



**REGIONE SICILIA**  
**COMUNE DI SANT'ALESSIO SICULO**  
**PROVINCIA DI MESSINA**

**OGGETTO:**

**"Lavori di Recupero ristrutturazione e/o costruzione  
nuovo edificio scolastico scuola A. Gussio".**

**PROGETTO ESECUTIVO**

**PROGETTISTA:**

Ing. Faranna Claudio G.

**ELABORATO C**

**TAV. 1.5**

**TABULATO VERIFICA COLLEGAMENTO  
4 TRAVI COLONNA**

**DATA: 16/05/2022**

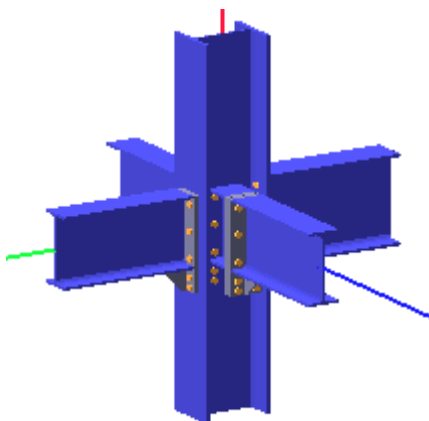
**RUP :**

Ing. Pietro Mifa



N°	Data	Descrizione della Revisione o Sostituisce

## Verifica secondo il D.M. 17/01/2018 del nodo 12



### Colonna

Tipo di profilo: HEB 360

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Classe sezione: 1

### Coefficienti di sicurezza utilizzati

$\gamma_{M0} = 1.05$

$\gamma_{M1} = 1.10$

$\gamma_{M2} = 1.25$

### Trave lato 2+

Tipo di profilo: IPE 360

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Classe sezione: 1

### Flangia:

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Dimensioni (B x H x Sp): 170.0 x 480.0 x 30.0 mm

### Bullonature:

Viti cl. 10.9 Dadi 10 o 12 ( $f_{yb} = 900 \text{ N/mm}^2$ ,  $f_{tb} = 1000 \text{ N/mm}^2$ )

Diametro gambo  $\varnothing = 20 \text{ mm}$   $A_{res} = 314.2 \text{ mm}^2$

Diametro dado/testa  $d_m = 30 \text{ mm}$

Diametro foro  $\varnothing_0 = 21 \text{ mm}$

### Saldature:

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\beta_1 = 0.70$   $\beta_2 = 0.85$

Spessore cordoni d'angolo  $s_c = 12 \text{ mm}$

### Sollecitazioni nella sezione d'attacco dell'elemento:

Nodo.CMB	V2 [N]	V3 [N]	N [N]	M2 [N mm]	M3 [N mm]	T [N mm]
12.1	81838.1	-0.1	10.8	318.0	-62439140.0	4338.0
12.2	81751.1	-0.1	7.9	311.0	-62314800.0	4339.0
12.3	168900.0	-0.2	35.9	678.0	-127398000.0	7305.0
12.4	168800.0	-0.2	33.0	671.0	-127316000.0	7306.0
12.5	57844.5	-0.1	7.7	226.0	-44237990.0	3161.0
12.6	57757.5	0.0	4.8	219.0	-44113650.0	3163.0
12.7	144900.0	-0.1	32.8	586.0	-109218000.0	6128.0
12.8	144800.0	-0.1	29.9	579.0	-109136000.0	6130.0
12.9	81664.1	-0.1	5.1	304.0	-62190460.0	4341.0
12.10	142800.0	-0.1	28.4	570.0	-107896000.0	6414.0
12.11	142600.0	-0.1	22.6	556.0	-107632000.0	6418.0
12.12	57670.5	0.0	1.9	211.0	-43989310.0	3164.0
12.13	118800.0	-0.1	25.3	478.0	-89716000.0	5238.0

12.14	118600.0	-0.1	19.5	463.0	-89452000.0	5241.0
12.15	132600.0	-3999.1	-4103.8	5166000.0	-164232000.0	1803.0
12.16	129200.0	-1530.3	-3882.9	915123.1	-157744000.0	25949.0
12.17	27038.9	1530.2	3909.1	-914505.9	38987000.0	-18241.0
12.18	23696.5	3999.0	4129.9	-5166000.0	45435370.0	5904.0
12.19	131500.0	-4737.9	-4036.8	5764000.0	-162030000.0	1056.0
12.20	130400.0	-791.6	-3949.9	317272.0	-159928000.0	26695.0
12.21	25917.6	791.4	3976.1	-316655.0	41145170.0	-18988.0
12.22	24817.8	4737.7	4062.9	-5764000.0	43277200.0	6651.0
12.23	148700.0	-2069.1	-5581.9	3061000.0	-195234000.0	-4902.0
12.24	145300.0	399.8	-5361.1	-1190000.0	-188746000.0	19243.0
12.25	10940.5	-399.9	5387.3	1191000.0	69989290.0	-11535.0
12.26	7598.1	2068.9	5608.1	-3061000.0	76437660.0	12610.0
12.27	147600.0	-2807.8	-5514.9	3659000.0	-193032000.0	-5649.0
12.28	146500.0	1138.5	-5428.1	-1788000.0	-190930000.0	19990.0
12.29	9819.2	-1138.6	5454.3	1788000.0	72147460.0	-12282.0
12.30	8719.4	2807.6	5541.1	-3659000.0	74269500.0	13357.0
12.31	99543.6	-4944.2	-1556.9	7998000.0	-100582200.0	-33382.0
12.32	88402.3	3285.2	-820.8	-6173000.0	-79107580.0	47103.0
12.33	67879.6	-3285.4	847.0	6174000.0	-39651670.0	-39395.0
12.34	56738.4	4944.0	1583.0	-7997000.0	-18147090.0	41089.0
12.35	104400.0	-4365.1	-2000.3	7367000.0	-109908000.0	-35394.0
12.36	93231.8	3864.3	-1264.3	-6805000.0	-88418270.0	45091.0
12.37	63050.1	-3864.4	1290.4	6805000.0	-30350980.0	-37383.0
12.38	51908.8	4365.0	2026.5	-7366000.0	-8856416.0	43101.0
12.39	95806.0	-7406.6	-1333.6	9991000.0	-93354920.0	-35871.0
12.40	92140.0	5747.6	-1044.1	-8166000.0	-86314800.0	49592.0
12.41	64142.0	-5747.8	1070.3	8167000.0	-32444440.0	-41885.0
12.42	60476.0	7406.4	1359.7	-9990000.0	-25354320.0	43579.0
12.43	100600.0	-6827.5	-1777.0	9359000.0	-102692000.0	-37883.0
12.44	96969.5	6326.7	-1487.6	-8798000.0	-95645490.0	47580.0
12.45	59312.5	-6326.8	1513.7	8798000.0	-23153750.0	-39873.0
12.46	55646.5	6827.4	1803.2	-9359000.0	-16053630.0	45591.0

### Calcolo resistenze

Resistenza a trazione dei bulloni

$$F_{tb,Rd} = 0.9 \cdot f_{tb} \cdot A_{res} / \gamma_{M2} = 226194.7 \text{ N}$$

Resistenza a punzonamento flangia

$$B_{pf,Rd} = 0.6 \cdot \pi \cdot d_m \cdot t_f \cdot f_{tk} / \gamma_{M2} = 692155.7 \text{ N}$$

Resistenza a punzonamento ala passante

$$B_{pa,Rd} = 0.6 \cdot \pi \cdot d_m \cdot t_a \cdot f_{tk} / \gamma_{M2} = 519116.8 \text{ N}$$

Bull.	$F_{f,Rd}$ [N]	$F_{t,Rd}$ [N]
1	70658.7	70658.7
2	213712.7	213712.7
3	207854.8	207854.8
4	179805.2	179805.2
5	207854.8	207854.8
6	70658.7	70658.7
7	213712.7	213712.7
8	207854.8	207854.8
9	179805.2	179805.2
10	207854.8	207854.8

