



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. 1.4

**TABULATO VERIFICA COLLEGAMENTO
3 TRAVI COLONNA**

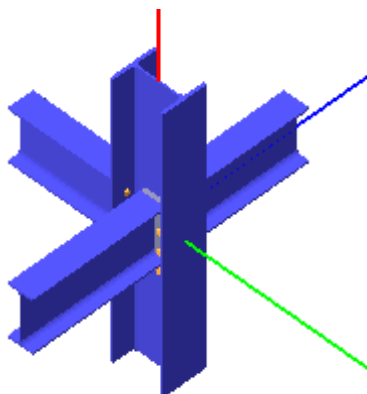
DATA: 16/05/2022

RUP :

Ing. Pietro Mifa

N°	Data	Descrizione della Revisione o Sostituisce

Verifica secondo il D.M. 17/01/2018 del nodo 14



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 464.4 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]
14.1	63698.1	-0.3	10.8	563.0	-24024340.0	-4923.0
14.2	63785.5	-0.3	7.9	558.0	-24248610.0	-4933.0
14.3	132600.0	-0.7	35.9	1143.0	-50382000.0	-8556.0
14.4	132700.0	-0.7	33.0	1138.0	-50604000.0	-8566.0
14.5	44908.1	-0.2	7.7	401.0	-16856540.0	-3570.0
14.6	44995.6	-0.2	4.8	395.0	-17080790.0	-3580.0
14.7	113800.0	-0.6	32.8	981.0	-43216000.0	-7203.0
14.8	113900.0	-0.6	29.9	976.0	-43448000.0	-7212.0
14.9	63873.0	-0.3	5.1	552.0	-24472860.0	-4943.0
14.10	111900.0	-0.6	28.4	969.0	-42478000.0	-7466.0
14.11	112100.0	-0.6	22.6	959.0	-42932000.0	-7486.0
14.12	45083.0	-0.2	1.9	390.0	-17305060.0	-3590.0
14.13	93153.3	-0.5	25.3	807.0	-35302410.0	-6113.0

14.14	93328.2	-0.5	19.5	796.0	-35760920.0	-6133.0
14.15	6402.3	2996.8	4179.8	-2551000.0	91252420.0	-11315.0
14.16	9758.4	1373.0	4409.6	-1071000.0	84236510.0	-34738.0
14.17	112300.0	-1373.6	-4383.4	1072000.0	-130286000.0	25899.0
14.18	115600.0	-2997.5	-4153.7	2552000.0	-137292000.0	2477.0
14.19	7526.9	3628.8	4250.2	-3046000.0	88894840.0	-10006.0
14.20	8633.8	741.1	4339.2	-575605.0	86594080.0	-36047.0
14.21	113400.0	-741.7	-4313.0	576675.0	-132688000.0	27208.0
14.22	114500.0	-3629.4	-4224.0	3047000.0	-134990000.0	1167.0
14.23	-9752.6	1503.0	5764.2	-1322000.0	125044500.0	1599.0
14.24	-6396.6	-120.9	5994.0	157330.0	118048600.0	-21824.0
14.25	128400.0	120.3	-5967.8	-156260.0	-164088000.0	12985.0
14.26	131800.0	-1503.6	-5738.1	1323000.0	-171176000.0	-10437.0
14.27	-8628.1	2134.9	5834.6	-1818000.0	122746900.0	2908.0
14.28	-7521.2	-752.8	5923.6	652856.0	120446200.0	-23133.0
14.29	129500.0	752.2	-5897.5	-651786.0	-166490000.0	14295.0
14.30	130600.0	-2135.5	-5808.4	1819000.0	-168792000.0	-11747.0
14.31	39533.9	3361.7	914.7	-3009000.0	21876100.0	29036.0
14.32	50720.5	-2051.2	1680.5	1923000.0	-1490310.0	-49039.0
14.33	71288.3	2050.5	-1654.3	-1922000.0	-44598110.0	40200.0
14.34	82475.0	-3362.3	-888.5	3010000.0	-67964500.0	-37875.0
14.35	34687.4	2913.5	1390.0	-2640000.0	32013730.0	32910.0
14.36	45874.0	-2499.3	2155.8	2291000.0	8652368.0	-45165.0
14.37	76134.8	2498.7	-2129.6	-2290000.0	-54735740.0	36326.0
14.38	87321.5	-2914.1	-1363.8	2641000.0	-78102130.0	-41749.0
14.39	43282.3	5468.1	1149.2	-4660000.0	14033810.0	33400.0
14.40	46972.1	-4157.5	1446.0	3575000.0	6349978.0	-53403.0
14.41	75036.8	4156.9	-1419.8	-3573000.0	-52433380.0	44565.0
14.42	78726.5	-5468.7	-1123.0	4661000.0	-60119230.0	-42239.0
14.43	38435.8	5019.9	1624.5	-4292000.0	24178440.0	37275.0
14.44	42125.6	-4605.7	1921.3	3943000.0	16492610.0	-49529.0
14.45	79883.3	4605.1	-1895.1	-3942000.0	-62581010.0	40691.0
14.46	83573.0	-5020.5	-1598.3	4293000.0	-70266860.0	-46113.0

