8.5	8.9	9.3	9.6	9.8	10.3	10.6	10.9	11.1
	35.6	90	4.3	4.8	5.3	5.8	6.3	6.7	7.6	8.4	9.0	9.6	10.1	10.5	10.9	11.2	11.8	12.2	12.6	12.9
	32.0	100	4.5	5.1	5.6	6.2	6.7	7.1	8.2	9.1	9.9	10.6	11.2	11.7	12.2	12.6	13.3	13.9	14.4	14.8
	29.1	110	4.6	5.3	5.9	6.5	7.1	7.6	8.8	9.9	10.8	11.6	12.3	13.0	13.5	14.1	14.9	15.7	16.3	16.8
	26.7	120	4.7	5.4	6.1	6.8	7.4	8.0	9.4	10.6	11.7	12.6	13.5	14.2	14.9	15.5	16.6	17.4	18.2	18.8
	24.6	130	4.9	5.6	6.3	7.1	7.7	8.4	9.9	11.3	12.5	13.6	14.6	15.5	16.2	17.0	18.2	19.2		
	22.9	140	5.0	5.8	6.6	7.3	8.1	8.8	10.5	12.0	13.3	14.6	15.7	16.7	17.6	18.4	19.8			
	21.3	150	5.1	5.9	6.7	7.6	8.4	9.1	11.0	12.6	14.1	15.5	16.7	17.9	18.9	19.8				
	20.0	160	5.2	6.0	6.9	7.8	8.6	9.5	11.4	13.2	14.9	16.4	17.8	19.1						
	18.8	170	5.2	6.2	7.1	8.0	8.9	9.8	11.9	13.8	15.7	17.3	18.8							
	17.8	180	5.3	6.3	7.2	8.2	9.1	10.1	12.3	14.4	16.4	18.2	19.8							
	16.8	190	5.4	6.4	7.4	8.4	9.4	10.3	12.7	15.0	17.1	19.0								
	16.0	200	5.4	6.5	7.5	8.5	9.6	10.6	13.1	15.5	17.7	19.8								
	15.2	210	5.5	6.6	7.6	8.7	9.8	10.9	13.5	16.0	18.4									
	14.5	220	5.6	6.6	7.7	8.8	10.0	11.1	13.9	16.5	19.0									
	13.9	230	5.6	6.7	7.8	9.0	10.2	11.3	14.2	17.0	19.6									
	13.3	240	5.7	6.8	7.9	9.1	10.3	11.5	14.5	17.4										
	12.8	250	5.7	6.9	8.0	9.3	10.5	11.7	14.8	17.9						20				
	12.3	260	5.8	6.9	8.1	9.4	10.6	11.9	15.1	18.3										
	11.9	270	5.8	7.0	8.2	9.5	10.8	12.1	15.4	18.7										
	11.4	280	5.8	7.0	8.3	9.6	10.9	12.3	15.7	19.1										
	11.0	290	5.9	7.1	8.4	9.7	11.1	12.5	16.0	19.5										
	10.7	300	5.9	7.1	8.5	9.8	11.2	12.6	16.2	19.8										
	10.0	320	6.0	7.2	8.6	10.0	11.4	12.9	16.7											
	9.4	340	6.0	7.3	8.7	10.2	11.7	13.2	17.2											
	9.1	350	6.1	7.4	8.8	10.3	11.8	13.3	17.4											
	8.9	360	6.1	7.4	8.8	10.3	11.9	13.5	17.6											
	8.4	380	6.1	7.5	8.9	10.5	12.1	13.7	18.0											
	8.0	400	6.2	7.6	9.0	10.6	12.2	13.9	18.3											
21	52.5	80	3.2	3.5	3.8	4.1	4.3	4.5	5.0	5.4	5.7	6.0	6.3	6.5	6.6	6.8	7.1	7.3	7.5	7.6
	46.7	90	3.4	3.7	4.0	4.3	4.6	4.9	5.4	5.9	6.3	6.7	7.0	7.2	7.5	7.7	8.0	8.3	8.5	8.7
	42.0	100	3.5	3.8	4.2	4.5	4.9	5.2	5.8	6.4	6.9	7.3	7.7	8.0	8.3	8.5	9.0	9.3	9.6	9.9
	38.2	110	3.6	4.0	4.4	4.7	5.1	5.4	6.2	6.8	7.4	7.9	8.4	8.8	9.1	9.4	9.9	10.4	10.8	11.1
	35.0	120	3.6	4.1	4.5	4.9	5.3	5.7	6.5	7.3	8.0	8.5	9.1	9.5	9.9	10.3	10.9	11.5	11.9	12.3
	32.3	130	3.7	4.2	4.7	5.1	5.5	5.9	6.9	7.7	8.5	9.1	9.7	10.3	10.7	11.2	11.9	12.6	13.1	13.6
	30.0	140	3.8	4.3	4.8	5.3	5.7	6.2	7.2	8.1	9.0	9.7	10.4	11.0	11.6	12.1	12.9	13.7	14.3	14.8
	28.0	150	3.8	4.4	4.9	5.4	5.9	6.4	7.5	8.5	9.5	10.3	11.0	11.7	12.4	12.9	13.9	14.8	15.5	16.1
	26.3	160	3.9	4.5	5.0	5.5	6.1	6.6	7.8	8.9	9.9	10.9	11.7	12.5	13.2	13.8	14.9	15.9	16.7	17.5
	24.7	170	4.0	4.5	5.1	5.7	6.2	6.8	8.1	9.3	10.4	11.4	12.3	13.2	13.9	14.7	15.9	17.0	18.0	18.8
	23.3	180	4.0	4.6	5.2	5.8	6.4	7.0	8.3	9.6	10.8	11.9	12.9	13.9	14.7	15.5	16.9	18.1	19.2	
	22.1	190	4.0	4.7	5.3	5.9	6.5	7.1	8.6	10.0	11.2	12.4	13.5	14.5	15.5	16.3	17.9	19.2		
	21.0	200	4.1	4.7	5.4	6.0	6.7	7.3	8.8	10.3	11.7	12.9	14.1	15.2	16.2	17.2	18.9			
	20.0	210	4.1	4.8	5.4	6.1	6.8	7.4	9.1	10.6	12.1	13.4	14.7	15.9	17.0	18.0	19.8			
	19.1	220	4.2	4.8	5.5	6.2	6.9	7.6	9.3	10.9	12.4	13.9	15.2	16.5	17.7	18.8				
	18.3	230	4.2	4.9	5.6	6.3	7.0	7.7	9.5	11.2	12.8	14.3	15.8	17.1	18.4	19.6				
	17.5	240	4.2	4.9	5.7	6.4	7.1	7.9	9.7	11.5	13.2	14.8	16.3	17.7	19.1					
	16.8	250	4.3	5.0	5.7	6.5	7.2	8.0	9.9	11.7	13.5	15.2	16.8	18.3	19.8					
	16.2	260	4.3	5.0	5.8	6.5	7.3	8.1	10.1	12.0	13.8	15.6	17.3	18.9						
	15.6	270	4.3	5.0	5.8	6.6	7.4	8.2	10.2	12.2	14.2	16.0	17.8	19.5						
	15.0	280	4.3	5.1	5.9	6.7	7.5	8.3	10.4	12.5	14.5	16.4	18.3							
	14.5	290	4.4	5.1	5.9	6.7	7.6	8.4	10.6	12.7	14.8	16.8	18.7			20				
	14.0	300	4.4	5.2	6.0	6.8	7.7	8.5	10.7	12.9	15.1	17.2	19.2							
	13.1	320	4.4	5.2	6.1	6.9	7.8	8.7	11.0	13.3	15.6	17.9								
	12.4	340	4.4	5.3	6.1	7.0	8.0	8.9	11.3	13.7	16.2	18.6								
	12.0	350	4.5	5.3	6.2	7.1	8.0	9.0	11.4	13.9	16.4	18.9								
	11.7	360	4.5	5.3	6.2	7.1	8.1	9.1	11.6	14.1	16.7	19.2								
	11.1	380	4.5	5.4	6.3	7.2	8.2	9.2	11.8	14.5	17.1	19.8								
	10.5	400	4.5	5.4	6.3	7.3	8.3	9.3	12.0	14.8	17.6									



