CALCULATION SHEFT	Document Ref:	SX034a-EN-EU	Sheet	<i>1</i> of	8	
	Title	Example: Bolted conne a gusset plate	ection of	an angle l	brace in te	ension to
steel	Eurocode Ref					
🖈 Eurocodes made easy 🌟	Made by	Edurne Nuñez		Date	April 2	2006
	Checked by	Jose A Chica		Date	April 2	2006
<b>Example: Bolted</b> <b>tension to a gus</b> <i>This worked example sho</i> <i>an angle brace in tension</i> <i>preloaded bolts are used</i>	<b>Connect</b> <b>Set plate</b> we sthe proceed to a gusset proceed (Category A:	ion of an ang lure to check the bolt late welded to a colur bearing type).	l <b>e bra</b> Ted cont nn web	ace in nection o . Non	<i>of</i>	
These types of connection and in roofs to withstand longitudinal axis of the sin In order to avoid eccentric angle axis is aligned to me and the gusset plate is pla plane.	as are typical f the actions of ngle storey bu cities of the lo eet the column ced as close as	For cross bracings used the horizontal wind lo ilding. This is illustra ads brought to the fou a vertical axis plane at s possible to the colur	d both in bad in th ted in S undation t the bas nn majo	n facades ne S048 n, the se plate or axis	s <u>SS04</u>	<u>8</u>
Table 1.1         Modes of           Mode of failure	f failure of the	bracing connection	sistanc	<u>ب</u>	-	
Bolts in shear			sistait		-	
Bolts in bearing (on the	angle leg)	NRd,1			-	
Angle in tension		NRd,2			-	
Weld design		a a a a a a a a a a a a a a a a a a a			-	

