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PLANNING					

BSF – A SHORT GUIDE TO BSF SLIDING INSERTS

This short guide is intended to give a brief overview of the use and design methods for the BSF without drilling into the details.

BSF inserts are a mechanical alternative to other beam supports such as integral corbels, bolt-on corbels or cast-in solid billets. Four different BSF units are available, with various capacities according to their size.

The system consists of 3 main parts.

a) A beam box. This is cast into the beam which is being supported. It works in conjunction with purpose-bent reinforcing bars and threaded rods to transfer loads into the body of the concrete.
b) A column box. This is cast into the column.
c) A sliding 'knife'. This solid steel member actually carries the load from one member to another. It is placed within the beam box, and then partially slid out when in position, to bear on the bottom of the column box. Threaded rods, and a welded-on bar transfer loads into the concrete.

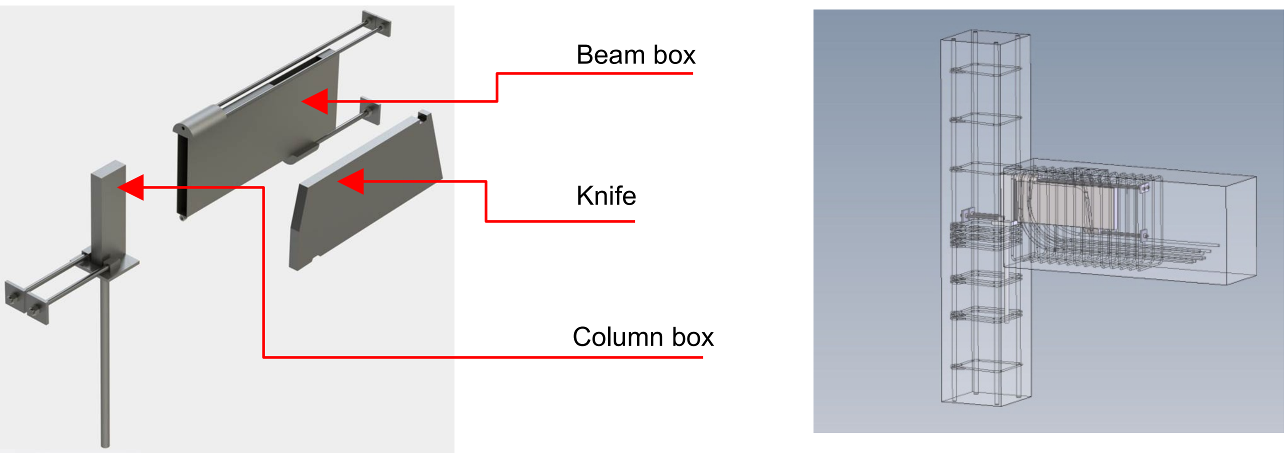


Figure 1: Illustration of unit

The nominal capacities and approximate minimum beam dimensions for the different units is as given in Table 1. A final evaluation of the beam dimension and required reinforcement in the beam end shall be done by qualified engineer in each case. For this purpose, Memo 521 from the manufacturer may be used as guideline along with the general rules in EC2.

Type	Max vertical ultimate limit load on unit [kN]	Approximate absolute minimum beam dimension to allow for space of the unit		
		W×H [MM]	X [MM]	Y [MM]
BSF225	225	190×370	≈116mm	≈306mm
BSF300	300	190×420	≈116mm	≈349mm
BSF450	450	190×440	≈116mm	≈369mm
BSF700	700	310×500	≈239mm	≈424mm
BSF1100	1100	310×590	≈239mm	≈518mm

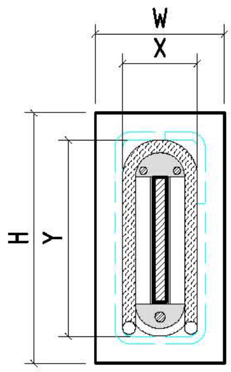
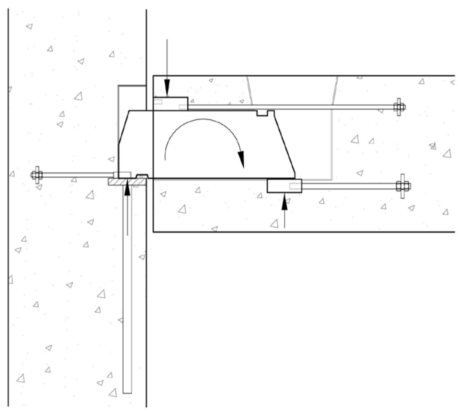


Table 1: Capacities and approximate minimum beam dimension to allow for space of the different units.