Picture 3: Elastic bearing deformation with perm. load depending on bearing thickness and shape factor

The diagram serves to estimate the maximum elastic deformation expected, as the actual elastic deformation in practice is depending on parameter like temperature, condition of surface of adjoining components, etc.

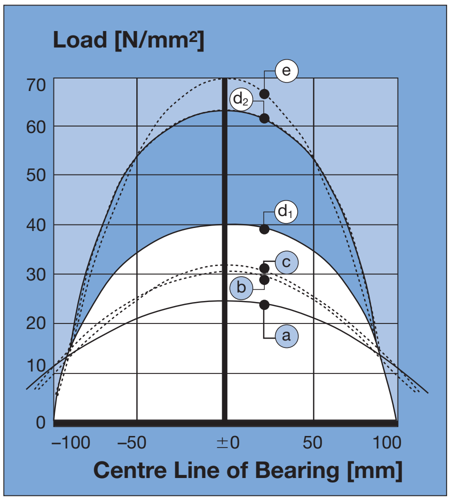
Shape Factor	Compression Modulus	Shape Factor	Compression Modulus	Shape Factor	Compression Modulus	Shape Factor	Compression Modulus
1.0	13.5	**3.6**	79.0	**6.2**	205.4	**8.8**	392.6
1.1	14.9	**3.7**	82.8	**6.3**	211.5	**8.9**	401.0
1.2	16.4	**3.8**	86.6	**6.4**	217.6	**9.0**	409.5
1.3	18.0	**3.9**	90.5	**6.5**	223.9	**9.1**	418.1
1.4	19.6	**4.0**	94.5	**6.6**	230.2	**9.2**	426.8
1.5	21.4	**4.1**	98.6	**6.7**	236.7	**9.3**	435.6
1.6	23.2	**4.2**	102.8	**6.8**	243.2	**9.4**	444.4
1.7	25.2	**4.3**	107.1	**6.9**	249.8	**9.5**	453.4
1.8	27.2	**4.4**	111.4	**7.0**	256.5	**9.6**	462.4
1.9	29.3	**4.5**	115.9	**7.1**	263.3	**9.7**	471.6
2.0	31.5	**4.6**	120.4	**7.2**	270.2	**9.8**	480.8
2.1	33.8	**4.7**	125.1	**7.3**	277.2	**9.9**	490.1
2.2	36.2	**4.8**	129.8	**7.4**	284.2	**10.0**	499.5
2.3	38.7	**4.9**	134.6	**7.5**	291.4	**10.1**	509.0
2.4	41.2	**5.0**	139.5	**7.6**	298.6	**10.2**	518.6
2.5	43.9	**5.1**	144.5	**7.7**	306.0	**10.3**	528.3
2.6	46.6	**5.2**	149.6	**7.8**	313.4	**10.4**	538.0
2.7	49.5	**5.3**	154.8	**7.9**	320.9	**10.5**	547.9
2.8	52.4	**5.4**	160.0	**8.0**	328.5	**10.6**	557.8
2.9	55.4	**5.5**	165.4	**8.1**	336.2	**10.7**	567.9
3.0	58.5	**5.6**	170.8	**8.2**	344.0	**10.8**	578.0
3.1	61.7	**5.7**	176.4	**8.3**	351.9	**10.9**	588.2
3.2	65.0	**5.8**	182.0	**8.4**	359.8	**11.0**	598.5
3.3	68.4	**5.9**	187.7	**8.5**	367.9	**11.1**	608.9
3.4	71.8	**6.0**	193.5	**8.6**	376.0	**11.2**	619.4
3.5	75.4	**6.1**	199.4	**8.7**	384.3	**11.3**	630.0

Table 1: Compression Modulus E_D [N/mm^2] of Compact Bearing CR 2000 depending on shape factor

Example of Calculation for Bearing Class 2 according to DIN 4141 Part 3 with Calculation of Transverse and Tensile Splitting Reinforcement.