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access	Title	Example: Bolted con a gusset plate	inection of	an ang	le bra	ice in t	tension
	Eurocode Ref						
<ul> <li>Eurocodes made easy</li> <li>Eurocodes made easy</li> </ul>	Made by	Edurne Nuñez		Date		April	2006
	Checked by	Jose A Chica		Date		April	2006
<b>Bracing Connection – I</b> The Figure 1.1 shows the gusset plate.	Details e long leg of th	L120x80 angle that	is attache	ed to t	he		
HEB300, S275				tp=15mm	300		
<i>Figure 1.1 Detail of the</i> Common practice is to n	e <i>bolted connect</i> ninimize the ec	<i>tion: plan and section</i> ccentricity between t	<i>view</i> he bracing	g men	nber		
<i>Figure 1.1 Detail of the</i> Common practice is to n and the column axis. The base plate using double t eccentricity in order to a better than having the br	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho racing plane on	tion: plan and section ecentricity between t is welded to the column is Figure 1.1). Althou r bolt on the column the column flange a	wiew he bracing mn web a ugh there a axis, this axis.	g men nd to is son s is mu	nber the ne uch		
Figure 1.1 Detail of the Common practice is to n and the column axis. The base plate using double is eccentricity in order to a better than having the br Main joint data	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho racing plane on	tion: plan and section ecentricity between t is welded to the column is Figure 1.1). Althou r bolt on the column the column flange a	<i>view</i> he bracing mn web a ugh there a axis, this axis.	g men nd to is son s is mu	nber the ne ich		
<i>Figure 1.1 Detail of the</i> Common practice is to n and the column axis. The base plate using double is eccentricity in order to a better than having the br <u>Main joint data</u> Configuration	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho racing plane on Angle to	<i>tion: plan and section</i> ccentricity between t s welded to the colum e Figure 1.1). Althou r bolt on the column the column flange a	he bracing mn web a ugh there a axis, this axis.	g men nd to is son s is mu mn w	nber the ne uch eb		
<i>Figure 1.1 Detail of the</i> Common practice is to n and the column axis. The base plate using double i eccentricity in order to a better than having the br <u>Main joint data</u> Configuration Column	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho racing plane on Angle to HEB 300	<i>tion: plan and section</i> ecentricity between t is welded to the colum e Figure 1.1). Althou r bolt on the column the column flange a o gusset plate welded 0, S275	he bracing mn web a ugh there a axis, this axis.	g men nd to is son s is mu mn w	nber the ne nch eb		
<i>Figure 1.1 Detail of the</i> Common practice is to n and the column axis. The base plate using double is eccentricity in order to a better than having the br <u>Main joint data</u> Configuration Column Bracing	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho racing plane on Angle to HEB 300 120 × 80	<i>tion: plan and section</i> ccentricity between t s welded to the colum e Figure 1.1). Althou r bolt on the column the column flange a o gusset plate welded 0, S275 $0 \times 12$ angle, S275	he bracing mn web a ugh there n axis, this axis.	g men nd to is son s is mu mn w	nber the ne uch eb		
<i>Figure 1.1 Detail of the</i> Common practice is to n and the column axis. The base plate using double is eccentricity in order to a better than having the br <u>Main joint data</u> Configuration Column Bracing Type of connection	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho acing plane on Angle to HEB 300 120 × 80 Bracing plate and	<i>tion: plan and section</i> ccentricity between the swelded to the column e Figure 1.1). Althout r bolt on the column the column flange at 0 gusset plate welded 0, S275 $0 \times 12$ angle, S275 connection using an d non-preloaded bolt	the bracing mn web a ugh there a axis, this axis. to a colu	g men nd to is son is mu mn w usset	nber the ne uch eb		
Figure 1.1 Detail of the Common practice is to n and the column axis. The base plate using double is eccentricity in order to a better than having the br Main joint data Configuration Column Bracing Type of connection	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho acing plane on Angle to HEB 300 120 × 80 Bracing plate and Category	<i>tion: plan and section</i> be centricity between t is welded to the column is Figure 1.1). Althout r bolt on the column the column flange a o gusset plate welded 0, S275 $0 \times 12$ angle, S275 connection using an d non-preloaded bolt y A: Bearing type	e <i>view</i> he bracing mn web a ugh there a axis, this axis. I to a colu ugle to a g ts	g men nd to is son is mu mn w usset	nber the ne nch eb		
Figure 1.1 Detail of the Common practice is to m and the column axis. The base plate using double is eccentricity in order to a better than having the br Main joint data Configuration Column Bracing Type of connection Gusset plate	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho racing plane on Angle to HEB 300 $120 \times 80$ Bracing plate and Category $250 \times 30$	<i>tion: plan and section</i> ccentricity between t is welded to the colum e Figure 1.1). Althou r bolt on the column the column flange a o gusset plate welded 0, S275 $0 \times 12$ angle, S275 connection using an l non-preloaded bolt y A: Bearing type $00 \times 15$ , S275	e <i>view</i> he bracing mn web a ugh there a axis, this axis. I to a colu ugle to a gr ts	g men nd to is son is is mu mn w	nber the ne nch eb		
Figure 1.1 Detail of the Common practice is to r and the column axis. The base plate using double is eccentricity in order to a better than having the br Main joint data Configuration Column Bracing Type of connection Gusset plate Bolts	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho racing plane on Angle to HEB 300 $120 \times 80$ Bracing plate and Category $250 \times 30$ M20, gra	<i>tion: plan and section</i> ccentricity between t is welded to the column e Figure 1.1). Althou r bolt on the column the column flange a o gusset plate welded 0, S275 $0 \times 12$ angle, S275 connection using an d non-preloaded bolt y A: Bearing type $00 \times 15$ , S275 ade 8.8	e <i>view</i> he bracing mn web a ugh there a axis, this axis. I to a colu	g men nd to is son s is mu mn w	nber the ne nch eb		
<i>Figure 1.1 Detail of the</i> Common practice is to mand the column axis. The base plate using double is eccentricity in order to a better than having the br <u>Main joint data</u> Configuration Column Bracing Type of connection Gusset plate Bolts Welds	e bolted connect ninimize the ec e gusset plate is fillet welds (see void the ancho acing plane on Angle to HEB 300 $120 \times 80$ Bracing plate and Category $250 \times 30$ M20, gra Gusset a = 4 mr	<i>tion: plan and section</i> be centricity between t is welded to the column is Figure 1.1). Althou r bolt on the column the column flange a o gusset plate welded 0, S275 $0 \times 12$ angle, S275 connection using an d non-preloaded bolt y A: Bearing type $00 \times 15$ , S275 adde 8.8 plate to column n (see section 4).	web: fil	g men nd to is son is mu mn w usset	nber the uch eb		