### Legenda

$F_{f,Rd} = M_{res,m} / (B_m \cdot R_m)$  resistenza a flessione flangia

$F_{t,Rd} = \min [ F_{tb,Rd} , B_{pf,Rd} , B_{pa,Rd} , F_{f,Rd} ]$  resistenza a trazione di progetto

Resistenza a taglio dei bulloni

$$F_{vb,Rd} = 0.6 \cdot f_{tb} \cdot A_{res} / \gamma_{M2} = 150796.5 \text{ N}$$

Bull.	$F_{bf,x,Rd}$ [N]	$F_{ba,x,Rd}$ [N]	$F_{v,x,Rd}$ [N]	$F_{bf,y,Rd}$ [N]	$F_{ba,y,Rd}$ [N]	$F_{v,y,Rd}$ [N]
1	167707.6	459000.0	150796.5	172992.1	459000.0	150796.5
2	139419.3	253367.8	139419.3	209031.9	221849.9	150796.5
3	252571.4	459000.0	150796.5	432480.0	459000.0	150796.5
4	252571.4	459000.0	150796.5	432480.0	459000.0	150796.5
5	252571.4	459000.0	150796.5	313719.6	459000.0	150796.5
6	167707.6	459000.0	150796.5	172992.1	459000.0	150796.5

7	139419.3	253367.8	139419.3	209031.9	221849.9	150796.5
8	252571.4	459000.0	150796.5	432480.0	459000.0	150796.5
9	252571.4	459000.0	150796.5	432480.0	459000.0	150796.5
10	252571.4	459000.0	150796.5	313719.6	459000.0	150796.5

#### Legenda

$F_{bf,x,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_f / \gamma_{M2}$  resistenza a rifollamento flangia in direzione x

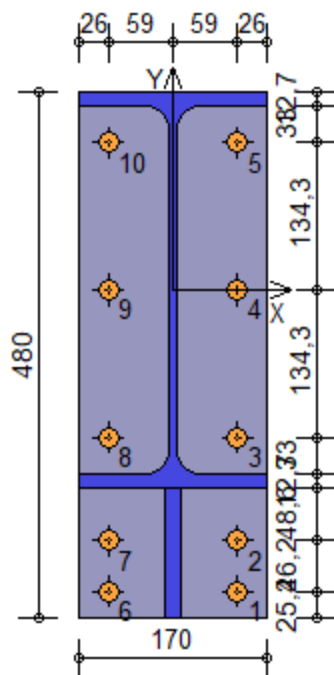
$F_{ba,x,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_a / \gamma_{M2}$  resistenza a rifollamento ala passante in direzione x

$F_{v,x,Rd} = \min [ F_{vb,Rd} , F_{bf,x,Rd} , F_{ba,x,Rd} ]$  resistenza a taglio di progetto in direzione x

$F_{bf,y,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_f / \gamma_{M2}$  resistenza a rifollamento flangia in direzione y

$F_{ba,y,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_a / \gamma_{M2}$  resistenza a rifollamento ala passante in direzione y

$F_{v,y,Rd} = \min [ F_{vb,Rd} , F_{bf,y,Rd} , F_{ba,y,Rd} ]$  resistenza a taglio di progetto in direzione y



#### Verifiche sui bulloni

##### 1-Taglio e trazione (Nodo n. 12, CMB n. 23)

Bull.	X [mm]	Y [mm]	$F_{v,Ed}$ [N]	$F_{v,Rd}$ [N]	$F_{t,Ed}$ [N]	$F_{t,Rd}$ [N]	$FV_1$	VER
1	59.00	-274.80	14872.6	150796.5	0.0	70658.7	0.098627	Ok
2	59.00	-228.60	14872.6	150796.5	677.9	213712.7	0.100893	Ok
3	59.00	-134.30	14872.6	150796.5	41607.4	207854.8	0.241609	Ok
4	59.00	0.00	14872.5	150796.5	99898.2	179805.2	0.495478	Ok
5	59.00	134.30	14872.5	150796.5	158189.1	207854.8	0.642238	Ok
6	-59.00	-274.80	14870.4	150796.5	0.0	70658.7	0.098612	Ok
7	-59.00	-228.60	14870.4	150796.5	0.0	213712.7	0.098612	Ok
8	-59.00	-134.30	14870.3	150796.5	38195.5	207854.8	0.229869	Ok
9	-59.00	0.00	14870.3	150796.5	96486.4	179805.2	0.481909	Ok
10	-59.00	134.30	14870.3	150796.5	154777.2	207854.8	0.630498	Ok

##### 2-Trazione (Nodo n. 12, CMB n. 23)

Bull.	X [mm]	Y [mm]	$F_{t,Ed}$ [N]	$F_{t,Rd}$ [N]	$FV_2$	VER
1	59.00	-274.80	0.0	70658.7	0.000000	Ok
2	59.00	-228.60	677.9	213712.7	0.003172	Ok
3	59.00	-134.30	41607.4	207854.8	0.200175	Ok
4	59.00	0.00	99898.2	179805.2	0.555592	Ok
5	59.00	134.30	158189.1	207854.8	0.761056	Ok
6	-59.00	-274.80	0.0	70658.7	0.000000	Ok
7	-59.00	-228.60	0.0	213712.7	0.000000	Ok
8	-59.00	-134.30	38195.5	207854.8	0.183760	Ok
9	-59.00	0.00	96486.4	179805.2	0.536616	Ok
10	-59.00	134.30	154777.2	207854.8	0.744641	Ok

#### Legenda

$F_{v,Ed}$  forza di taglio agente sul bullone  
 $F_{v,Rd}$  resistenza a taglio di progetto del bullone  
 $F_{t,Ed}$  forza di trazione agente sul bullone  
 $F_{t,Rd}$  resistenza a trazione di progetto del bullone  
 $FV_1 = F_{v,Ed} / F_{v,Rd} + F_{t,Ed} / (1.4 \cdot F_{t,Rd})$   
 $FV_2 = F_{t,Ed} / F_{t,Rd}$   
 $VER \rightarrow FV_i \leq 1$

### Verifiche sulle saldature profilo-flangia (versione beta)

Si considera la sezione di gola (avente altezza  $a = s_c / 2^{0.5} = 8.485$ ) in posizione ribaltata: vengono considerate positive le tensioni normali di trazione e le tensioni tangenziali agenti verso destra e verso il basso. Tutte le tensioni sono espresse in N/mm<sup>2</sup>.

Verifica formula (4.2.84) (Nodo n. 12, CMB n. 23)

Cordoni	$n_{\perp}$	$t_{\perp}$	$\tau_{\parallel}$	$FV_1$	$VER_1$
Nervatura inferiore lato destro	-229.15	0.00	21.55	230.17	Ok
Nervatura inferiore lato sinistro	-229.15	0.00	21.55	230.17	Ok
Ala inferiore esterno	-166.20	0.00	-0.58	166.20	Ok
Ala inferiore interno lato destro	-118.26	0.00	-0.58	118.26	Ok
Ala inferiore interno lato sinistro	-150.05	0.00	-0.58	150.05	Ok
Anima lato destro	-114.31	0.00	21.55	116.32	Ok
Anima lato sinistro	-114.31	0.00	21.55	116.32	Ok
Ala superiore interno lato destro	148.99	0.00	-0.58	148.99	Ok
Ala superiore interno lato sinistro	117.19	0.00	-0.58	117.19	Ok

Verifica formula (4.2.85) (Nodo n. 12, CMB n. 23)

Cordoni	$n_{\perp}$	$t_{\perp}$	$\tau_{\parallel}$	$FV_2$	$VER_2$
Nervatura inferiore lato destro	-229.15	0.00	21.55	229.15	Ok
Nervatura inferiore lato sinistro	-229.15	0.00	21.55	229.15	Ok
Ala inferiore esterno	-166.20	0.00	-0.58	166.20	Ok
Ala inferiore interno lato destro	-118.26	0.00	-0.58	118.26	Ok
Ala inferiore interno lato sinistro	-150.05	0.00	-0.58	150.05	Ok
Anima lato destro	-114.31	0.00	21.55	114.31	Ok
Anima lato sinistro	-114.31	0.00	21.55	114.31	Ok
Ala superiore interno lato destro	148.99	0.00	-0.58	148.99	Ok
Ala superiore interno lato sinistro	117.19	0.00	-0.58	117.19	Ok