MATERIALS

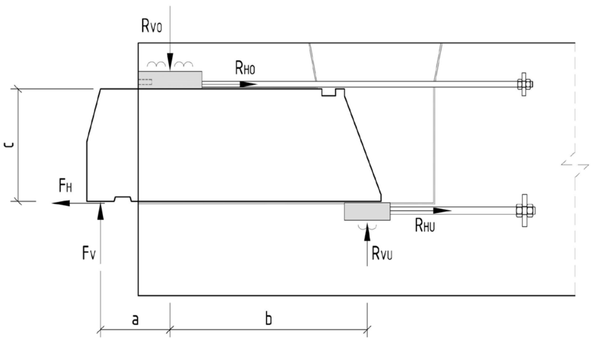
All parts are made from steel. The three main components shown above are grade S355 steel. Threaded rods are grade 8.8, and plate washers are grade S355. Designs are based on concrete grade C35/45. (BSF1100: B45/55 in column) Stronger concrete will not increase capacities as they are limited by the steel unit capacity. Weaker concrete **<u>may</u>** lower capacities.

DESIGN PRINCIPLES



When deployed, the sliding knife cantilevers from the beam into the column. It bears onto the base of the column box at the free end, which induces rotation of the knife. This is resisted by bearing against half-round bearing blocks in the beam (see below). These half-round blocks in turn bear against reinforcement which is not shown in the diagram, but is dealt with later in the guide.

VERTICAL FORCES



The horizontal forces R_{HO} and R_{HU} are assumed to be $0.2F_V$ and $0.1F_V$ respectively (see later for explanation of why. The BSF1100 has a slightly different distribution of horizontal forces, see Memo521.)

Considering rotation about the rear stress block at equilibrium:

$R_{VO} \times b = F_V \times (a+b) + R_{HO} \times c = F_V \times (a+b) + 0.2F_V \times c$ from which

$R_{VO} = F_V \times (a + b) / b + 0.2F_V \times c / b$

and vertically: $R_{VU} = R_{VO} - F_V$

From these equations, values for R_{VO}, R_{VU}, R_{HO} and R_{HU} are found as below.

Type	Fv (kN)	a (mm)	b (mm)	c (mm)	R_{VO} (kN)	R_{VU} (kN)
BSF225	225	115	340	195	327	102
BSF300	300	125	330	235	456.4	156.4
BSF450	450	152.5	432.5	250	660.7	210.7
BSF700	700	165	420	280	1068	368
BSF1100	1100	206	704	360	1557	457

Table 2: Vertical forces (nominal).

The above table is for 'ideal' values for a, b and c. More critical values are obtained by including the unfavorable tolerance on position of the anchoring reinforcement (±5mm) and the maximum site erection tolerance (10mm). This will lead to the values given in table 2 below.

Type	Fv (kN)	a (mm)	b (mm)	c (mm)	R_{VO} (kN)	R_{VU} (kN)
BSF225	225	130	330	195	340.2	115.2
BSF300	300	140	320	235	475.3	175.3
BSF450	450	167.5	422.5	250	681.7	231.7
BSF700	700	180	410	280	1103	403
BSF1100	1100	221	694	360	1587	487

Table 3: Vertical forces (maximum).