CALCULATION SHEET	Document Ref:	SX034a-EN-EU	Sheet 3 of	8		
	Title	Example: Bolted conne a gusset plate	ction of an angle i	brace in tension to		
	Eurocode Ref					
<ul> <li>Eurocodes made easy</li> <li>K</li> </ul>	Made by	Edurne Nuñez	Date	April 2006		
	Checked by	Jose A Chica	Date	April 2006		
Column HEB 300, S275						
Depth	$h_{\rm c} = 30$	0 mm				
Width	$b_{\rm c} = 30$	0 mm				
Thickness of the web	$t_{\rm w,c} = 11$	mm				
Thickness of the flange	$t_{\rm f,c} = 19$	mm				
Fillet radius	<i>r</i> = 27	mm				
Area	$A_{\rm c} = 14$	9,1 cm <sup>2</sup>				
Second moment of area	$I_{\rm y} = 25$	$170 \text{ cm}^4$				
Depth between fillets	$d_{\rm c} = 20$	8 mm				
Yield strength	$f_{\rm y,c} = 27$	5 N/mm <sup>2</sup>				
Ultimate tensile strength	$f_{\rm u,c} = 43$	0 N/mm <sup>2</sup>				
Angle 120 × 80 × 12, S27	75					
Depth		$h_{\rm ac}$ = 120 m	m			
Width		$b_{\rm ac} = 80  \rm mm$	1			
Thickness of the angle		$t_{\rm ac} = 12  \rm mm$	1			
Fillet radius		$r_1 = 11 \text{ mm}$	1			
Fillet radius		$r_2 = 5,5 \text{ mm}$	n			
Area		$A_{\rm ac}$ = 22,7 c	$m^2$			
Second moment of area		$I_{\rm y} = 322,8$	$cm^4$			
Yield strength		$f_{\rm y,ac}$ = 275 N.	$/\mathrm{mm}^2$			
Ultimate tensile strength		$f_{\rm u,ac}$ = 430 N.	/mm <sup>2</sup>			

CALCULATION SHEET	Document Ref:	SX034a-EN	-EU	Sheet	<b>4</b> of	8	
	Title	Example: B a gusset pla	olted connec te	ction of an	angle br	ace in t	ension to
	Eurocode Ref						
Eurocodes made easy	Made by	Edurne Nuñez			ite	April 2	2006
	Checked by	Jose A Chic	za –	Da	ite	April 2	2006
Gusset plate 250 × 300 >	< 15, S275						
Depth		$h_{ m p}$	= 300 mi	m			
Width		$b_{ m p}$	= 250 mi	m			
Thickness		t <sub>p</sub>	= 15 mm	1			
Yield strength		$f_{ m y,p}$	= 275 N/	mm <sup>2</sup>			
Ultimate tensile strength		$f_{\mathrm{u,p}}$	= 430 N/	/mm <sup>2</sup>			
Direction of load transfer	r (1)						
Number of bolt rows		$n_1$	= 3				
Angle edge to first bolt ro	DW	$e_1$	= 50 mm	1			
Pitch between bolt rows		$p_1$	= 80 mm	1			
Direction perpendicular	to load transfe	r (2)					
Number of lines of bolts		$n_2$	= 1				
Angle attached leg edge t	o bolt line	$e_2$	= 80 mm	1			
Bolts M20, 8.8							
Total number of bolts ( <i>n</i>	$= n_1 \times n_2$ )	n	= 3				
Tensile stress area		$A_{\rm s}$	= 245 mi	$m^2$			
Diameter of the shank		d	= 20 mm	1			
Diameter of the holes		$d_{ m o}$	= 22 mm	1			
Diameter of the washer		$d_{ m w}$	=37 mm				
Yield strength		$f_{ m yb}$	= 640 N/	mm <sup>2</sup>			
Ultimate tensile strength		$f_{ m ub}$	= 800 N/	/mm <sup>2</sup>			
Partial safety factors							
$\gamma_{M0} = 1,0$							
$\gamma_{M2} = 1,25$ (for shear	resistance of	bolts)					
Design axial tensile forc	e applied by t	he angle bi	ace to the	gusset pl	late.		
$N_{\rm Ed} = 250  \rm kN$							

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	Title	Example: Bolted connect a gusset plate	ion of an angle brace in tension to					
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Eurocodes made easy	Made by	Edurne Nuñez		Date		April 2	2006	
	Checked by	Jose A Chica		Date		April 2	2006	

## 1 Bolts in shear

 $N_{\mathrm{Rd},1} = nF_{\mathrm{v,Rd}}$ 

$$F_{\rm v,Rd} = \alpha_{\rm v} \frac{f_{\rm ub}A}{\gamma_{\rm M,2}} = 0.6 \times \frac{800 \times 245}{1.25} \times 10^{-3} = 94.08 \,\rm kN$$

$$N_{\rm Rd,1} = 3 \times 94,08 = 282 \text{ kN}$$

## 2 Bolts in bearing (on the angle leg)

Note: The angle leg thickness, 12mm, being less than that of the gusset plate, 15mm, and assuming an end distance of 50 mm or greater for the gusset plate, only the attached angle leg requires a design check for bearing.