### Legenda

$n_{\perp}$  tensione normale perpendicolare all'asse del cordone

$t_{\perp}$  tensione tangenziale perpendicolare all'asse del cordone

$\tau_{\parallel}$  tensione tangenziale parallela all'asse del cordone

$$FV_1 = (n_{\perp}^2 + t_{\perp}^2 + \tau_{\parallel}^2)^{0.5}$$

$$FV_2 = |n_{\perp}| + |t_{\perp}|$$

$$VER_i \rightarrow FV_i \leq \beta_i \cdot f_{yk} \quad (\beta_1 \cdot f_{yk} = 248.50 \text{ N/mm}^2 \quad \beta_2 \cdot f_{yk} = 301.75 \text{ N/mm}^2)$$

### Verifica del momento di progetto del giunto (Nodo n. 12, CMB n. 23)

Momento resistente del giunto	$M_{j,Rd} =$	327907200.0 N mm
Momento di progetto	$M_{j,Ed} =$	193697200.0 N mm
$M_{j,Ed} / M_{j,Rd} = 0.590707 \quad \text{Ok}$		

### Trave lato 2-

Tipo di profilo: IPE 450

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Classe sezione: 1

### Flangia:

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Dimensioni (B x H x Sp): 190.0 x 570.0 x 30.0 mm

### Bullonature:

Viti cl. 10.9 Dadi 10 o 12 ( $f_{yb} = 900 \text{ N/mm}^2$ ,  $f_{tb} = 1000 \text{ N/mm}^2$ )

Diametro gambo  $\varnothing = 20 \text{ mm}$   $A_{res} = 314.2 \text{ mm}^2$

Diametro dado/testa  $d_m = 30$  mm

Diametro foro  $\varnothing_0 = 21$  mm

Saldature:

Materiale: Acciaio S355  $f_y = 355$  N/mm<sup>2</sup>  $f_t = 510$  N/mm<sup>2</sup>  $\beta_1 = 0.70$   $\beta_2 = 0.85$

Spessore cordoni d'angolo  $s_c = 12$  mm

Sollecitazioni nella sezione d'attacco dell'elemento:

Nodo.CMB	V2 [N]	V3 [N]	N [N]	M2 [N mm]	M3 [N mm]	T [N mm]
12.1	137500.0	0.1	163.8	58.0	-154850000.0	799.3
12.2	137500.0	0.1	150.5	67.0	-154650000.0	810.8
12.3	282800.0	0.2	395.9	67.0	-318396000.0	1881.5
12.4	282800.0	0.2	382.7	76.0	-318296000.0	1893.2
12.5	97232.3	0.1	116.2	41.0	-109498200.0	548.0
12.6	97236.5	0.1	103.0	51.0	-109297400.0	559.5
12.7	242500.0	0.2	348.4	51.0	-273050000.0	1630.2
12.8	242500.0	0.2	335.1	60.0	-272950000.0	1640.9
12.9	137600.0	0.1	137.3	76.0	-154432000.0	822.2
12.10	239300.0	0.2	326.3	64.0	-269326000.0	1557.0
12.11	239300.0	0.2	299.8	83.0	-269026000.0	1580.2
12.12	97240.7	0.0	89.7	60.0	-109196700.0	571.2
12.13	198900.0	0.2	278.7	48.0	-223998000.0	1304.8
12.14	198900.0	0.1	252.2	66.0	-223698000.0	1328.0
12.15	102000.0	5281.1	12398.5	-8058000.0	-26850000.0	7526.6
12.16	103800.0	-1586.7	11753.7	2551000.0	-34066000.0	-34648.7
12.17	158500.0	1586.9	-11417.3	-2551000.0	-261170000.0	36252.7
12.18	160200.0	-5280.9	-12062.1	8058000.0	-268464000.0	-5921.4
12.19	103200.0	5460.6	12199.4	-8240000.0	-31624000.0	8569.7
12.20	102600.0	-1766.2	11952.8	2734000.0	-29292000.0	-35691.7
12.21	159600.0	1766.4	-11616.4	-2734000.0	-265972000.0	37295.8
12.22	159100.0	-5460.4	-11863.0	8240000.0	-263662000.0	-6964.5
12.23	93497.9	4253.4	16811.5	-6539000.0	8764622.0	15007.0
12.24	95239.3	-2614.5	16166.7	4070000.0	1533073.0	-27168.2
12.25	167000.0	2614.7	-15830.4	-4069000.0	-296840000.0	28772.4
12.26	168800.0	-4253.2	-16475.2	6539000.0	-304016000.0	-13402.0
12.27	94650.3	4432.8	16612.4	-6722000.0	3987055.0	16050.1
12.28	94086.9	-2794.0	16365.8	4252000.0	6315643.0	-28211.3
12.29	168200.0	2794.2	-16029.5	-4252000.0	-301524000.0	29815.2
12.30	167600.0	-4432.6	-16276.1	6722000.0	-299232000.0	-14445.1
12.31	119800.0	12000.6	4815.2	-18510000.0	-100436000.0	66784.2
12.32	125600.0	-10892.1	2665.9	16860000.0	-124492000.0	-73797.9
12.33	136700.0	10892.3	-2329.6	-16860000.0	-170694000.0	75402.7
12.34	142500.0	-12000.4	-4478.8	18510000.0	-194850000.0	-65180.1
12.35	117200.0	11692.3	6139.1	-18050000.0	-89704000.0	69028.8
12.36	123000.0	-11200.5	3989.8	17310000.0	-113860000.0	-71554.0
12.37	139300.0	11200.7	-3653.5	-17310000.0	-181426000.0	73158.1
12.38	145100.0	-11692.1	-5802.7	18050000.0	-205482000.0	-67424.0
12.39	123600.0	12598.9	4151.5	-19120000.0	-116352000.0	70260.8
12.40	121700.0	-11490.4	3329.5	17460000.0	-108594000.0	-77274.4
12.41	140500.0	11490.6	-2993.2	-17460000.0	-186710000.0	78879.6
12.42	138700.0	-12598.7	-3815.2	19120000.0	-178934000.0	-68656.7
12.43	121000.0	12290.6	5475.5	-18660000.0	-105720000.0	72505.7
12.44	119200.0	-11798.8	4653.5	17920000.0	-97944000.0	-75030.6
12.45	143100.0	11799.0	-4317.1	-17920000.0	-197342000.0	76634.8
12.46	141200.0	-12290.4	-5139.1	18660000.0	-189584000.0	-70900.5

**Calcolo resistenze**

Resistenza a trazione dei bulloni

$$F_{tb,Rd} = 0.9 \cdot f_{tb} \cdot A_{res} / \gamma_{M2} = 226194.7 \text{ N}$$

Resistenza a punzonamento flangia

$$B_{pf,Rd} = 0.6 \cdot \pi \cdot d_m \cdot t_f \cdot f_{tk} / \gamma_{M2} = 692155.7 \text{ N}$$

Resistenza a punzonamento ala passante

$$B_{pa,Rd} = 0.6 \cdot \pi \cdot d_m \cdot t_a \cdot f_{tk} / \gamma_{M2} = 519116.8 \text{ N}$$

Bull.  $F_{f,Rd}$  [N]  $F_{t,Rd}$  [N]

1	64460.5	64460.5
2	207307.2	207307.2
3	211225.1	211225.1
4	177799.3	177799.3
5	211225.1	211225.1
6	64460.5	64460.5
7	207307.2	207307.2
8	211225.1	211225.1
9	177799.3	177799.3
10	211225.1	211225.1

#### Legenda

$F_{f,Rd} = M_{res,m} / (B_m \cdot R_m)$  resistenza a flessione flangia

$F_{t,Rd} = \min [ F_{tb,Rd} , B_{pf,Rd} , B_{pa,Rd} , F_{f,Rd} ]$  resistenza a trazione di progetto