These higher values are used to evaluate reinforcement quantities. Reinforcement is grade 500C, with working stress = 435 N/mm^2. (Note: *Reinforcement steel of different qualities may be chosen provided that the calculations take into account the actual yield strength ($f_y \leq 500$ MPa) and that the bendability is sufficient for fitting the vertical suspension reinforcement to the half round steels in front and back of the unit.)*

VERTICAL ANCHORAGE REINFORCEMENT

Special bars, commonly called 'saddle bars' are provided to transmit vertical forces imposed on the half round blocks by the knife. The front saddle bars should transmit forces into the lower part of the member, preferably lapping on to the main tension steel in a beam. Similarly, the rear saddle bars should transmit forces into the top of the member. It is considered good practice for the bends in saddle bars to be greater than the minimum allowable to prevent any local concrete crushing inside the bend.

Reinforcement to carry force R_{VO} is as below.

Type	R_{VO} (kN)	A_s reqd (mm^2)	Bars	A_s prov (mm^2)
BSF225	340.2	782	2 x 16 dia	804
BSF300	475.3	1093	3 x 16 dia	1206
BSF450	681.7	1567	4 x 16 dia	1608
BSF700	1103	2536	3 x 25 dia	2940
BSF1100	1587	3648	4 x 25 dia	3920

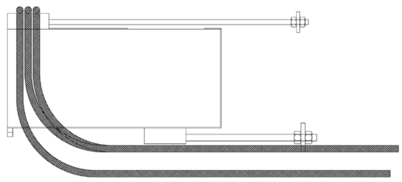


Table 4: Reinforcement for R_{VO}.

Reinforcement to carry force R_{VU} is as below.

Type	R_{VU} (kN)	A_s reqd (mm^2)	Bars	A_s prov (mm^2)
BSF225	115.2	265	2 x 10 dia	312
BSF300	175.3	403	2 x 12 dia	452
BSF450	231.7	533	2 x 16 dia	804
BSF700	403	926	2 x 16 dia + 1 x 12 dia	1030
BSF1100	487	1120	3 x 16 dia	1206

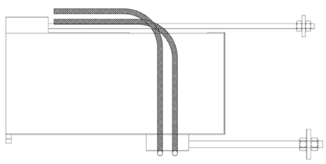


Table 5: Reinforcement for R_{VU}.

Memo 521 gives guidance for calculating the required bending radii. Typical bending radii for saddle bars will be as below. Values shown ' * ' are to suit the half round bearing blocks and cannot be reduced.

Type	Bar dia (mm)	Top radius (mm) *	Bottom radius (mm)
BSF225	16	38	125
BSF300	16	38	175
BSF450	16	38	225
BSF700	25	87,5	225
BSF1100	25	87,5	250

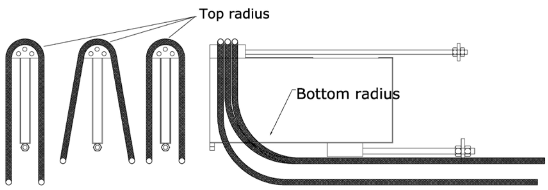


Table 6: Front saddle bars – typical bending radii.

Type	Bar dia (mm)	Bottom radius (mm) *	Top radius (mm)
BSF225	10	38	50
BSF300	12	38	80
BSF450	16	38	75
BSF700	16 & 12	38	100
BSF1100	16	50	100

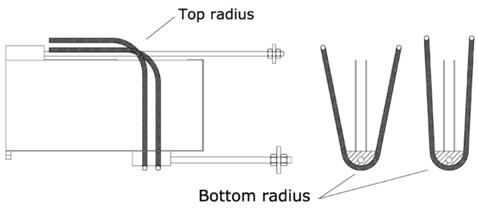


Table 7: Rear saddle bars – typical bending radii.

HORIZONTAL FORCES

Significant horizontal forces may be developed due to shrinkage and thermal effects, especially if the column is stiff. Once these forces exceed frictional resistance, the knife will slide, thus relieving the stresses. Typical steel/steel coefficients of friction range between 0.2 and 0.5. The design assumes a global value for μ of 0.3. Thus the connection is designed to resist a longitudinal tension of 0.3 x F_V. Due to the geometry of the knife, it will be seen from Table 3 that R_{VU} is approximately half of F_V (does not apply to the BSF1100). Assuming the minimum value of μ = 0.2 at the back of the knife, then a horizontal force of 0.1 F_V can be taken at this contact point, and the remaining 0.2 Fv must be taken at the front. A different distribution of horizontal forces is given for the BSF1100 due to the slightly different geometry of the knife.