$$N_{\rm Rd,2} = nF_{\rm b,Rd}$$
$$F_{\rm c} = t - \frac{k_1 \alpha_{\rm b} f_{\rm u,ac} dt_{\rm ac}}{k_1 \alpha_{\rm b} f_{\rm u,ac} dt_{\rm ac}}$$

$$F_{\rm b,Rd} = \frac{\gamma_{\rm 100B} \gamma_{\rm u,acc}}{\gamma_{\rm M2}}$$

All bolts

$$k_{1} = \min\left(2,8 \times \frac{e_{2}}{d_{0}} - 1,7; 2,5\right)$$

$$2,8 \times \frac{e_{2}}{d_{0}} - 1,7 = 2,8 \times \frac{80}{22} - 1,7 = 8,48$$

$$\therefore k_{1} = \min(8,48; 2,5) = 2,5$$
End bolt:
$$\alpha_{b} = \min\left(\frac{e_{1}}{3d_{0}}; \frac{f_{ub}}{f_{u,ac}}; 1,0\right)$$

$$\frac{e_{1}}{3d_{0}} = \frac{50}{3 \times 22} = 0,76$$

$$\frac{f_{ub}}{f_{u,ac}} = \frac{800}{430} = 1,86$$

$$\therefore \alpha_{b} = \min(0,76; 1,86; 1,0) = 0,76$$

$$F_{b,Rd,end bolt} = \frac{2,5 \times 0,76 \times 430 \times 20 \times 12}{1,25} \times 10^{-3} = 156,9 \text{ kN}$$

<u>EN1993-1-8</u> Table 3.4.

EN1993-1-8 Table 3.4.

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	Title	Example: Bolted connection of an angle brace in tensio a gusset plate					
	Eurocode Ref						
Eurocodes made easy	Made by	Edurne Nuñez		Date		April	2006
	Checked by	Jose A Chica		Date		April .	2006
Interior bolts:							
$\alpha_{\rm b} = \min\left(\frac{p_1}{3d_0} - \frac{1}{4}; \frac{f_{\rm ut}}{f_{\rm u,a}}\right)$	$\frac{1}{c}; 1,0$						
$\frac{p_1}{3d_0} - \frac{1}{4} = \frac{80}{3 \times 22} - \frac{1}{4} = 0.9$	96						
$\frac{f_{\rm ub}}{f_{\rm u,ac}} = \frac{800}{430} = 1,86$							
$\therefore \alpha_{\rm b} = \min(0,96; 1,86;$	1,0) = 0,96						
$\therefore F_{\rm b,Rd,interior \ bolt} = \frac{2.5 \times 10^{-10}}{10^{-10}}$	$\frac{0,96 \times 430 \times 20}{1,25}$	$1 \times 12 \times 10^{-3} = 198,1 \mathrm{kN}$					
The bearing strength of the bolt shear strength. The lease connection is adopted for	e end bolt and east value for th all bolts.	of the interior bolt is g ne bearing strength of a	greater a bolt	than in the	the	<u>EN19</u> <u>§3.7(</u>	<u>993-1-8</u> ( <u>1)</u>
$\therefore N_{\rm Rd,2} = 3 \times 156,9 = 4712$	kN						
3 Angle in ten	sion						
$N_{\rm Rd,3} = \frac{\beta_3 A_{\rm net} f_{\rm u}}{\gamma_{\rm M2}}$						<u>EN19</u> §3.10	<u>993-1-8</u> ).3
2,5 $d_0$ = 2,5 × 22 = 55 mm							
$5d_0 = 5 \times 22 = 110 \text{ mm}$							
$2,5d_0 < p_1 < 5d_0$							
$\beta_3$ can be determined by	linear interpol	ation:					
$\therefore \beta_3 = 0,59$		2					
$A_{\rm net} = A - t_{\rm ac} d_0 = 2270 - $	$12 \times 22 = 2006$	mm <sup>2</sup>					
$\therefore N_{\rm Rd,3} = \frac{0.59 \times 2006 \times 43}{1.25}$	$\frac{30}{30} \times 10^{-3} = 407$	kN					