1 Preliminary Remark

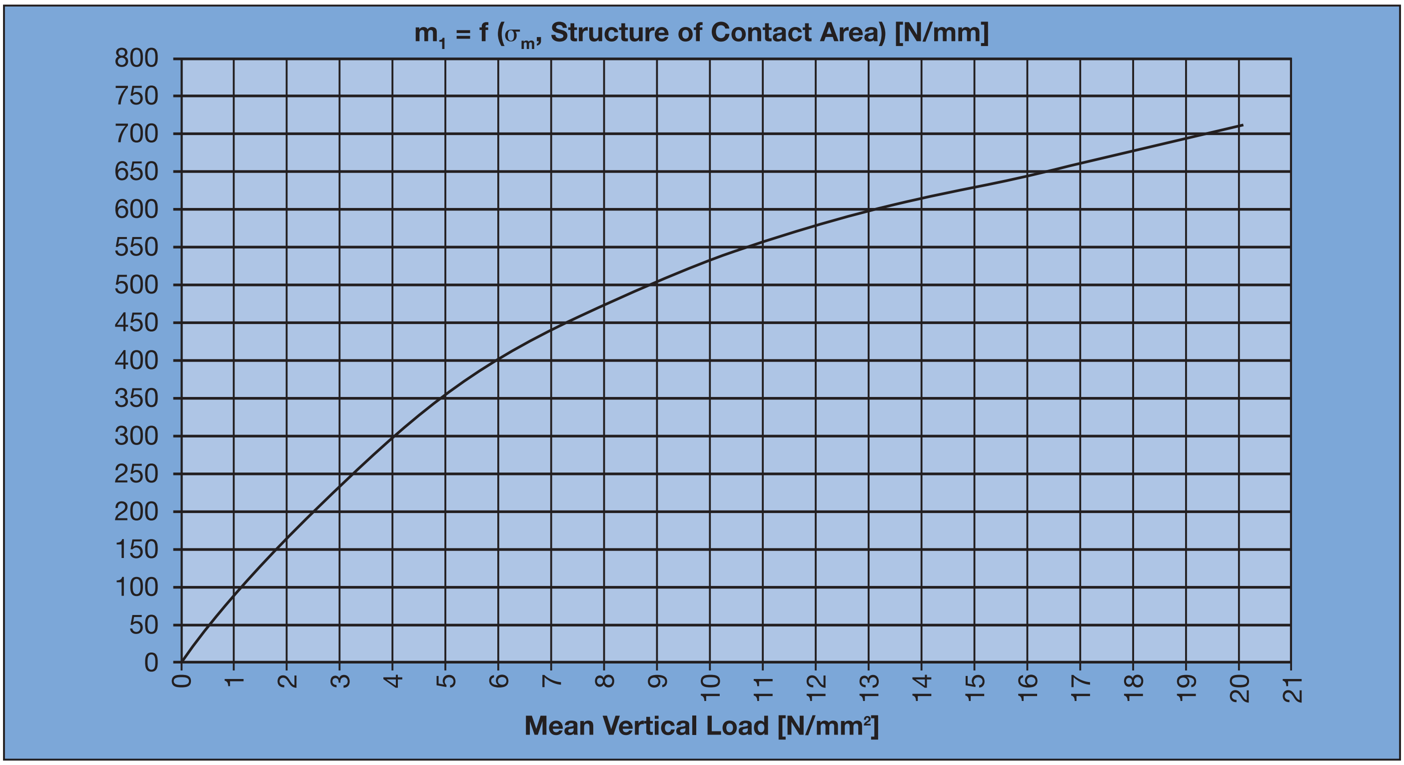
Extensive test sequences with high centric and ex-centric load initiation (oblique positioning of components adjoining to the bearing) should give information about load characteristics and stress concentration in the centre of the bearing pad, which cause higher tensile splitting forces in the adjoining components. The results showed serious differences in the level of stress concentration between reinforced and unreinforced elastomer bearings. In the assembly of tested unreinforced bearings the Calenberg Compact Bearing CR 2000 showed the most even distribution of compressive stress over the bearing cross section. The ratio of maximum load to mean load, max. σ/σ_m, was the smallest with 1.2 (picture 4).