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	69325.5	69325.5
2	190275.0	190275.0
3	207854.8	207854.8
4	179805.2	179805.2
5	207854.8	207854.8
6	69325.5	69325.5
7	190275.0	190275.0
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

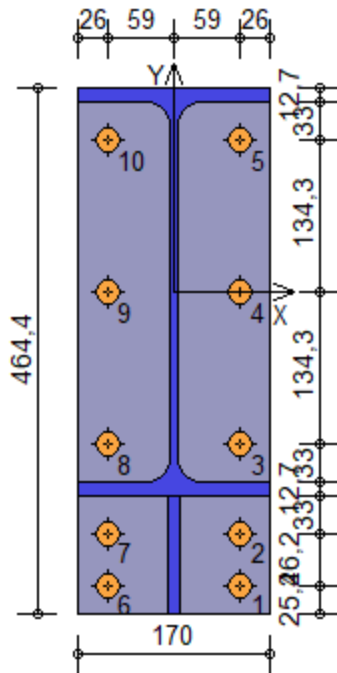
$$F_{vb,Rd} = 0.6 \cdot f_{tb} \cdot A_{res} / \gamma_{M2} = 150796.5 \text{ N}$$

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	167707.3	459000.0	150796.5	172991.9	459000.0	150796.5
2	139419.5	253368.2	139419.5	209032.1	221850.1	150796.5
3	252571.4	459000.0	150796.5	432136.8	458635.7	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	167707.3	459000.0	150796.5	172991.9	459000.0	150796.5

7	139419.5	253368.2	139419.5	209032.1	221850.1	150796.5
8	252571.4	459000.0	150796.5	432136.8	458635.7	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. 14, 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	-259.20	987.3	150796.5	65440.8	69325.5	0.680808	Ok
2	59.00	-213.00	987.3	150796.5	56798.8	190275.0	0.219768	Ok
3	59.00	-134.30	987.2	150796.5	42077.4	207854.8	0.151144	Ok
4	59.00	0.00	987.1	150796.5	16955.8	179805.2	0.073903	Ok
5	59.00	134.30	986.9	150796.5	0.0	207854.8	0.006545	Ok
6	-59.00	-259.20	986.6	150796.5	66611.4	69325.5	0.692864	Ok
7	-59.00	-213.00	986.5	150796.5	57969.4	190275.0	0.224157	Ok
8	-59.00	-134.30	986.4	150796.5	43248.1	207854.8	0.155162	Ok
9	-59.00	0.00	986.3	150796.5	18126.4	179805.2	0.078549	Ok
10	-59.00	134.30	986.2	150796.5	0.0	207854.8	0.006540	Ok

2-Trazione (Nodo n. 14, CMB n. 23)