#### Resistenza a taglio dei bulloni

$$F_{vb,Rd} = 0.6 \cdot f_{tb} \cdot A_{res} / \gamma_{M2} =$$

150796.5 N

Bull.	$F_{bf,x,Rd}$ [N]	$F_{ba,x,Rd}$ [N]	$F_{v,x,Rd}$ [N]	$F_{bf,y,Rd}$ [N]	$F_{ba,y,Rd}$ [N]	$F_{v,y,Rd}$ [N]
1	199959.0	459000.0	150796.5	238272.1	459000.0	150796.5
2	166230.7	253367.8	150796.5	287911.8	221849.9	150796.5
3	301142.8	459000.0	150796.5	595680.0	459000.0	150796.5
4	301142.8	459000.0	150796.5	595680.0	459000.0	150796.5
5	301142.8	459000.0	150796.5	450069.4	459000.0	150796.5
6	199959.0	459000.0	150796.5	238272.1	459000.0	150796.5
7	166230.7	253367.8	150796.5	287911.8	221849.9	150796.5
8	301142.8	459000.0	150796.5	595680.0	459000.0	150796.5
9	301142.8	459000.0	150796.5	595680.0	459000.0	150796.5
10	301142.8	459000.0	150796.5	450069.4	459000.0	150796.5

#### Legenda

$F_{bf,x,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \varnothing \cdot t_f / \gamma_{M2}$  resistenza a rifollamento flangia in direzione x

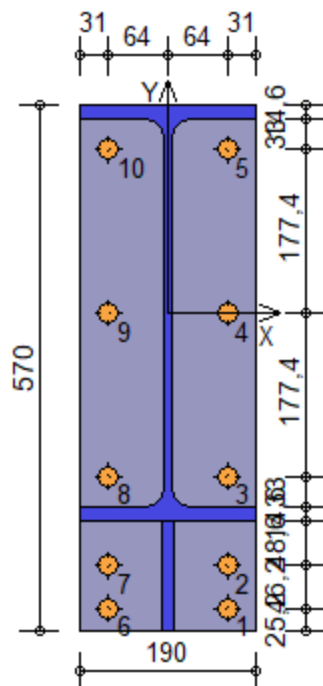
$F_{ba,x,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \varnothing \cdot t_a / \gamma_{M2}$  resistenza a rifollamento ala passante in direzione x

$F_{v,x,Rd} = \min [ F_{vb,Rd} , F_{bf,x,Rd} , F_{ba,x,Rd} ]$  resistenza a taglio di progetto in direzione x

$F_{bf,y,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \varnothing \cdot t_f / \gamma_{M2}$  resistenza a rifollamento flangia in direzione y

$F_{ba,y,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \varnothing \cdot t_a / \gamma_{M2}$  resistenza a rifollamento ala passante in direzione y

$F_{v,y,Rd} = \min [ F_{vb,Rd} , F_{bf,y,Rd} , F_{ba,y,Rd} ]$  resistenza a taglio di progetto in direzione y



#### Verifiche sui bulloni

##### 1-Taglio e trazione (Nodo n. 12, CMB n. 3)

Bull.	X [mm]	Y [mm]	$F_{v,Ed}$ [N]	$F_{v,Rd}$ [N]	$F_{t,Ed}$ [N]	$F_{t,Rd}$ [N]	FV1	VER
1	64.00	-319.80	28279.7	150796.5	0.0	64460.5	0.187536	Ok

2	64.00	-273.60	28279.7	150796.5	0.0	207307.2	0.187536	Ok
3	64.00	-177.40	28279.7	150796.5	45584.0	211225.1	0.341684	Ok
4	64.00	0.00	28279.7	150796.5	133411.7	177799.3	0.723500	Ok
5	64.00	177.40	28279.7	150796.5	221239.5	211225.1	0.935686	Ok
6	-64.00	-319.80	28280.3	150796.5	0.0	64460.5	0.187540	Ok
7	-64.00	-273.60	28280.3	150796.5	0.0	207307.2	0.187540	Ok
8	-64.00	-177.40	28280.3	150796.5	45583.9	211225.1	0.341688	Ok
9	-64.00	0.00	28280.3	150796.5	133411.7	177799.3	0.723504	Ok
10	-64.00	177.40	28280.3	150796.5	221239.5	211225.1	0.935690	Ok

## 2-Trazione (Nodo n. 12, CMB n. 3)

Bull.	X [mm]	Y [mm]	F <sub>t,Ed</sub> [N]	F <sub>t,Rd</sub> [N]	FV <sub>2</sub>	VER
1	64.00	-319.80	0.0	64460.5	0.000000	Ok
2	64.00	-273.60	0.0	207307.2	0.000000	Ok
3	64.00	-177.40	45584.0	211225.1	0.215808	Ok
4	64.00	0.00	133411.7	177799.3	0.750350	Ok
5	64.00	177.40	221239.5	211225.1	0.047411	Ok
6	-64.00	-319.80	0.0	64460.5	0.000000	Ok
7	-64.00	-273.60	0.0	207307.2	0.000000	Ok
8	-64.00	-177.40	45583.9	211225.1	0.215807	Ok
9	-64.00	0.00	133411.7	177799.3	0.750350	Ok
10	-64.00	177.40	221239.5	211225.1	0.047411	Ok

## Legenda

F<sub>v,Ed</sub> forza di taglio agente sul bullone  
 F<sub>v,Rd</sub> resistenza a taglio di progetto del bullone  
 F<sub>t,Ed</sub> forza di trazione agente sul bullone  
 F<sub>t,Rd</sub> resistenza a trazione di progetto del bullone  
 $FV_1 = F_{v,Ed} / F_{v,Rd} + F_{t,Ed} / (1.4 \cdot F_{t,Rd})$   
 $FV_2 = F_{t,Ed} / F_{t,Rd}$   
 VER → FV<sub>i</sub> ≤ 1

## Verifiche sulle saldature profilo-flangia (versione beta)

Si considera la sezione di gola (avente altezza  $a = s_c / 2^{0.5} = 8.485$ ) in posizione ribaltata: vengono considerate positive le tensioni normali di trazione e le tensioni tangenziali agenti verso destra e verso il basso. Tutte le tensioni sono espresse in N/mm<sup>2</sup>.

### Verifica formula (4.2.84) (Nodo n. 12, CMB n. 3)

Cordoni	n <sub>⊥</sub>	t <sub>⊥</sub>	τ <sub>  </sub>	FV <sub>1</sub>	VER <sub>1</sub>
Nervatura inferiore lato destro	-262.40	0.00	34.23	264.62	Ok
Nervatura inferiore lato sinistro	-262.40	0.00	34.23	264.62	Ok
Ala inferiore esterno	-174.35	0.00	0.00	174.35	Ok
Ala inferiore interno lato destro	-156.79	0.00	0.00	156.79	Ok
Ala inferiore interno lato sinistro	-156.79	0.00	0.00	156.79	Ok
Anima lato destro	144.10	0.00	34.23	148.11	Ok
Anima lato sinistro	144.10	0.00	34.23	148.11	Ok
Ala superiore interno lato destro	156.85	0.00	0.00	156.85	Ok
Ala superiore interno lato sinistro	156.85	0.00	0.00	156.85	Ok

### Verifica formula (4.2.85) (Nodo n. 12, CMB n. 3)

Cordoni	n <sub>⊥</sub>	t <sub>⊥</sub>	τ <sub>  </sub>	FV <sub>2</sub>	VER <sub>2</sub>
Nervatura inferiore lato destro	-262.40	0.00	34.23	262.40	Ok
Nervatura inferiore lato sinistro	-262.40	0.00	34.23	262.40	Ok
Ala inferiore esterno	-174.35	0.00	0.00	174.35	Ok
Ala inferiore interno lato destro	-156.79	0.00	0.00	156.79	Ok
Ala inferiore interno lato sinistro	-156.79	0.00	0.00	156.79	Ok
Anima lato destro	144.10	0.00	34.23	144.10	Ok
Anima lato sinistro	144.10	0.00	34.23	144.10	Ok
Ala superiore interno lato destro	156.85	0.00	0.00	156.85	Ok
Ala superiore interno lato sinistro	156.85	0.00	0.00	156.85	Ok

