

## VERIFICHE CONCLUSIVE

La verifica allo stato limite ultimo per flessione consiste nel controllare che in ogni sezione risulti:

$$M_{Sd} < M_{Rd}$$

Allo stesso modo la verifica allo stato limite ultimo per il taglio consista nel verificare che in ogni sezione risulti:

$$V_{Sd} < V_{Rd}$$

La verifica allo stato limite di servizio viene eseguita nell'ipotesi di trovarsi in un ambiente moderatamente aggressivo. Pertanto la normativa vigente impone il rispetto delle seguenti limitazioni:

combinazione RARA

calcestruzzo  $\sigma_c < 0.60 f_{ck}$

acciaio  $\sigma_s < 0.70 f_{yk}$

combinazione QUASI PERMANENTE

calcestruzzo  $\sigma_c < 0.45 f_{ck}$

Il calcolo delle tensioni in esercizio può essere eseguito nell'ipotesi di comportamento elastico-lineare dei materiali, in quanto le sollecitazioni non sono relativamente elevate.

Per il calcolo delle tensioni in esercizio si assume un coefficiente di omogeneizzazione  $n$  pari a 15 come consente l'attuale normativa.

Formule utilizzate:

$$f_{ck} = 0,83 R_{ck} = 20,75 \text{ N/mm}^2$$

$$f_{yk} = 380 \text{ N/mm}^2$$

SLU

$$y_c = \frac{A_S \cdot f_{Sd}}{\psi \cdot b \cdot f'_{cd}} \quad M_{Rd} = \psi b y_c f'_{cd} (h - d' - \lambda y_c)$$

SLS

$$y_c = \frac{n \cdot (A_S + A'_S)}{b} \cdot \left[ -1 + \sqrt{1 + \frac{2 \cdot b \cdot (A_S \cdot d + A'_S \cdot d')}{n \cdot (A_S + A'_S)^2}} \right] \quad M_{rc,qp} = \frac{I_n}{y_c} \cdot 0,45 \cdot f_{ck}$$

$$M_{rc,r} = \frac{I_n}{y_c} \cdot 0,60 \cdot f_{ck}$$

$$I_n = \frac{b \cdot y_c^3}{3} + n \cdot [A_S \cdot (d - y_c)^2 + A'_S \cdot (y_c - d')^2] \quad M_{rs} = \frac{I_n}{n \cdot (d - y_c)} \cdot 0,70 \cdot f_{sk}$$

### MOMENTI RESISTENTI

#### CAMPATA AB

##### NEGATIVI

Sezioni	z (m)	b (mm)	h (mm)	d <sub>tesa</sub> (mm)	d <sub>compr</sub> (mm)	A <sub>s</sub> (mm) <sup>2</sup>	A <sub>s</sub> (mm) <sup>2</sup>	Y <sub>c,SLU</sub> (mm)	M <sub>Rd</sub> (kNm)	Y <sub>c,SLS</sub> (mm)	I <sub>n</sub> (mm) <sup>4</sup>	M <sub>rc,r</sub> (kNm)	M <sub>rc,qp</sub> (kNm)	M <sub>rs,r</sub> (kNm)
1	0.00	1000	240	70	30	226	452	16.97	24.38	40.94	1.36E+08	41.42	31.07	18.72
2	0.30	200	240	70	30	226	452	84.86	20.32	72.15	9.60E+07	16.56	12.42	17.39
3	0.64	200	240	70	30	452	226	42.43	11.43	51.05	5.98E+07	14.59	10.95	8.92
4	1.68	200	240	70	30	452	226	42.43	11.43	51.05	5.98E+07	14.59	10.95	8.92
5	2.78	200	240	30	30	452	226	42.43	14.41	57.50	9.66E+07	20.93	15.69	11.24
6	3.65	200	240	30	30	452	452	84.86	26.30	76.66	1.65E+08	26.85	20.14	21.99
7	4.05	200	240	30	30	452	678	127.29	35.64	90.10	2.19E+08	30.32	22.74	32.46
8	4.30	200	240	30	30	452	678	127.29	35.64	90.10	2.19E+08	30.32	22.74	32.46
9	4.85	600	240	30	30	226	678	42.43	43.24	66.67	2.73E+08	50.94	38.20	33.75
10	5.15	1000	240	30	30	226	678	25.46	44.77	54.69	3.02E+08	68.72	51.54	34.47