Bull.	X [mm]	Y [mm]	$F_{t,Ed}$ [N]	$F_{t,Rd}$ [N]	FV_2	VER
1	59.00	-259.20	65440.8	69325.5	0.943964	Ok
2	59.00	-213.00	56798.8	190275.0	0.298509	Ok
3	59.00	-134.30	42077.4	207854.8	0.202437	Ok
4	59.00	0.00	16955.8	179805.2	0.094301	Ok
5	59.00	134.30	0.0	207854.8	0.000000	Ok
6	-59.00	-259.20	66611.4	69325.5	0.960850	Ok
7	-59.00	-213.00	57969.4	190275.0	0.304661	Ok
8	-59.00	-134.30	43248.1	207854.8	0.208069	Ok
9	-59.00	0.00	18126.4	179805.2	0.100811	Ok
10	-59.00	134.30	0.0	207854.8	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/mm².

Verifica formula (4.2.84) (Nodo n. 14, CMB n. 26)

Cordoni	n_{\perp}	t_{\perp}	τ_{\parallel}	FV_1	VER_1
Nervatura inferiore lato destro	-208.98	0.00	19.86	209.92	Ok
Nervatura inferiore lato sinistro	-208.98	0.00	19.86	209.92	Ok
Ala inferiore esterno	-146.50	0.00	-0.42	146.50	Ok
Ala inferiore interno lato destro	-117.23	0.00	-0.42	117.23	Ok
Ala inferiore interno lato sinistro	-130.97	0.00	-0.42	130.97	Ok
Anima lato destro	-109.97	0.00	19.86	111.75	Ok
Anima lato sinistro	-109.97	0.00	19.86	111.75	Ok
Ala superiore interno lato destro	129.85	0.00	-0.42	129.85	Ok
Ala superiore interno lato sinistro	116.11	0.00	-0.42	116.11	Ok

Verifica formula (4.2.85) (Nodo n. 14, CMB n. 26)

Cordoni	n_{\perp}	t_{\perp}	τ_{\parallel}	FV_2	VER_2
Nervatura inferiore lato destro	-208.98	0.00	19.86	208.98	Ok
Nervatura inferiore lato sinistro	-208.98	0.00	19.86	208.98	Ok
Ala inferiore esterno	-146.50	0.00	-0.42	146.50	Ok
Ala inferiore interno lato destro	-117.23	0.00	-0.42	117.23	Ok
Ala inferiore interno lato sinistro	-130.97	0.00	-0.42	130.97	Ok
Anima lato destro	-109.97	0.00	19.86	109.97	Ok
Anima lato sinistro	-109.97	0.00	19.86	109.97	Ok
Ala superiore interno lato destro	129.85	0.00	-0.42	129.85	Ok
Ala superiore interno lato sinistro	116.11	0.00	-0.42	116.11	Ok

Legenda

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

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

τ_{\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. 14, CMB n. 26)

Momento resistente del giunto	$M_{j,Rd} =$	310287200.0 N mm
Momento di progetto	$M_{j,Ed} =$	169681100.0 N mm
$M_{j,Ed} / M_{j,Rd} = 0.546852 \quad \text{Ok}$		

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 464.4 x 29.0 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/mm² $f_t = 510$ N/mm² $\beta_1 = 0.70$ $\beta_2 = 0.85$