## Legenda

n<sub>⊥</sub> tensione normale perpendicolare all'asse del cordone  
 t<sub>⊥</sub> tensione tangenziale perpendicolare all'asse del cordone  
 τ<sub>||</sub> tensione tangenziale parallela all'asse del cordone  
 $FV_1 = (n_{\perp}^2 + t_{\perp}^2 + \tau_{||}^2)^{0.5}$



$$FV_2 = |n_{\perp}| + |t_{\perp}|$$

$$VER_i \rightarrow FV_i \leq \beta_i \cdot f_{yk} \quad (\beta_1 \cdot f_{yk} = 248.50 \text{ N/mm}^2 \quad \beta_2 \cdot f_{yk} = 301.75 \text{ N/mm}^2)$$

#### Verifica del momento di progetto del giunto (Nodo n. 12, CMB n. 3)

Momento resistente del giunto	$M_{j,Rd} =$	383948900.0 N mm
Momento di progetto	$M_{j,Ed} =$	318522600.0 N mm
$M_{j,Ed} / M_{j,Rd} = 0.829596 \quad \text{Ok}$		

#### Trave lato 3+

Tipo di profilo: IPE 360

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Classe sezione: 1

#### Flangia:

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Dimensioni (B x H x Sp): 170.0 x 480.0 x 30.0 mm

#### Bullonature:

Viti cl. 10.9 Dadi 10 o 12 ( $f_{yb} = 900 \text{ N/mm}^2$ ,  $f_{tb} = 1000 \text{ N/mm}^2$ )

Diametro gambo  $\varnothing = 20 \text{ mm}$   $A_{res} = 314.2 \text{ mm}^2$

Diametro dado/testa  $d_m = 30 \text{ mm}$

Diametro foro  $\varnothing_0 = 21 \text{ mm}$

#### Saldature:

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\beta_1 = 0.70$   $\beta_2 = 0.85$

Spessore cordoni d'angolo  $s_c = 12 \text{ mm}$

#### Sollecitazioni nella sezione d'attacco dell'elemento:

Nodo.CMB	V2 [N]	V3 [N]	N [N]	M2 [N mm]	M3 [N mm]	T [N mm]
12.1	11522.3	-0.1	-3.8	407.0	-5410927.0	-295.0
12.2	11509.9	-0.1	-1.1	401.0	-5367262.0	-298.0
12.3	21990.5	-0.3	-23.0	831.0	-9960288.0	-579.0
12.4	21978.1	-0.3	-20.3	825.0	-9922623.0	-582.0
12.5	8249.6	-0.1	-2.6	290.0	-3907013.0	-209.0
12.6	8237.2	-0.1	0.1	284.0	-3863347.0	-212.0
12.7	18717.8	-0.2	-21.8	714.0	-8456374.0	-493.0
12.8	18705.4	-0.2	-19.1	708.0	-8418709.0	-496.0
12.9	11497.5	-0.1	1.6	395.0	-5324596.0	-301.0
12.10	18850.0	-0.2	-17.2	704.0	-8601488.0	-494.0
12.11	18825.3	-0.2	-11.8	692.0	-8506138.0	-500.0
12.12	8224.8	-0.1	2.8	278.0	-3819681.0	-215.0
12.13	15577.4	-0.2	-16.0	587.0	-7097555.0	-408.0
12.14	15552.6	-0.2	-10.6	575.0	-7006223.0	-414.0
12.15	12484.4	-639.3	-107.0	1988000.0	-10279810.0	-7866.0
12.16	-4975.3	480.7	-81.5	-1494000.0	41713400.0	-6550.0
12.17	26355.6	-480.9	68.3	1495000.0	-51638560.0	5998.0
12.18	8895.8	639.1	93.8	-1987000.0	361634.4	7314.0
12.19	13006.8	-631.2	-106.2	1962000.0	-11841470.0	-7399.0
12.20	-5497.8	472.5	-82.2	-1469000.0	43265040.0	-7017.0
12.21	26878.0	-472.8	69.1	1470000.0	-53190220.0	6465.0
12.22	8373.4	630.9	93.1	-1962000.0	1914703.0	6847.0
12.23	17219.7	-684.0	-98.5	2127000.0	-24218390.0	-3009.0
12.24	-240.1	436.0	-73.0	-1355000.0	27774800.0	-1693.0
12.25	21620.3	-436.3	59.9	1356000.0	-37699980.0	1141.0
12.26	4160.6	683.7	85.3	-2126000.0	14293230.0	2457.0
12.27	17742.1	-675.8	-97.8	2120000.0	-25770050.0	-2543.0
12.28	-762.5	427.9	-73.7	-1330000.0	29336460.0	-2160.0
12.29	22142.8	-428.2	60.6	1331000.0	-39251620.0	1608.0
12.30	3638.2	675.6	84.6	-2101000.0	15844890.0	1990.0
12.31	37709.0	-1890.6	-75.3	5877000.0	-85421280.0	-4549.0

12.32	-20490.1	1842.8	9.5	-5729000.0	87902740.0	-162.0
12.33	41870.4	-1843.1	-22.7	5730000.0	-97817900.0	-390.0
12.34	-16328.8	1890.3	62.1	-5877000.0	75496100.0	3997.0
12.35	39129.6	-1904.0	-72.7	5919000.0	-89603850.0	-3092.0
12.36	-19069.6	1829.4	12.1	-5687000.0	83720150.0	1295.0
12.37	40449.8	-1829.7	-25.2	5688000.0	-93685330.0	-1847.0
12.38	-17749.4	1903.7	59.6	-5918000.0	79678670.0	2540.0
12.39	39450.4	-1863.5	-72.9	5793000.0	-90593460.0	-2993.0
12.40	-22231.5	1815.7	7.1	-5645000.0	93074920.0	-1719.0
12.41	43611.8	-1815.9	-20.3	5646000.0	-102990100.0	1166.0
12.42	-18070.2	1863.2	59.7	-5793000.0	80668290.0	2441.0
12.43	40871.0	-1876.9	-70.4	5835000.0	-94806030.0	-1536.0
12.44	-20811.0	1802.3	9.7	-5603000.0	88902330.0	-262.0
12.45	42191.2	-1802.6	-22.9	5604000.0	-98857500.0	-291.0
12.46	-19490.7	1876.6	57.2	-5834000.0	84850870.0	984.0

### Calcolo resistenze

Resistenza a trazione dei bulloni  $F_{tb,Rd} = 0.9 \cdot f_{tb} \cdot A_{res} / \gamma_{M2} = 226194.7 \text{ N}$

Resistenza a punzonamento flangia  $B_{pf,Rd} = 0.6 \cdot \pi \cdot d_m \cdot t_f \cdot f_{tk} / \gamma_{M2} = 692155.7 \text{ N}$

Bull.	$F_{f,Rd} \text{ [N]}$	$F_{t,Rd} \text{ [N]}$
1	84465.5	84465.5
2	223197.3	223197.3
3	252394.4	226194.7
4	184861.8	184861.8
5	252394.4	226194.7
6	84465.5	84465.5
7	223197.3	223197.3
8	252394.4	226194.7
9	184861.8	184861.8
10	252394.4	226194.7

### Legenda

$F_{f,Rd} = M_{res,m} / (B_m \cdot R_m)$  resistenza a flessione flangia

$F_{t,Rd} = \min [ F_{tb,Rd} , B_{pf,Rd} , F_{f,Rd} ]$  resistenza a trazione di progetto

Resistenza a taglio dei bulloni  $F_{vb,Rd} = 0.6 \cdot f_{tb} \cdot A_{res} / \gamma_{M2} = 150796.5 \text{ N}$