Threaded bars to carry force R_{HO} and R_{HU} are as below. Bars are grade 8.8 steel.

Type	R_{HO} (kN)	Bars	$Capacity_{prov}$ (kN)	R_{HU} (kN)	Bars	$Capacity_{prov}$ (kN)
BSF225	45	2 x M12	96	22.5	1 x M16	90
BSF300	60	2 x M12	96	30	1 x M16	90
BSF450	90	2 x M12	96	45	1 x M16	90
BSF700	140	2 x M16	180	70	1 x M20	141
BSF1100	330	2 x M24	406	165	1 x M24	203

Table 8: Bars for R_{HO} and R_{HU}.

COLUMN BOX

These same longitudinal forces are transferred into the column box by friction. The forces are then resisted by a pair of threaded horizontal bars. Bars are grade 8.8 steel. The horizontal force must be included in the design of the column. More information on this issue is found in Memo 521.

Type	Force (kN)	Bars	$Capacity_{prov}$ (kN)
BSF225 - Column box	67.5	2 x M12	96
BSF300 - Column box	90	2 x M12	96
BSF450 - Column box	135	2 x M16	180
BSF700 - Column box	210	2 x M20	282
BSF1100 – Column box	330	2 x M24	406

Table 9: Threaded bars in column box.

Vertical forces in the column are taken by a combination of a vertical welded-on bar, and by direct bearing under the base of the column box. This determines both the diameter and length of bar, as well as the size of the base. Calculations and design method are given in Memo 521.

Type	Bar dia / length (mm)	Base plate Depth x Width x Thickness (mm)
BSF225 - Column box	20 x 600	110 x 100 x 20
BSF300 - Column box	20 x 600	110 x 150 x 25
BSF450 - Column box	25 x 600	125 x 180 x 30
BSF700 - Column box	25 x 790 x 2	150 x 200 x 40
BSF1100 - Column box	32 x 690 x 2	200 x 250 x 60

Table 10: Sizing of column box base.

BB BOXES

These are a variation of the column box for use where the vertical welded-on bar cannot be used because of a lack of concrete depth below the box. They are used in beam – beam situations, either onto the end, or onto the side of a supporting beam. They may also be used in other situations where there is no concrete depth below the box. Memo 525 and Memo 526 gives some examples on use and calculations.

The base plate and vertical bar is substituted by a half-round pressure block and stirrup bars that pass under the box. Following the same principals as used in the beam unit, these stirrup bars will take the vertical load. The size and number of bars are given in Table 11. Due to the possible variations in concrete profile however, the geometry of these bars is highly variable and is a matter for practical consideration depending on how the flow of forces is intended to be. The BB-boxes also have a threaded bar, with plate washer on the rear face to take horizontal loads. The required length of the threaded bar will depend on the concrete cover and reinforcement in the anchoring zone.

Type	Stirrup bars	Threaded bars	Plate washer
BSF225 - BB box	2 x 16 Ø	2 x M12 x 650	50 x 50 x 8
BSF300 - BB box	2 x 16 Ø	2 x M12 x 650	50 x 50 x 8
BSF450 - BB box	3 x 16 Ø	1 x M20 x 750	90 x 90 x 12
BSF700 - BB box	2 x 25 Ø	2 x M20 x 750	160 x 90 x 12
BSF1100 - BB box	3 x 25 Ø	2 x M24 x 1000	110 x 110 x 15

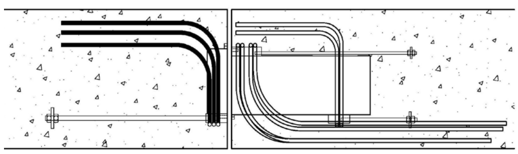


Table 11: Bars for BB boxes.