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]
14.1	3049.0	-0.1	53.2	392.0	3368190.0	-509.0
14.2	3036.5	-0.1	55.4	391.0	3408037.0	-512.0
14.3	4219.0	-0.3	95.6	781.0	8434723.0	-993.0
14.4	4206.6	-0.3	97.8	780.0	8474587.0	-997.0
14.5	2280.0	-0.1	37.8	278.0	2280730.0	-362.0
14.6	2267.6	-0.1	40.0	278.0	2320594.0	-365.0
14.7	3450.1	-0.2	80.2	668.0	7347280.0	-846.0
14.8	3437.6	-0.2	82.4	667.0	7387127.0	-850.0
14.9	3024.0	-0.1	57.7	390.0	3447884.0	-516.0
14.10	3868.0	-0.2	82.9	664.0	6915264.0	-848.0
14.11	3843.1	-0.2	87.3	663.0	6994974.0	-855.0
14.12	2255.1	-0.1	42.2	277.0	2360441.0	-369.0
14.13	3099.1	-0.2	67.5	551.0	5826820.0	-701.0
14.14	3074.1	-0.2	71.9	550.0	5906514.0	-708.0
14.15	-3478.4	-432.7	-129.1	1374000.0	21690850.0	-9888.0
14.16	-19869.3	-186.2	-214.0	591326.0	71017510.0	-8303.0
14.17	24971.3	185.9	310.1	-590588.0	-64078690.0	7352.0
14.18	8580.4	432.5	225.2	-1374000.0	-14752030.0	8937.0
14.19	-2486.2	-515.5	-138.4	1637000.0	18701750.0	-9310.0
14.20	-20861.6	-103.4	-204.7	328604.0	74006580.0	-8880.0
14.21	25963.5	103.1	300.8	-327865.0	-67067790.0	7930.0
14.22	7588.1	515.3	234.5	-1636000.0	-11762950.0	8360.0
14.23	6345.0	-223.1	-147.6	708270.0	-7800074.0	-3869.0
14.24	-10045.8	23.5	-232.5	-74790.0	41529610.0	-2284.0
14.25	15147.8	-23.7	328.5	75528.0	-34590790.0	1333.0
14.26	-1243.1	222.8	243.7	-707531.0	14735880.0	2918.0
14.27	7337.3	-305.9	-156.9	970992.0	-10786150.0	-3291.0
14.28	-11038.1	106.3	-223.2	-337512.0	44518690.0	-2861.0
14.29	16140.1	-106.5	319.3	338251.0	-37579870.0	1911.0
14.30	-2235.3	305.6	253.0	-970254.0	17724970.0	2341.0
14.31	25601.6	-503.9	123.6	1600000.0	-65880120.0	-5703.0
14.32	-29034.5	318.0	-159.3	-1010000.0	98598810.0	-419.0
14.33	34136.5	-318.3	255.4	1011000.0	-91609980.0	-531.0
14.34	-20499.6	503.6	-27.6	-1599000.0	72818940.0	4753.0
14.35	28548.6	-441.0	118.1	1400000.0	-74732500.0	-3898.0
14.36	-26087.5	380.9	-164.8	-1210000.0	89706420.0	1387.0
14.37	31189.5	-381.2	260.9	1211000.0	-82767610.0	-2337.0
14.38	-23446.7	440.7	-22.0	-1400000.0	81671300.0	2947.0
14.39	28909.2	-779.8	92.7	2476000.0	-75850380.0	-3778.0
14.40	-32342.1	594.0	-128.3	-1886000.0	108529100.0	-2345.0
14.41	37444.1	-594.2	224.4	1886000.0	-101550300.0	1394.0
14.42	-23807.2	779.6	3.4	-2475000.0	82779220.0	2827.0
14.43	31856.2	-716.9	87.1	2276000.0	-84692770.0	-1972.0
14.44	-29395.1	656.9	-133.9	-2086000.0	99636700.0	-539.0
14.45	34497.0	-657.1	230.0	2086000.0	-92727900.0	-412.0
14.46	-26754.2	716.7	9.0	-2275000.0	91631580.0	1022.0

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

$$B_{pf,Rd} = 0.6 \cdot \pi \cdot d_m \cdot t_f \cdot f_{tk} / \gamma_{M2} = 669083.8 \text{ N}$$

Bull.	$F_{f,Rd}$ [N]	$F_{t,Rd}$ [N]
1	77154.7	77154.7

2	216222.7	216222.7
3	235848.5	226194.7
4	172743.0	172743.0
5	235848.5	226194.7
6	77154.7	77154.7
7	216222.7	216222.7
8	235848.5	226194.7
9	172743.0	172743.0
10	235848.5	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 N