Bull.	$F_{bf,x,Rd} \text{ [N]}$	$F_{v,x,Rd} \text{ [N]}$	$F_{bf,y,Rd} \text{ [N]}$	$F_{v,y,Rd} \text{ [N]}$
1	222535.1	150796.5	244800.1	150796.5
2	184998.7	150796.5	295799.8	150796.5
3	335142.8	150796.5	612000.0	150796.5
4	335142.8	150796.5	612000.0	150796.5
5	335142.8	150796.5	443942.8	150796.5
6	222535.1	150796.5	244800.1	150796.5
7	184998.7	150796.5	295799.8	150796.5
8	335142.8	150796.5	612000.0	150796.5
9	335142.8	150796.5	612000.0	150796.5
10	335142.8	150796.5	443942.8	150796.5

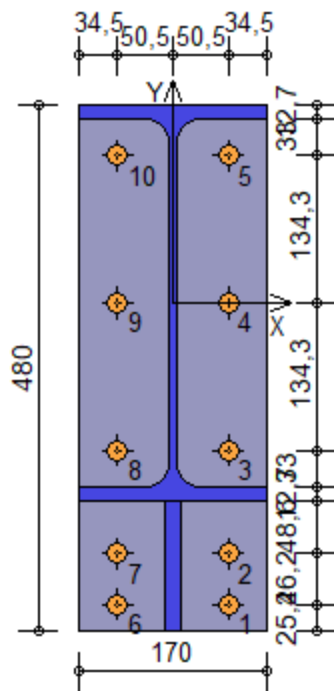
### Legenda

$F_{bf,x,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_f / \gamma_{M2}$  resistenza a rifollamento flangia in direzione x

$F_{v,x,Rd} = \min [ F_{vb,Rd} , F_{bf,x,Rd} ]$  resistenza a taglio di progetto in direzione x

$F_{bf,y,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_f / \gamma_{M2}$  resistenza a rifollamento flangia in direzione y

$F_{v,y,Rd} = \min [ F_{vb,Rd} , F_{bf,y,Rd} ]$  resistenza a taglio di progetto in direzione y



### Verifiche sui bulloni

#### 1-Taglio e trazione (Nodo n. 12, CMB n. 40)

Bull.	X [mm]	Y [mm]	$F_{v,Ed}$ [N]	$F_{v,Rd}$ [N]	$F_{t,Ed}$ [N]	$F_{t,Rd}$ [N]	$FV_1$	VER
1	50.50	-274.80	2230.1	150796.5	45808.4	84465.5	0.402169	Ok
2	50.50	-228.60	2230.1	150796.5	39781.2	223197.3	0.142099	Ok
3	50.50	-134.30	2230.2	150796.5	27479.0	226194.7	0.101564	Ok
4	50.50	0.00	2230.3	150796.5	9958.4	184861.8	0.053268	Ok
5	50.50	134.30	2230.3	150796.5	0.0	226194.7	0.014790	Ok
6	-50.50	-274.80	2230.8	150796.5	50256.2	84465.5	0.439787	Ok
7	-50.50	-228.60	2230.8	150796.5	44229.1	223197.3	0.156337	Ok
8	-50.50	-134.30	2230.9	150796.5	31926.8	226194.7	0.115614	Ok
9	-50.50	0.00	2231.0	150796.5	14406.3	184861.8	0.070459	Ok
10	-50.50	134.30	2231.0	150796.5	0.0	226194.7	0.014795	Ok

#### 2-Trazione (Nodo n. 12, CMB n. 40)

Bull.	X [mm]	Y [mm]	$F_{t,Ed}$ [N]	$F_{t,Rd}$ [N]	$FV_2$	VER
1	50.50	-274.80	45808.4	84465.5	0.542332	Ok
2	50.50	-228.60	39781.2	223197.3	0.178233	Ok
3	50.50	-134.30	27479.0	226194.7	0.121484	Ok
4	50.50	0.00	9958.4	184861.8	0.053870	Ok
5	50.50	134.30	0.0	226194.7	0.000000	Ok
6	-50.50	-274.80	50256.2	84465.5	0.594991	Ok
7	-50.50	-228.60	44229.1	223197.3	0.198161	Ok
8	-50.50	-134.30	31926.8	226194.7	0.141148	Ok
9	-50.50	0.00	14406.3	184861.8	0.077930	Ok
10	-50.50	134.30	0.0	226194.7	0.000000	Ok

#### Legenda

- $F_{v,Ed}$  forza di taglio agente sul bullone
- $F_{v,Rd}$  resistenza a taglio di progetto del bullone
- $F_{t,Ed}$  forza di trazione agente sul bullone
- $F_{t,Rd}$  resistenza a trazione di progetto del bullone
- $FV_1 = F_{v,Ed} / F_{v,Rd} + F_{t,Ed} / (1.4 \cdot F_{t,Rd})$
- $FV_2 = F_{t,Ed} / F_{t,Rd}$
- VER  $\rightarrow FV_i \leq 1$

### Verifiche sulle saldature profilo-flangia (versione beta)

Si considera la sezione di gola (avente altezza  $a = s_c / 2^{0.5} = 8.485$ ) in posizione ribaltata: vengono considerate positive le tensioni normali di trazione e le tensioni tangenziali agenti verso destra e verso il basso. Tutte le tensioni sono espresse in  $N/mm^2$ .

Verifica formula (4.2.84) (Nodo n. 12, CMB n. 41)

Cordoni	$n_{\perp}$	$t_{\perp}$	$\tau_{\parallel}$	FV <sub>1</sub>	VER <sub>1</sub>
Nervatura inferiore lato destro	-120.60	0.00	6.32	120.77	Ok
Nervatura inferiore lato sinistro	-120.60	0.00	6.32	120.77	Ok
Ala inferiore esterno	-120.66	0.00	-0.51	120.66	Ok
Ala inferiore interno lato destro	-53.50	0.00	-0.51	53.50	Ok
Ala inferiore interno lato sinistro	-112.14	0.00	-0.51	112.14	Ok
Anima lato destro	-60.02	0.00	6.32	60.35	Ok
Anima lato sinistro	-60.02	0.00	6.32	60.35	Ok
Ala superiore interno lato destro	112.13	0.00	-0.51	112.14	Ok
Ala superiore interno lato sinistro	53.49	0.00	-0.51	53.49	Ok

Verifica formula (4.2.85) (Nodo n. 12, CMB n. 41)

Cordoni	$n_{\perp}$	$t_{\perp}$	$\tau_{\parallel}$	FV <sub>2</sub>	VER <sub>2</sub>
Nervatura inferiore lato destro	-120.60	0.00	6.32	120.60	Ok
Nervatura inferiore lato sinistro	-120.60	0.00	6.32	120.60	Ok
Ala inferiore esterno	-120.66	0.00	-0.51	120.66	Ok
Ala inferiore interno lato destro	-53.50	0.00	-0.51	53.50	Ok
Ala inferiore interno lato sinistro	-112.14	0.00	-0.51	112.14	Ok
Anima lato destro	-60.02	0.00	6.32	60.02	Ok
Anima lato sinistro	-60.02	0.00	6.32	60.02	Ok
Ala superiore interno lato destro	112.13	0.00	-0.51	112.13	Ok
Ala superiore interno lato sinistro	53.49	0.00	-0.51	53.49	Ok

#### Legenda

$n_{\perp}$  tensione normale perpendicolare all'asse del cordone

$t_{\perp}$  tensione tangenziale perpendicolare all'asse del cordone

$\tau_{\parallel}$  tensione tangenziale parallela all'asse del cordone

$$FV_1 = (n_{\perp}^2 + t_{\perp}^2 + \tau_{\parallel}^2)^{0.5}$$

$$FV_2 = |n_{\perp}| + |t_{\perp}|$$

$$VER_i \rightarrow FV_i \leq \beta_i \cdot f_{yk} \quad (\beta_1 \cdot f_{yk} = 248.50 \text{ N/mm}^2 \quad \beta_2 \cdot f_{yk} = 301.75 \text{ N/mm}^2)$$

#### **Verifica del momento di progetto del giunto** (Nodo n. 12, CMB n. 41)

Momento resistente del giunto	$M_{j,Rd} =$	349805000.0 N mm
Momento di progetto	$M_{j,Ed} =$	102984500.0 N mm
$M_{j,Ed} / M_{j,Rd} = 0.294405 \quad \text{Ok}$		