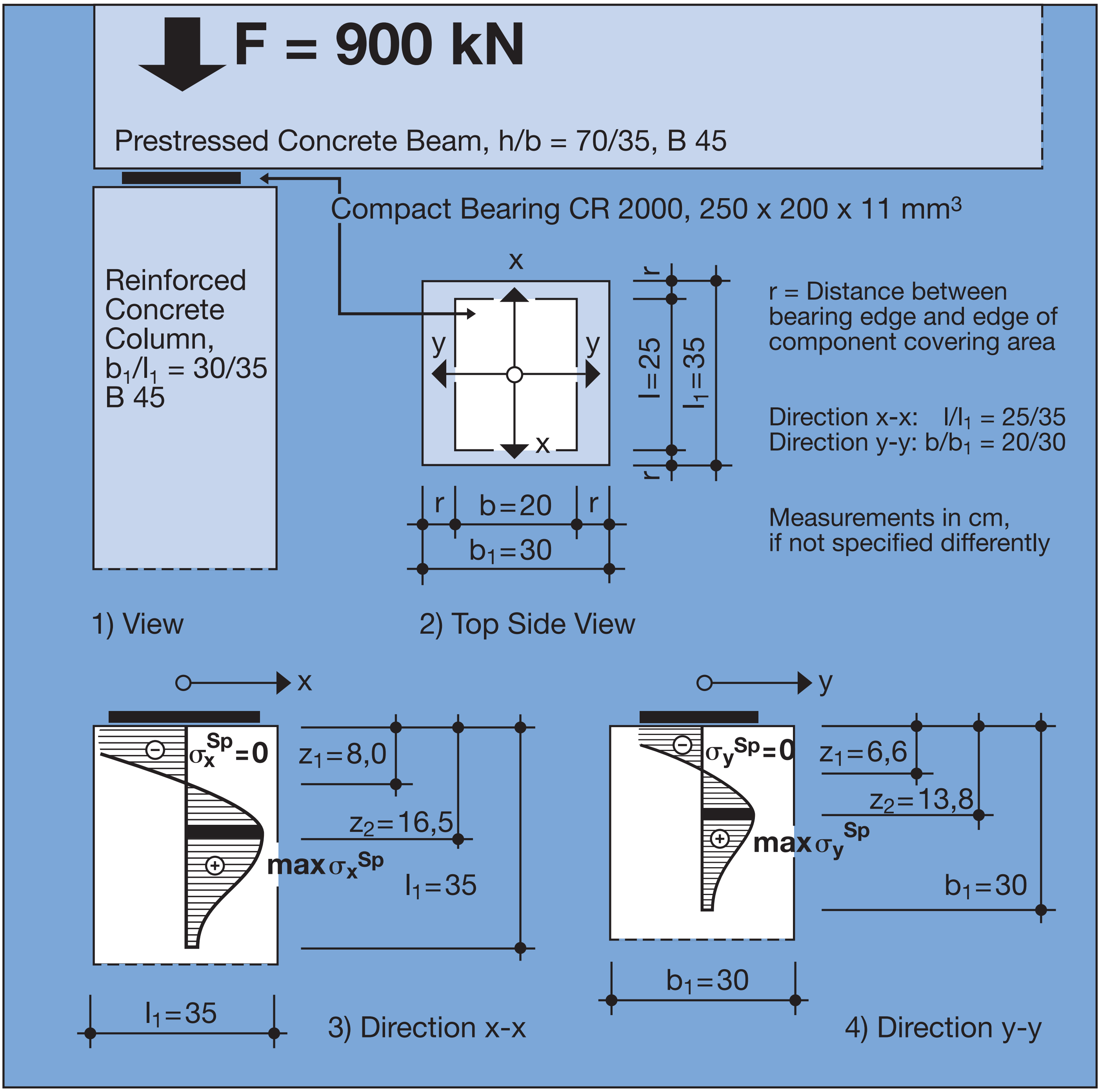
Picture 4: Load distribution in a support joint on the centre lines of bearing areas of different unreinforced and reinforced elastomer bearings. Requirement: Area of all bearings: 200 x 200 mm, centric load initiation.

a	Compact Bearing CR 2000, t = 20 mm, σ_m = 20 N/mm²
b	unreinforced EPDM-Bearing, t = 20 mm, σ_m = 20 N/mm²
c	unreinforced CR-Bearing, t = 20 mm, σ_m = 20 N/mm²
d_1	Sandwich Bearing Q, t = 30 mm, σ_m = 20 N/mm²
d_2	Sandwich Bearing Q, t = 30 mm, σ_m = 30 N/mm²
e	reinforced bearing with smooth contact areas, t = 30 mm, σ_m = 30 N/mm²

Compression stressed Compact Bearings CR 2000 are causing cross and splitting tensile forces in adjoining components, which are in size dependent on load, format and condition of the contact areas. Cross and splitting tensile forces can be calculated and sustained by steel reinforcement of the adjoining concrete components.



Picture 5: Calculation diagram for cross tensile forces caused by Compact Bearing CR 2000. Valid for non-fixed bearing pads put between even concrete surfaces (partly limited transverse strain), orientation curve; deviation due to tolerance of hardness and differences of contact area is possible.



Picture 6: Example of calculation, details about component- and bearing dimensions, vertical loads and splitting tensile stress

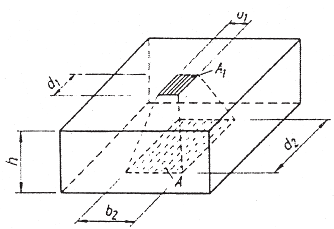
Load on partial Area

If splitting tensile forces underneath the partial area can be sustained (e.g. by reinforcement), it is allowed to calculate with increased concrete stress in the loaded partial area. Further requirements are shown in the opposite picture.

$$\sigma_1 = \frac{\beta_R}{2{,}1}\sqrt{\frac{A}{A_1}} \leq 1{,}4\beta_R$$

Requirements:

1. Centre of gravity A is positioned vertically underneath centre of gravity of area A_1
2. $b_2 \leq 3\, b_1$; $d_2 \leq 3\, d_1$
3. $h \geq b_2 - b_1$; $h \geq d_2 - d_1$;



Picture 7: Arithmetical distribution area
(no overlapping of several distribution areas permitted)

2 Actual Data

2.1 Components, Building Materials

- Prestressed concrete beam, B 45: **h/b = 70/35 [cm]**
- Reinforced concrete column, B 45: **b_1/l_1 = 30/35 [cm]**
- perm. normal concrete stress **zul $\sigma_b = \beta_R / \gamma = 27 / 2{,}1$ = 12,86 N/mm²**
- **perm. stress on partial area (s. picture 7) zul. $\sigma_1 = \beta_R / \gamma \times \sqrt{A/A_1} = 27/2{,}1 \times \sqrt{0{,}105/0{,}05}$ = 18,63 N/mm²**
- perm. stress of reinforcing steel, BSt 500 S **zul $\sigma_S = \beta_S / \gamma = 500 / 1{,}75$ = 287,0 N/mm²**

2.2 Static Values

- Vertical load: **F = 900 kN**
- Arithmetical horizontal movement of the beam due to creep and shrinkage: **Δl = 3,5 mm**
- Arithmetical bearing distortion: **α = 9,6‰**
- Max. actual support area (= area covered by both components): **A_A = 30 x 35 cm²**

3 Bearing Check Up

The calculation of the bearing is done with the given values according to the Calculation formulae (page 2) resp. to the calculation tables 1–2 (page 4–5). The following has to be taken into consideration:

- The distance between bearing edge and component edge has to be at least 4 cm.
- With reinforced concrete components the bearing pad area in the ground plan must be enclosed by the reinforcement (picture 2).
- Chamfered component edges have to be taken into consideration.