Bull.	$F_{bf,x,Rd}$ [N]	$F_{v,x,Rd}$ [N]	$F_{bf,y,Rd}$ [N]	$F_{v,y,Rd}$ [N]
1	215116.8	150796.5	236639.9	150796.5
2	178832.3	150796.5	285940.1	150796.5
3	323971.4	150796.5	591130.4	150796.5
4	323971.4	150796.5	591600.0	150796.5
5	323971.4	150796.5	429144.7	150796.5
6	215116.8	150796.5	236639.9	150796.5
7	178832.3	150796.5	285940.1	150796.5
8	323971.4	150796.5	591130.4	150796.5
9	323971.4	150796.5	591600.0	150796.5
10	323971.4	150796.5	429144.7	150796.5

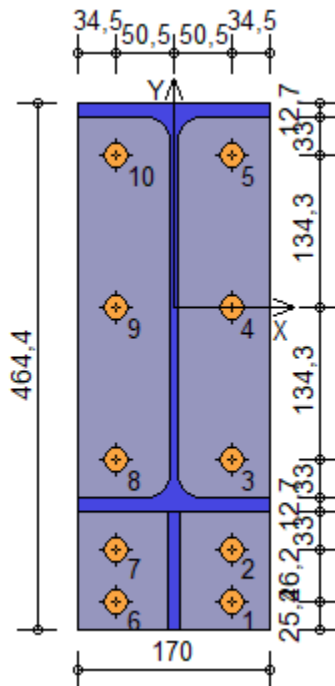
Legenda

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

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

$F_{bf,y,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \varnothing \cdot t_f / \gamma_{M2}$ 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. 14, 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	-259.20	3234.2	150796.5	56226.5	77154.7	0.541983	Ok
2	50.50	-213.00	3234.2	150796.5	48758.7	216222.7	0.182521	Ok
3	50.50	-134.30	3234.2	150796.5	36037.8	226194.7	0.135249	Ok
4	50.50	0.00	3234.3	150796.5	14329.7	172743.0	0.080701	Ok

5	50.50	134.30	3234.3	150796.5	0.0	226194.7	0.021448	Ok
6	-50.50	-259.20	3235.2	150796.5	57710.4	77154.7	0.555728	Ok
7	-50.50	-213.00	3235.2	150796.5	50242.7	216222.7	0.187430	Ok
8	-50.50	-134.30	3235.3	150796.5	37521.7	226194.7	0.139942	Ok
9	-50.50	0.00	3235.3	150796.5	15813.6	172743.0	0.086843	Ok
10	-50.50	134.30	3235.3	150796.5	0.0	226194.7	0.021455	Ok

2-Trazione (Nodo n. 14, CMB n. 40)

Bull.	X [mm]	Y [mm]	F _{t,Ed} [N]	F _{t,Rd} [N]	FV ₂	VER
1	50.50	-259.20	56226.5	77154.7	0.728750	Ok
2	50.50	-213.00	48758.7	216222.7	0.225502	Ok
3	50.50	-134.30	36037.8	226194.7	0.159322	Ok
4	50.50	0.00	14329.7	172743.0	0.082954	Ok
5	50.50	134.30	0.0	226194.7	0.000000	Ok
6	-50.50	-259.20	57710.4	77154.7	0.747983	Ok
7	-50.50	-213.00	50242.7	216222.7	0.232366	Ok
8	-50.50	-134.30	37521.7	226194.7	0.165882	Ok
9	-50.50	0.00	15813.6	172743.0	0.091544	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 → FV_i ≤ 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/mm².