Title       Example: Bolted connection of an angle brace in tensi         a gusset plate       a gusset plate         Eurocode Ref       Eurocode Ref         Made by       Edurne Nuñez       Date         April 2000       Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Checked by       Jose A Chica         Date       April 2000         Date       April 2000         Date       April 2000 <tr< th=""><th>on to</th></tr<>	on to
Eurocode Ref       Made by       Edurne Nuñez       Date       April 2000         Checked by       Jose A Chica       Date       April 2000 <b>4 Weld design</b> The weld is designed as follows:       The gusset plate is welded to the column web and to the base plate using double fillet welds.       The procedure to determine the throat thickness of the double fillet welds is the same for the gusset plate/column web connection and for the gusset	<b>í</b>
Made by       Edurne Nuñez       Date       April 2000         Checked by       Jose A Chica       Date       April 2000 <b>4 Weld design</b> The weld is designed as follows:       The gusset plate is welded to the column web and to the base plate using double fillet welds.       The procedure to determine the throat thickness of the double fillet welds is the same for the gusset plate/column web connection and for the gusset	<u>í</u>
Checked byJose A ChicaDateApril 2000 <b>4 Weld design</b> The weld is designed as follows:The gusset plate is welded to the column web and to the base plate using double fillet welds.The procedure to determine the throat thickness of the double fillet welds is the same for the gusset plate/column web connection and for the gusset	ŝ
<ul> <li><b>4 Weld design</b></li> <li>The weld is designed as follows:</li> <li>The gusset plate is welded to the column web and to the base plate using double fillet welds.</li> <li>The procedure to determine the throat thickness of the double fillet welds is the same for the gusset plate/column web connection and for the gusset</li> </ul>	
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The procedure to determine the throat thickness of the double fillet welds is the same for the gusset plate/column web connection and for the gusset	
plate/base plate connection.	
The following calculations show the design of the weld between the gusset plate and the base plate.	
It is possible to provide full strength double fillet welds following simplified recommendations, see SN017, however that approach is too conservative for this example.	
The recommended procedure to follow is to propose a size of the weld throat and to check whether it complies with the requirement of resistance:	
Here, propose $a = 4 \text{ mm}$	
Design resistance for the double weld, according to the simplified method is: <u>\$4.5.3.3</u>	<u>-1-8</u>
$N_{\rm Rd,w,hor} = 2F_{\rm w,Rd}l$	
$F_{\rm w,Rd} = f_{\rm vw,d}a$	
$f_{\rm vw,d} = \frac{f_{\rm u}/\sqrt{3}}{\beta_{\rm w}\gamma_{\rm M2}} = \frac{430/\sqrt{3}}{0.85 \times 1.25} = 233,66 \mathrm{N/mm^2}$	
$\therefore F_{w,Rd} = 233,66 \times 4 = 934,6 \text{ N/mm}$	
:. $N_{\rm Rd,w,hor} = 2 \times 934, 6 \times 250 \times 10^{-3} = 467 \rm kN$	
It supports the horizontal component of the force acting in the bracing, which is:	
$N_{\rm Ed,hor} = N_{\rm Ed} \sin 40 = 250 \times \sin 40 = 161  \rm kN$	
Therefore the horizontal weld is OK.	
Similar approach applies to the vertical weld (the gusset plate is welded to the column web).	

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_					Document Ref:	SX034a-EN-EU	Sheet	8	of	8	
		CALCU		SHEET	Title	Example: Bolted con a gusset plate	nnection of	an ang	le bra	ce in ten	sion to
a T		S	<u>'ee</u>		Eurocode Ref						
		× Eu	rocodes made ea	sy 📩	Made by	Edurne Nuñez		Date		April 20	06
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٩		5 Su	mma	n <b>ry</b>	norizes the resi	stones values for t	ha aritical	moda	o of		
0		failure. T	The gove	erning va	lue for the join	t (i.e. the minimum	n value) is	show	n in		
> O		Table 5.1 connectio	on	Summar	ry of the resistar	nce values in the bo	lted bracin	g			
σ		Mode of	failure			Component resi	stance				
		Bolts in	shear			NRd 1	282 kN	_			
o v		Bolts in b	pearing on	the angle	lea	NRd 2	471 kN	_			
		Angle in	tension		3	N <sub>Rd 3</sub>	407 kN				
υ		Some mo bearing a of the an	odes of f and in te agle, and	ailure ar nsion is t therefor	e not checked. not checked be e the angle clea	For example, the g cause its thickness at would fail before	gusset plat is greater e the plate	e in than t	hat		
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## **Quality Record**

RESOURCE TITLE	Example: Bolted connection of an angle brace in tension to a gusset plate							
Reference(s)								
ORIGINAL DOCUMENT								
	Name	Company	Date					
Created by	Edurne Nuñez	Labein	Apr 2006					
Technical content checked by	Jose A Chica	Labein	Apr 2006					
Editorial content checked by								
Technical content endorsed by the following STEEL Partners:								
1. UK	G W Owens	SCI	4/9/06					
2. France	A Bureau	CTICM	3/7/06					
3. Sweden	B Uppfeldt	SBI	3/7/06					
4. Germany	C Müller	RWTH	29/6/06					
5. Spain	J Chica	Labein	4/9/06					
Resource approved by Technical Coordinator	G W Owens	SCI	12/9/06					