3.1 Chosen Elastomer Bearing:

Calenberg Compact Bearing CR 2000: **l x b x t = 250 mm x 200 mm x 11 mm**

3.2 Bearing Calculation:

- perm. mean load (according to calculation table 1):
  perm. σ_m = 20,0 N/mm² > act. σ_m = 900 x 10³/(250 x 200) = 18,00 N/mm² < perm. σ_1 = 18,63 N/mm²
- perm. horizontal bearing deformation: **perm. u = ± 4,8 mm > act. Δl = 3,5 mm**
- perm. bearing distortion: **perm. α_{200} = 11‰ > act. α = 9,6‰**

4 Calculation of the Cross Tensile Reinforcement

In order to take up cross tensile forces caused by the strained bearing, the necessary reinforcement in the beam component above the support area and in the top end of the column is determined.

4.1 Calculation of the Cross Tensile Force (according to picture 5 and table 1)

with act. σ_m = 18,0 N/mm² ⊳ m_1 = 680 N/mm (see picture 5)
act. mean cross tensile force Z_m = 680 x 250 x 200 / (2 x 11 x (250 + 200)) x 11 x c = 37778 x c ⊳ 37,8 x c [kN]
for concrete component surfaces made of:

a) wood shuttering: c = 1,00 ⊳ Z_m = 37,8 x 1,00 = **37,80 kN** reinforcement BSt 500 S, **required A_s = 1,32 cm²**
b) plastic/grp shuttering: c = 0,66 ⊳ Z_m = 37,8 x 0,66 = **24,95 kN** reinforcement BSt 500 S, **required A_s = 0,87 cm²**
c) steel shuttering: c = 0,50 ⊳ Z_m = 37,8 x 0,50 = **18,90 kN** reinforcement BSt 500 S, **required A_s = 0,66 cm²**

4.2 Chosen Cross Tensile Reinforcement

arrangement of reinforcement according to method A (see picture 9), above and below the bearing

- in the beam: horizontal loop 2 Ø 10 mm and stirrup rectangular to loop 2 Ø 10 ⊳ **act. A_s = 1,57 cm²**
- in the column: stirrups crosswise respectively 2 Ø 10 ⊳ **act. A_s = 1,57 cm²**

5 Calculation of Splitting Tensile Reinforcement

Splitting tensile forces, caused by onion-shape-like distribution of stress with concentrated initiation of forces in the support area, are becoming the more intense the smaller the ratio of initiation area to distribution area is.
In the following the splitting tensile reinforcement is determined according to F. Leonhardt “Reinforcing of concrete construction”, chapter 13, Betonkalender 1971, part 2 (see picture 6 and 8).

5.1 Direction x-x:

l/l_1 = 25/35 = 0,71 ⊳ $Z_{x,Sp}$ = 0,06 x F = 0,06 x 900 = **54,0 kN**, reinforcement BSt 500 S, **required. A_s = 1,89 cm²**
Position of σ_{Sp} = 0: z_1 = 0,23 x l_1 = 0,23 x 35 = **8,0 cm; position of max. σ_{Sp}:** z_2 = 0,47 x l_1 = 0,47 x 35 = **16,5 cm**

Chosen Splitting Tensile Reinforcement

- in the beam: horizontal loop 2 Ø 12 mm and stirrup rectangular to loop 2 Ø 10 mm ⊳ **act. A_s = 2,26 cm²**
- in the column: stirrups 2 Ø 12 mm at z = 15 cm ⊳ **act. A_s = 2,26 cm²**

5.2 Direction y-y:

b/b_1 = 20/30 = 0,66 ⋗ $Z_{x,Sp}$ = 0,08 x F = 0,08 x 900 = **72,0 kN**, reinforcement BSt 500 S, **required A_s = 2,52 cm²**
Position of σ_{Sp} = 0: z_1 = 0,22 x b_1 = 0,22 x 30 = **6,6 cm; position of max. σ_{Sp}**: z_2 = 0,46 x b_1 = 0,46 x 30 = **13,8 cm**