Verifica formula (4.2.84) (Nodo n. 14, CMB n. 40)

Cordoni	n _⊥	t _⊥	τ	FV ₁	VER ₁
Nervatura inferiore lato destro	132.13	0.00	-4.87	132.22	Ok
Nervatura inferiore lato sinistro	132.13	0.00	-4.87	132.22	Ok
Ala inferiore esterno	101.15	0.00	0.17	101.16	Ok
Ala inferiore interno lato destro	71.72	0.00	0.17	71.72	Ok
Ala inferiore interno lato sinistro	91.31	0.00	0.17	91.31	Ok
Anima lato destro	-69.38	0.00	-4.87	69.55	Ok
Anima lato sinistro	-69.38	0.00	-4.87	69.55	Ok
Ala superiore interno lato destro	-91.34	0.00	0.17	91.34	Ok
Ala superiore interno lato sinistro	-71.75	0.00	0.17	71.75	Ok

Verifica formula (4.2.85) (Nodo n. 14, CMB n. 40)

Cordoni	n _⊥	t _⊥	τ	FV ₂	VER ₂
Nervatura inferiore lato destro	132.13	0.00	-4.87	132.13	Ok
Nervatura inferiore lato sinistro	132.13	0.00	-4.87	132.13	Ok
Ala inferiore esterno	101.15	0.00	0.17	101.15	Ok
Ala inferiore interno lato destro	71.72	0.00	0.17	71.72	Ok
Ala inferiore interno lato sinistro	91.31	0.00	0.17	91.31	Ok
Anima lato destro	-69.38	0.00	-4.87	69.38	Ok
Anima lato sinistro	-69.38	0.00	-4.87	69.38	Ok
Ala superiore interno lato destro	-91.34	0.00	0.17	91.34	Ok
Ala superiore interno lato sinistro	-71.75	0.00	0.17	71.75	Ok

Legenda

n_⊥ tensione normale perpendicolare all'asse del cordone
 t_⊥ tensione tangenziale perpendicolare all'asse del cordone
 τ_{||} 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. 14, CMB n. 41)Momento resistente del giunto $M_{j,Rd} = 325727400.0 \text{ N mm}$ Momento di progetto $M_{j,Ed} = 101608700.0 \text{ N mm}$

$$M_{j,Ed} / M_{j,Rd} = 0.311944 \quad \text{Ok}$$

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 464.4 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]
14.1	9258.9	-0.1	11.0	330.0	-16092130.0	-713.0
14.2	9261.4	-0.1	13.2	327.0	-16092120.0	-718.0
14.3	16219.5	-0.2	12.5	672.0	-29288630.0	-1416.0
14.4	16222.0	-0.2	14.7	669.0	-29288610.0	-1421.0
14.5	6711.0	-0.1	7.7	235.0	-11608060.0	-506.0
14.6	6713.5	-0.1	10.0	232.0	-11608040.0	-511.0
14.7	13671.6	-0.2	9.2	577.0	-24794550.0	-1208.0
14.8	13674.1	-0.2	11.5	574.0	-24794540.0	-1213.0
14.9	9263.9	-0.1	15.5	324.0	-16092100.0	-724.0
14.10	14131.4	-0.2	12.1	570.0	-25331680.0	-1205.0
14.11	14136.4	-0.1	16.5	563.0	-25331650.0	-1215.0
14.12	6716.0	-0.1	12.2	228.0	-11598030.0	-516.0
14.13	11583.4	-0.1	8.8	474.0	-20837600.0	-998.0
14.14	11588.4	-0.1	13.2	468.0	-20837570.0	-1008.0
14.15	12896.5	-311.5	-236.2	1163000.0	-31369400.0	-10169.0
14.16	24724.1	-133.0	-183.2	497842.0	-75545470.0	-8697.0
14.17	-8052.9	132.8	200.1	-497214.0	46179670.0	7356.0
14.18	3774.6	311.3	253.1	-1162000.0	2005591.0	8828.0
14.19	12158.2	-370.4	-233.6	1384000.0	-28644010.0	-9597.0
14.20	25462.4	-74.1	-185.7	277176.0	-78270860.0	-9269.0
14.21	-8791.3	73.9	202.7	-276548.0	48915050.0	7928.0
14.22	4513.0	370.2	250.5	-1383000.0	-722571.8	8256.0
14.23	-570.4	-160.6	-295.5	599430.0	-3855565.0	-4037.0
14.24	11257.2	17.9	-242.5	-65601.0	-48029640.0	-2566.0
14.25	5414.0	-18.0	259.5	66230.0	18673840.0	1224.0
14.26	17241.5	160.4	312.5	-598801.0	-25512240.0	2696.0
14.27	-1308.7	-219.5	-293.0	820096.0	-1127179.0	-3465.0
14.28	11995.5	76.8	-245.1	-286268.0	-50765030.0	-3137.0
14.29	4675.7	-77.0	262.0	286896.0	21399220.0	1796.0
14.30	17979.9	219.3	309.9	-819468.0	-28237620.0	2124.0
14.31	-8234.6	-364.2	-145.3	1358000.0	47318540.0	-5752.0
14.32	31190.6	230.7	31.4	-859058.0	-99905060.0	-847.0
14.33	-14519.4	-230.9	-14.4	859686.1	70579260.0	-494.0