#### **Trave lato 3-**

Tipo di profilo: IPE 360

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Classe sezione: 1

#### Flangia:

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\gamma_{ov} = 1.25$

Dimensioni (B x H x Sp): 170.0 x 480.0 x 30.0 mm

#### Bullonature:

Viti cl. 10.9 Dadi 10 o 12 ( $f_{yb} = 900 \text{ N/mm}^2$ ,  $f_{tb} = 1000 \text{ N/mm}^2$ )

Diametro gambo  $\varnothing = 20 \text{ mm}$   $A_{res} = 314.2 \text{ mm}^2$

Diametro dado/testa  $d_m = 30 \text{ mm}$

Diametro foro  $\varnothing_0 = 21 \text{ mm}$

#### Saldature:

Materiale: Acciaio S355  $f_y = 355 \text{ N/mm}^2$   $f_t = 510 \text{ N/mm}^2$   $\beta_1 = 0.70$   $\beta_2 = 0.85$

Spessore cordoni d'angolo  $s_c = 12 \text{ mm}$

#### Sollecitazioni nella sezione d'attacco dell'elemento:

Nodo.CMB	V2 [N]	V3 [N]	N [N]	M2 [N mm]	M3 [N mm]	T [N mm]
12.1	16940.9	-0.1	-17.3	494.0	-23234120.0	5236.9
12.2	16942.0	-0.1	-15.3	490.0	-23224110.0	5224.3
12.3	32644.4	-0.3	-45.1	1000.0	-44945970.0	10113.8
12.4	32645.5	-0.3	-43.0	996.0	-44935960.0	10101.2

12.5	12105.1	-0.1	-12.3	352.0	-16594340.0	3744.7
12.6	12106.1	-0.1	-10.2	347.0	-16584340.0	3732.1
12.7	27808.5	-0.2	-40.0	857.0	-38306200.0	8620.6
12.8	27809.6	-0.2	-38.0	853.0	-38296190.0	8609.0
12.9	16943.1	-0.1	-13.3	486.0	-23204110.0	5210.3
12.10	27933.4	-0.2	-36.7	848.0	-38435420.0	8651.2
12.11	27935.5	-0.2	-32.7	840.0	-38405400.0	8624.7
12.12	12107.2	-0.1	-8.2	343.0	-16564330.0	3717.1
12.13	23097.5	-0.2	-31.7	706.0	-31795640.0	7159.1
12.14	23099.7	-0.2	-27.6	697.0	-31765630.0	7131.5
12.15	14714.3	-535.0	-89.4	1815000.0	-17368040.0	-3943.7
12.16	29259.0	402.1	-98.9	-1364000.0	-67637130.0	9856.3
12.17	2279.7	-402.4	62.1	1365000.0	24314250.0	-95.0
12.18	16824.5	534.7	52.5	-1814000.0	-25944840.0	13703.4
12.19	14236.1	-528.2	-88.9	1792000.0	-15771030.0	-3693.5
12.20	29737.2	395.4	-99.4	-1341000.0	-69234140.0	9606.2
12.21	1801.6	-395.6	62.6	1342000.0	25921260.0	153.6
12.22	17302.6	527.9	52.0	-1791000.0	-27551860.0	13454.8
12.23	6609.0	-572.6	-124.2	1942000.0	9265306.0	-1400.2
12.24	21153.7	364.5	-133.8	-1236000.0	-40997790.0	12399.3
12.25	10385.0	-364.7	97.0	1237000.0	-2319095.0	-2639.5
12.26	24929.8	572.4	87.4	-1941000.0	-52584190.0	11160.5
12.27	6130.8	-565.9	-123.7	1919000.0	10868320.0	-1150.6
12.28	21631.9	357.7	-134.3	-1213000.0	-42604800.0	12151.7
12.29	9906.8	-358.0	97.4	1214000.0	-719128.2	-2389.1
12.30	25407.9	565.6	86.9	-1918000.0	-54191200.0	10911.9
12.31	-6606.6	-1581.9	-25.3	5365000.0	55868710.0	-18698.1
12.32	41875.8	1541.8	-56.9	-5229000.0	-111738300.0	27315.4
12.33	-10337.0	-1542.1	20.1	5230000.0	68375390.0	-17544.0
12.34	38145.4	1581.6	-11.5	-5364000.0	-99181580.0	28456.9
12.35	-9038.2	-1593.2	-35.8	5403000.0	63853510.0	-17933.4
12.36	39444.2	1530.5	-67.4	-5191000.0	-103653500.0	28054.8
12.37	-7905.4	-1530.8	30.6	5192000.0	60380590.0	-18306.1
12.38	40577.0	1592.9	-1.0	-5402000.0	-107146400.0	27687.1
12.39	-8200.6	-1559.3	-23.6	5289000.0	61198740.0	-17863.1
12.40	43469.7	1519.3	-58.6	-5153000.0	-117028300.0	26471.3
12.41	-11931.0	-1519.5	21.8	5154000.0	73705430.0	-16709.0
12.42	39739.4	1559.0	-13.2	-5288000.0	-104551600.0	27632.9
12.43	-10632.2	-1570.6	-34.1	5327000.0	69193550.0	-17100.9
12.44	41038.1	1508.0	-69.1	-5115000.0	-109043500.0	27235.9
12.45	-9499.4	-1508.2	32.2	5116000.0	65710630.0	-17471.1
12.46	42170.9	1570.3	-2.7	-5326000.0	-112536400.0	26868.3

### Calcolo resistenze

Resistenza a trazione dei bulloni

$$F_{tb,Rd} = 0.9 \cdot f_{tb} \cdot A_{res} / \gamma_{M2} = 226194.7 \text{ N}$$

Resistenza a punzonamento flangia

$$B_{pf,Rd} = 0.6 \cdot \pi \cdot d_m \cdot t_f \cdot f_{tk} / \gamma_{M2} = 692155.7 \text{ N}$$

Resistenza a punzonamento anima passante

$$B_{pa,Rd} = 0.6 \cdot \pi \cdot d_m \cdot t_a \cdot f_{tk} / \gamma_{M2} = 288398.2 \text{ N}$$

Bull.	$F_{f,Rd}$ [N]	$F_{t,Rd}$ [N]
1	84465.5	84465.5
2	223197.3	223197.3
3	252394.4	226194.7
4	184861.8	184861.8
5	252394.4	226194.7
6	84465.5	84465.5
7	223197.3	223197.3
8	252394.4	226194.7
9	184861.8	184861.8
10	252394.4	226194.7

### Legenda

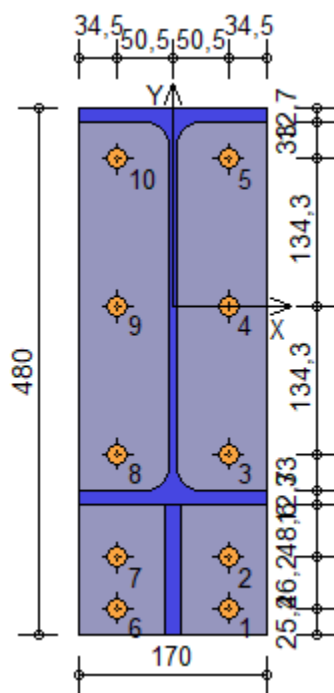
$F_{f,Rd} = M_{res,m} / (B_m \cdot R_m)$  resistenza a flessione flangia

$F_{t,Rd} = \min [ F_{tb,Rd} , B_{pf,Rd} , B_{pa,Rd} , F_{f,Rd} ]$  resistenza a trazione di progetto