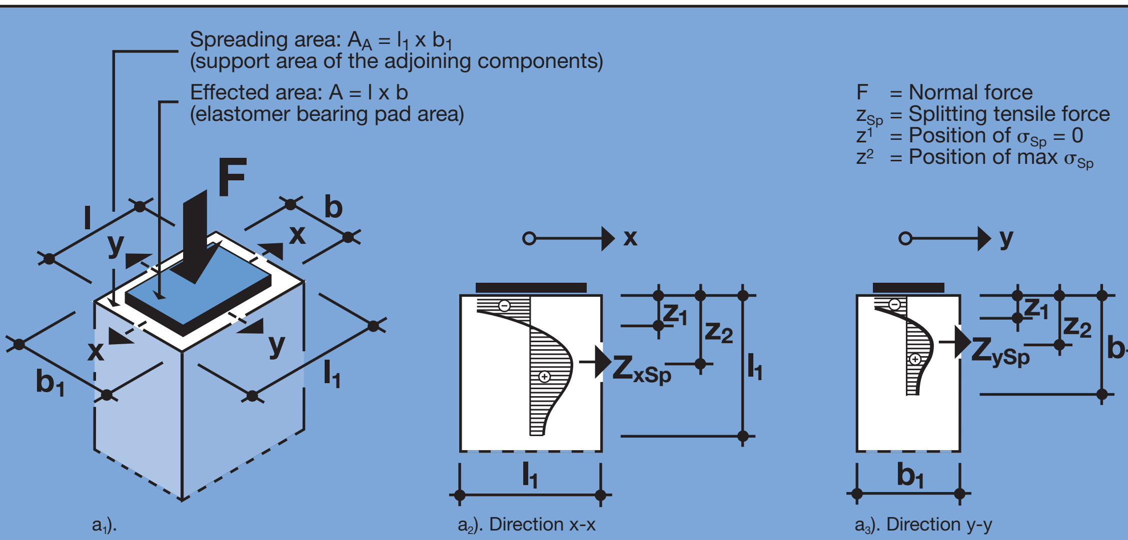
Chosen Splitting Tensile Reinforcement

- in the beam: horizontal loop 3 Ø 12 mm and stirrup rectangular to loop 2 Ø 10 mm ⋗ act. **A_s = 3,39 cm²**
- in the column: stirrups 3 Ø 12 mm at z = 15 cm ⋗ act. **A_s = 3,39 cm²**

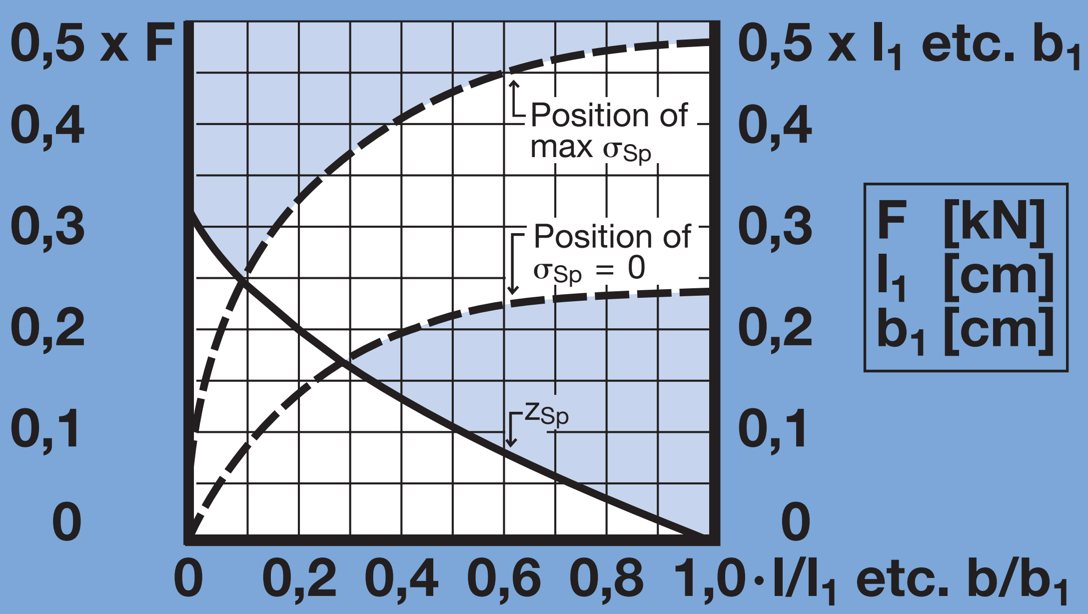
6 Hints

The necessary reinforcement calculated above under 4 and 5 can be combined. Here the different position of reinforcement inside the component has to be taken into consideration.

- **The cross tensile reinforcement has to be positioned as near as possible to the component surfaces.**
- **The splitting tensile reinforcement should be placed in the calculated position of max. σ_{Sp}.**