14.34	24905.7	364.0	162.3	-1357000.0	-76674340.0	4411.0
14.35	-12274.6	-318.9	-163.1	1189000.0	55563280.0	-3912.0
14.36	27150.5	276.0	13.6	-1028000.0	-91690300.0	993.0
14.37	-10479.3	-276.2	3.4	1029000.0	62324510.0	-2334.0
14.38	28945.8	318.8	180.1	-1188000.0	-84929090.0	2571.0
14.39	-10695.7	-560.5	-136.8	2093000.0	56403150.0	-3847.0
14.40	33651.7	427.1	22.8	-1595000.0	-108989700.0	-2752.0
14.41	-16980.6	-427.2	-5.9	1595000.0	79673870.0	1411.0
14.42	27366.9	560.4	153.7	-2093000.0	-85768960.0	2506.0
14.43	-14735.8	-515.3	-154.6	1924000.0	64657900.0	-2007.0
14.44	29611.7	472.3	5.0	-1764000.0	-100814900.0	-912.0
14.45	-12940.5	-472.5	11.9	1764000.0	71419120.0	-429.0
14.46	31407.0	515.1	171.5	-1924000.0	-94023700.0	666.0

Calcolo resistenze

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

Bull.	$F_{f,Rd}$ [N]	$F_{t,Rd}$ [N]
1	82567.4	82567.4
2	231391.7	226194.7
3	252394.4	226194.7
4	184861.8	184861.8
5	252394.4	226194.7
6	82567.4	82567.4
7	231391.7	226194.7
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

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	222534.7	255000.0	150796.5	244799.9	255000.0	150796.5
2	184999.0	140760.1	140760.1	295800.1	123250.0	123250.0
3	335142.8	255000.0	150796.5	611514.3	254797.6	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	222534.7	255000.0	150796.5	244799.9	255000.0	150796.5
7	184999.0	140760.1	140760.1	295800.1	123250.0	123250.0
8	335142.8	255000.0	150796.5	611514.3	254797.6	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

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

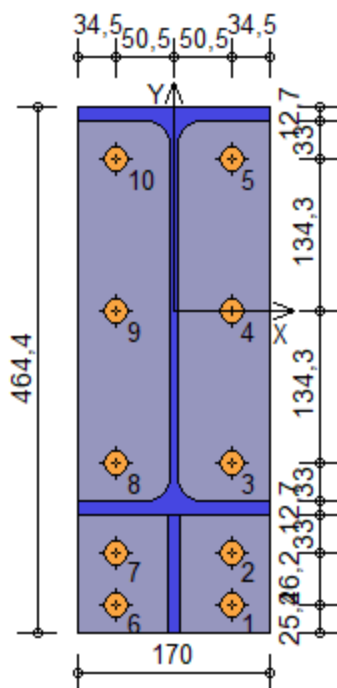
$F_{ba,x,Rd} = k \cdot \alpha \cdot f_{tk} \cdot \emptyset \cdot t_a / \gamma_{M2}$ resistenza a rifollamento anima passante in direzione x

$F_{v,x,Rd} = \min [F_{vb,Rd} , F_{bf,x,Rd} , F_{ba,x,Rd}]$ 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 anima 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. 14, CMB n. 41)