REFERENCE LEVELS IN DESIGN

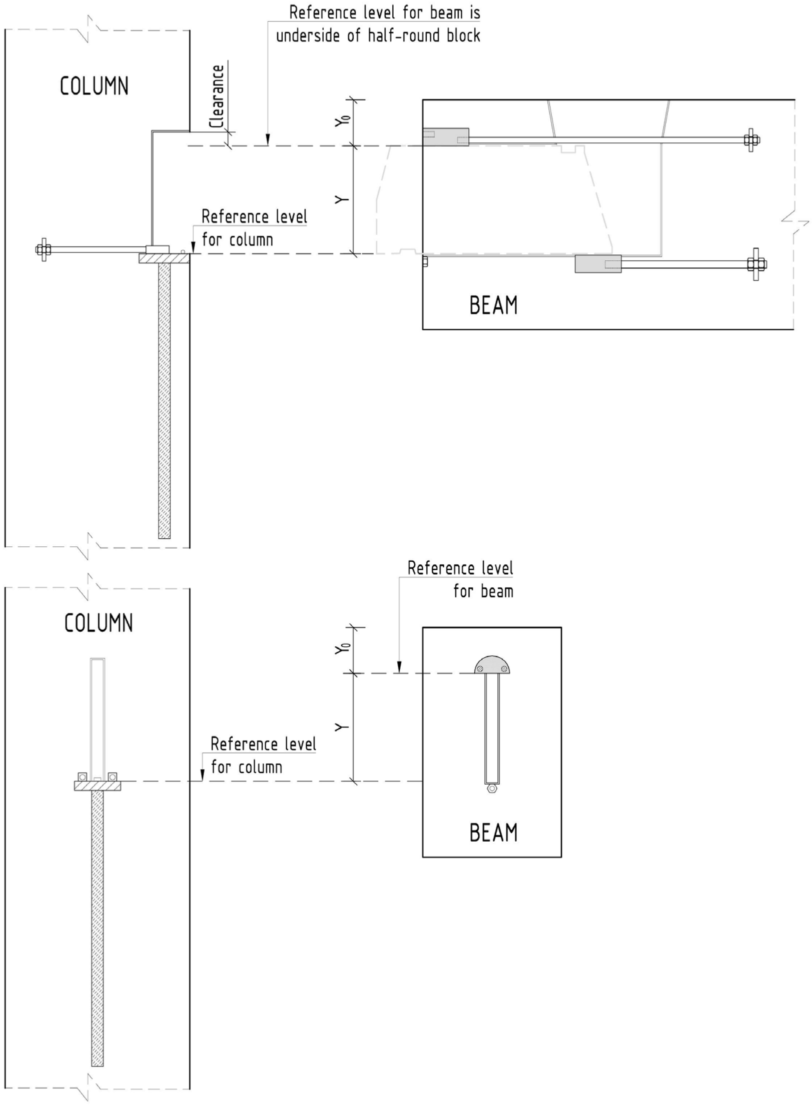


Figure 2: Illustration - reference levels

The reference levels indicated on the figures above are positioning points for the units. These are the points that must be specified on the production drawings of the components, in order to secure the correct placing of the units in the moulds. The differences in elevation between the two levels correspond to the height of the knife and are as listed in Table 12.

Type	Y (mm)	Y_0 (mm)	$Y + Y_0$ (mm)
BSF225	195	100	295
BSF300	235	100	335
BSF450	250	100	350
BSF700	280	125	405
BSF1100	360	125	485

Table 12: Distance between reference levels in column and beam.

REVISION HISTORY	
Date:	**Description:**
11.09.2014	First Edition
23.01.2015	Included reference levels
27.02.2015	Included a nut on the front side of the steel plate anchoring the threaded bars. (To ensure correct position of the plate when casting the concrete).
08.01.2016	Included note on reinforcement quality.
24.05.2016	New template.
16.11.2018	Included BSF1100
14.02.2020	Updated column unit. Included BSF1100 beam box.