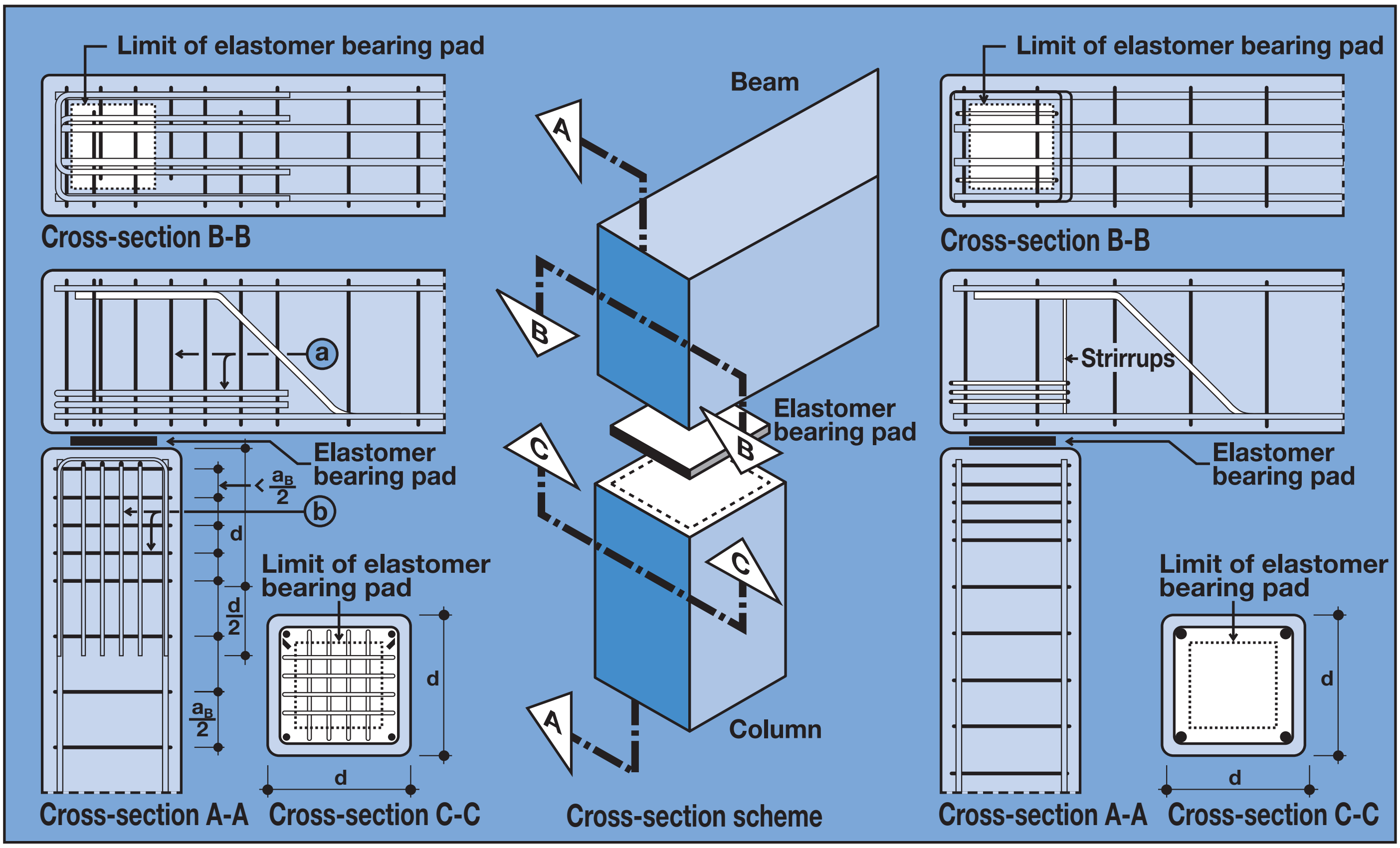


a) Extend of splitting tensile stress within a concrete prism under concentrated vertical load



b) Dimension of the splitting tensile force Z_{Sp} as part of F, position of the biggest splitting tensile stress max σ_{Sp} and beginning of the splitting tensile stress σ_{Sp} = 0

Picture 8: Diagram for calculation of splitting tensile forces Z_{Sp} and the position of z_1 (σ_{Sp} = 0) and z_2 (max. σ_{Sp})



Picture 9: Example of construction for the installation of elastomer bearings and positioning of the cross tensile reinforcement at the nodal point beam – column according to the proposal of Dr.-Ing. M. Flohrer and Dipl.-Ing. E. Stephan, engineering association Prof. R. v. Halász, Berlin.

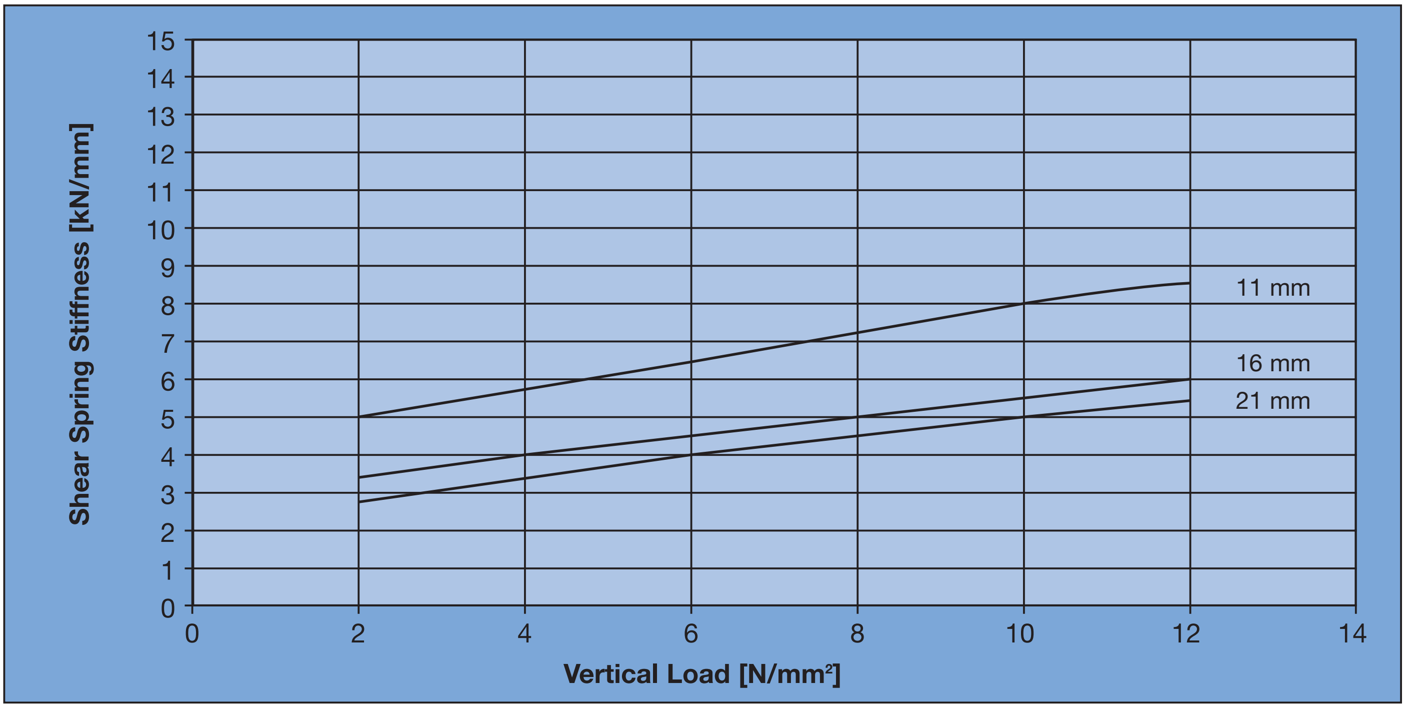
Method A (cross-sections left): Cross tensile forces are directly covered by reinforcement where they arise.

a) Beam-cross tensile reinforcement: horizontal loops and additional stirrups.

b) Column-cross tensile reinforcement: vertical loops and additional stirrups, arranged crosswise.