150796.5 N

Bull.	$F_{bf,x,Rd}$ [N]	$F_{ba,x,Rd}$ [N]	$F_{v,x,Rd}$ [N]	$F_{bf,y,Rd}$ [N]	$F_{ba,y,Rd}$ [N]	$F_{v,y,Rd}$ [N]
1	222535.1	255000.0	150796.5	244800.1	255000.0	150796.5
2	184998.7	140759.9	140759.9	295799.8	123249.9	123249.9
3	335142.8	255000.0	150796.5	612000.0	255000.0	150796.5
4	335142.8	255000.0	150796.5	612000.0	255000.0	150796.5
5	335142.8	255000.0	150796.5	443942.8	255000.0	150796.5
6	222535.1	255000.0	150796.5	244800.1	255000.0	150796.5
7	184998.7	140759.9	140759.9	295799.8	123249.9	123249.9
8	335142.8	255000.0	150796.5	612000.0	255000.0	150796.5
9	335142.8	255000.0	150796.5	612000.0	255000.0	150796.5
10	335142.8	255000.0	150796.5	443942.8	255000.0	150796.5

## Legenda

$$F_{bf,x,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_f / \gamma_{M2} \quad \text{resistenza a rifollamento flangia in direzione x}$$
$$F_{b a, x, R d} = k \cdot \alpha \cdot f_{t k} \cdot \varnothing \cdot t_a / \gamma_{M 2} \quad \text{resistenza a rifollamento anima passante in direzione x}$$
$$F_{v,x,Rd} = \min [ F_{vb,Rd} , F_{bf,x,Rd} , F_{ba,x,Rd} ] \quad \text{resistenza a taglio di progetto in direzione x}$$
$$F_{bf,y,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_f / \gamma_{M2} \quad \text{resistenza a rifollamento flangia in direzione y}$$
$$F_{ba,y,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \varnothing \cdot t_a / \gamma_{M2} \quad \text{resistenza a rifollamento anima passante in direzione y}$$
$$F_{v,y,Rd} = \min [ F_{vb,Rd} , F_{bf,y,Rd} , F_{ba,y,Rd} ] \quad \text{resistenza a taglio di progetto in direzione y}$$


## Verifiche sui bulloni

## 1-Taglio e trazione (Nodo n. 12, CMB n. 41)

Bull.	X [mm]	Y [mm]	F <sub>v,Ed</sub> [N]	F <sub>v,Rd</sub> [N]	F <sub>t,Ed</sub> [N]	F <sub>t,Rd</sub> [N]	FV <sub>1</sub>	VER
1	50.50	-274.80	1200.9	150796.5	40123.5	84465.5	0.347270	Ok
2	50.50	-228.60	1200.5	123249.9	35351.1	223197.3	0.122873	Ok
3	50.50	-134.30	1199.7	150796.5	25610.0	226194.7	0.088828	Ok
4	50.50	0.00	1198.6	150796.5	11736.9	184861.8	0.053299	Ok
5	50.50	134.30	1197.5	150796.5	0.0	226194.7	0.007941	Ok
6	-50.50	-274.80	1207.6	150796.5	36042.3	84465.5	0.312801	Ok
7	-50.50	-228.60	1207.2	123249.9	31269.9	223197.3	0.109866	Ok
8	-50.50	-134.30	1206.3	150796.5	21528.8	226194.7	0.075984	Ok
9	-50.50	0.00	1205.2	150796.5	7655.8	184861.8	0.037574	Ok
10	-50.50	134.30	1204.2	150796.5	0.0	226194.7	0.007986	Ok

**2-Trazione** (Nodo n. 12, CMB n. 41)

Bull.	X [mm]	Y [mm]	F <sub>t,Ed</sub> [N]	F <sub>t,Rd</sub> [N]	FV <sub>2</sub>	VER
1	50.50	-274.80	40123.5	84465.5	0.475028	Ok
2	50.50	-228.60	35351.1	223197.3	0.158385	Ok

3	50.50	-134.30	25610.0	226194.7	0.113221	Ok
4	50.50	0.00	11736.9	184861.8	0.063490	Ok
5	50.50	134.30	0.0	226194.7	0.000000	Ok
6	-50.50	-274.80	36042.3	84465.5	0.426711	Ok
7	-50.50	-228.60	31269.9	223197.3	0.140100	Ok
8	-50.50	-134.30	21528.8	226194.7	0.095178	Ok
9	-50.50	0.00	7655.8	184861.8	0.041414	Ok
10	-50.50	134.30	0.0	226194.7	0.000000	Ok

#### Legenda

$F_{v,Ed}$  forza di taglio agente sul bullone  
 $F_{v,Rd}$  resistenza a taglio di progetto del bullone  
 $F_{t,Ed}$  forza di trazione agente sul bullone  
 $F_{t,Rd}$  resistenza a trazione di progetto del bullone  
 $FV_1 = F_{v,Ed} / F_{v,Rd} + F_{t,Ed} / (1.4 \cdot F_{t,Rd})$   
 $FV_2 = F_{t,Ed} / F_{t,Rd}$   
 $VER \rightarrow FV_i \leq 1$

#### Verifiche sulle saldature profilo-flangia (versione beta)

Si considera la sezione di gola (avente altezza  $a = s_c / 2^{0.5} = 8.485$ ) in posizione ribaltata: vengono considerate positive le tensioni normali di trazione e le tensioni tangenziali agenti verso destra e verso il basso. Tutte le tensioni sono espresse in N/mm<sup>2</sup>.

##### Verifica formula (4.2.84) (Nodo n. 12, CMB n. 40)

Cordoni	$n_{\perp}$	$t_{\perp}$	$\tau_{\parallel}$	$FV_1$	$VER_1$
Nervatura inferiore lato destro	-137.05	0.00	6.30	137.19	Ok
Nervatura inferiore lato sinistro	-137.05	0.00	6.30	137.19	Ok
Ala inferiore esterno	-84.17	0.00	0.42	84.17	Ok
Ala inferiore interno lato destro	-117.01	0.00	0.42	117.01	Ok
Ala inferiore interno lato sinistro	-63.49	0.00	0.42	63.49	Ok
Anima lato destro	-68.21	0.00	6.30	68.50	Ok
Anima lato sinistro	-68.21	0.00	6.30	68.50	Ok
Ala superiore interno lato destro	63.48	0.00	0.42	63.48	Ok
Ala superiore interno lato sinistro	117.00	0.00	0.42	117.00	Ok

##### Verifica formula (4.2.85) (Nodo n. 12, CMB n. 40)

Cordoni	$n_{\perp}$	$t_{\perp}$	$\tau_{\parallel}$	$FV_2$	$VER_2$
Nervatura inferiore lato destro	-137.05	0.00	6.30	137.05	Ok
Nervatura inferiore lato sinistro	-137.05	0.00	6.30	137.05	Ok
Ala inferiore esterno	-84.17	0.00	0.42	84.17	Ok
Ala inferiore interno lato destro	-117.01	0.00	0.42	117.01	Ok
Ala inferiore interno lato sinistro	-63.49	0.00	0.42	63.49	Ok
Anima lato destro	-68.21	0.00	6.30	68.21	Ok
Anima lato sinistro	-68.21	0.00	6.30	68.21	Ok
Ala superiore interno lato destro	63.48	0.00	0.42	63.48	Ok
Ala superiore interno lato sinistro	117.00	0.00	0.42	117.00	Ok

#### Legenda

$n_{\perp}$  tensione normale perpendicolare all'asse del cordone  
 $t_{\perp}$  tensione tangenziale perpendicolare all'asse del cordone  
 $\tau_{\parallel}$  tensione tangenziale parallela all'asse del cordone  
 $FV_1 = (n_{\perp}^2 + t_{\perp}^2 + \tau_{\parallel}^2)^{0.5}$   
 $FV_2 = |n_{\perp}| + |t_{\perp}|$   
 $VER_i \rightarrow FV_i \leq \beta_i \cdot f_{yk} \quad (\beta_1 \cdot f_{yk} = 248.50 \text{ N/mm}^2 \quad \beta_2 \cdot f_{yk} = 301.75 \text{ N/mm}^2)$

#### Verifica del momento di progetto del giunto (Nodo n. 12, CMB n. 40)

Momento resistente del giunto	$M_{j,Rd} =$	350249800.0 N mm
Momento di progetto	$M_{j,Ed} =$	117012200.0 N mm
$M_{j,Ed} / M_{j,Rd} = 0.334082 \quad \text{Ok}$		