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	-259.20	1698.9	150796.5	42459.6	82567.4	0.378582	Ok
2	50.50	-213.00	1698.9	123250.0	36976.8	226194.7	0.130551	Ok
3	50.50	-134.30	1698.9	150796.5	27637.1	226194.7	0.098540	Ok
4	50.50	0.00	1698.9	150796.5	11699.0	184861.8	0.056470	Ok
5	50.50	134.30	1698.9	150796.5	0.0	226194.7	0.011266	Ok
6	-50.50	-259.20	1698.3	150796.5	41204.1	82567.4	0.367716	Ok
7	-50.50	-213.00	1698.3	123250.0	35721.3	226194.7	0.126581	Ok
8	-50.50	-134.30	1698.3	150796.5	26381.5	226194.7	0.094571	Ok
9	-50.50	0.00	1698.3	150796.5	10443.5	184861.8	0.051615	Ok
10	-50.50	134.30	1698.3	150796.5	0.0	226194.7	0.011262	Ok

2-Trazione (Nodo n. 14, CMB n. 41)

Bull.	X [mm]	Y [mm]	$F_{t,Ed}$ [N]	$F_{t,Rd}$ [N]	FV_2	VER
1	50.50	-259.20	42459.6	82567.4	0.514242	Ok
2	50.50	-213.00	36976.8	226194.7	0.163474	Ok
3	50.50	-134.30	27637.1	226194.7	0.122183	Ok
4	50.50	0.00	11699.0	184861.8	0.063285	Ok
5	50.50	134.30	0.0	226194.7	0.000000	Ok
6	-50.50	-259.20	41204.1	82567.4	0.499035	Ok
7	-50.50	-213.00	35721.3	226194.7	0.157923	Ok
8	-50.50	-134.30	26381.5	226194.7	0.116632	Ok
9	-50.50	0.00	10443.5	184861.8	0.056493	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. 14, CMB n. 40)

Cordoni	n_{\perp}	t_{\perp}	τ_{\parallel}	FV ₁	VER ₁
Nervatura inferiore lato destro	-132.70	0.00	5.07	132.80	Ok
Nervatura inferiore lato sinistro	-132.70	0.00	5.07	132.80	Ok
Ala inferiore esterno	-85.97	0.00	0.12	85.97	Ok
Ala inferiore interno lato destro	-89.24	0.00	0.12	89.24	Ok
Ala inferiore interno lato sinistro	-72.68	0.00	0.12	72.68	Ok
Anima lato destro	69.67	0.00	5.07	69.85	Ok
Anima lato sinistro	69.67	0.00	5.07	69.85	Ok
Ala superiore interno lato destro	72.68	0.00	0.12	72.68	Ok
Ala superiore interno lato sinistro	89.25	0.00	0.12	89.25	Ok

Verifica formula (4.2.85) (Nodo n. 14, CMB n. 40)

Cordoni	n_{\perp}	t_{\perp}	τ_{\parallel}	FV ₂	VER ₂
Nervatura inferiore lato destro	-132.70	0.00	5.07	132.70	Ok
Nervatura inferiore lato sinistro	-132.70	0.00	5.07	132.70	Ok
Ala inferiore esterno	-85.97	0.00	0.12	85.97	Ok
Ala inferiore interno lato destro	-89.24	0.00	0.12	89.24	Ok
Ala inferiore interno lato sinistro	-72.68	0.00	0.12	72.68	Ok
Anima lato destro	69.67	0.00	5.07	69.67	Ok
Anima lato sinistro	69.67	0.00	5.07	69.67	Ok
Ala superiore interno lato destro	72.68	0.00	0.12	72.68	Ok
Ala superiore interno lato sinistro	89.25	0.00	0.12	89.25	Ok

Legenda

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

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

τ_{\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. 14, CMB n. 40)

Momento resistente del giunto $M_{j,Rd} = 332094000.0 \text{ N mm}$

Momento di progetto $M_{j,Ed} = 108995600.0 \text{ N mm}$

$$M_{j,Ed} / M_{j,Rd} = 0.328207 \quad \text{Ok}$$