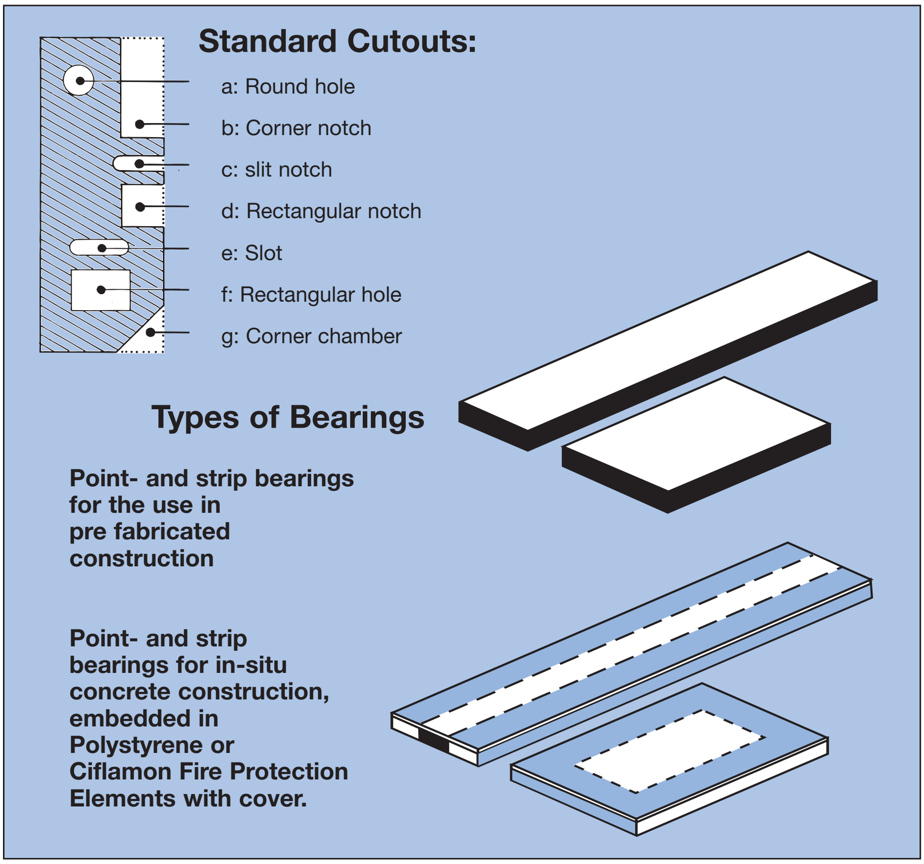
Method B (cross sections right): Cross tensile forces are taken up by reinforcement enclosing the bearing pad area.

A_B = distance between the stirrups; d = width of the column



Picture 10: Shear spring stiffness C_s [kN/mm] depending on vertical load

Horizontal shear deformation caused by unique horizontal forces has not to be proven, because unique minor sliding does not lead to any harmful changes of the support. If a “pure” shear deformation is required, a vertical load of **2,6 N/mm²** is necessary.



Picture 11: Calenberg Compact Bearing CR 2000, standard cutouts and types of bearings

Dimensions and Format

Calenberg Compact Bearings CR 2000 are available cut to size as requested (picture 11).
In the case that bolts have to be put through a bearing, it can be provided with holes, cutouts, slots etc.
For the use in in-situ construction Compact Bearings CR 2000 are available embedded in Polystyrene- or Ciflamon Fire Resistance Elements, so the support joint will not be affected by penetrating fresh concrete. This is important to ensure the necessary elastic bearing deformation without any resistance.

Measurements:
- Bearing thickness: 11, 16, 21 mm
- Maximum dimensions of ground area
  - – Length: 1500 mm
  - – Width: 1200 mm
  - – Diameter: 1200 mm

Application, Where to Use

Calenberg Compact Bearings CR 2000 are used in all areas of construction as permanent elastic and flexible joint elements.
The bearing pads are used in building construction as elastic rectangular, circular or strip bearings to support girders, beams, wallboards etc.

Fire Resistance Properties

The minimum bearing dimensions required for classification into Fire Resistance Class F 90 and F 120 are listed in the “Fire Protection Table” (Brandschutztechnische Beurteilung) No. 3799/7357-AR. For bearings with smaller dimensions a jacketing with a 30 mm wide Ciflamon Fire Protection Strip is necessary to meet the conditions of the F120-classification.

Directions for Bearing Installation

In precast construction Compact Bearings CR 2000 are to be placed in the centre of the support area. With reinforced concrete components the distance between bearing edge and component edge must be at least 4 cm, so that the steel reinforcement encloses the bearing pad area. Chamfered component edges have to be taken into consideration.

In-situ concrete construction requires a covering of gaps and joints around the bearing pad, so the support joint will not be affected by penetrating fresh concrete. A rigid connection must be avoided. The springing effect of the elastomer bearing has to be ensured in any case.

Certificate, Approval of Suitability

- Official Certificate No. 850.0425, basic research into classification of Compact Bearings CR 2000 according to DIN 4141 part 3, Testing Institute for Machine Material and Plastic, Technical University of Hannover, 2000.
- Fire Resistance Judgement No. 3799/7357–AR; Judgement of Calenberg elastomer bearings regarding to a classification into fire resistance class F 90 resp. F 120 according to DIN 4102 part 2 (edition 9/1977), Official Material Testing Institute of Civil Constructions, TU Braunschweig, November 1997.

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