##### POSITIVI

Sezioni	z (m)	b (mm)	b <sub>0</sub> (mm)	h (mm)	d <sub>tesa</sub> (mm)	d <sub>compr</sub> (mm)	A <sub>s</sub> (mm) <sup>2</sup>	A <sub>s</sub> (mm) <sup>2</sup>	Y <sub>c,SLU</sub> (mm)	M <sub>Rd</sub> (kNm)	Y <sub>c,SLS</sub> (mm)	I <sub>n</sub> (mm) <sup>4</sup>	M <sub>rc,r</sub> (kNm)	M <sub>rc,qp</sub> (kNm)	M <sub>rs,r</sub> (kNm)
1	0.00	1000	1000	240	30	70	452	226	8.49	15.43	39.59	1.25E+08	39.43	29.57	13.05
2	0.30	1000	200	240	30	70	452	226	8.49	15.43	39.60	1.25E+08	39.43	29.57	13.05
3	0.64	1000	200	240	30	70	226	452	16.97	30.35	48.90	2.16E+08	55.06	41.30	23.80
4	1.82	1000	200	240	30	70	0	452	16.97	30.35	47.42	2.15E+08	56.35	42.27	23.41
5	2.60	1000	200	240	30	30	0	452	16.97	30.35	47.42	2.15E+08	56.35	42.27	23.41
6	2.78	1000	200	240	30	30	226	452	16.97	30.35	46.27	2.16E+08	58.01	43.51	23.35
7	3.87	1000	200	240	30	30	452	452	16.97	30.35	45.27	2.16E+08	59.53	44.65	23.30
8	4.45	1000	200	240	30	30	678	226	8.49	15.43	33.85	1.18E+08	43.52	32.64	11.91
9	4.85	1000	600	240	30	30	678	226	8.49	15.43	33.70	1.18E+08	43.70	32.78	11.90
10	5.15	1000	1000	240	30	30	678	226	8.49	15.43	33.53	1.18E+08	43.91	32.93	11.88

#### CAMPATA BC

##### NEGATIVI

Sezioni	z (m)	b (mm)	h (mm)	d <sub>tesa</sub> (mm)	d <sub>compr</sub> (mm)	A <sub>s</sub> (mm) <sup>2</sup>	A <sub>s</sub> (mm) <sup>2</sup>	Y <sub>c,SLU</sub> (mm)	M <sub>Rd</sub> (kNm)	Y <sub>c,SLS</sub> (mm)	I <sub>n</sub> (mm) <sup>4</sup>	M <sub>rc,r</sub> (kNm)	M <sub>rc,qp</sub> (kNm)	M <sub>rs,r</sub> (kNm)
1	0.00	1000	240	30	30	226	678	25.46	44.77	54.69	3.02E+08	68.72	51.54	34.47
2	0.30	600	240	30	30	226	678	42.43	43.24	66.67	2.73E+08	50.94	38.20	33.75
3	0.80	200	240	30	30	226	678	127.29	35.64	96.43	2.06E+08	26.59	19.94	32.15
4	1.00	200	240	30	30	226	678	127.29	35.64	96.43	2.06E+08	26.59	19.94	32.15
5	1.50	200	240	30	30	452	452	84.86	26.30	76.66	1.65E+08	26.85	20.14	21.99
6	2.60	200	240	30	30	452	226	42.43	14.41	57.50	9.66E+07	20.93	15.69	11.24
7	3.51	200	240	30	30	452	226	42.43	14.41	57.50	9.66E+07	20.93	15.69	11.24
8	4.15	200	240	30	30	452	452	84.86	26.30	76.66	1.65E+08	26.85	20.14	21.99
9	4.65	200	240	30	30	226	678	127.29	35.64	96.43	2.06E+08	26.59	19.94	32.15
10	5.05	200	240	30	30	226	678	127.29	35.64	96.43	2.06E+08	26.59	19.94	32.15
11	5.30	600	240	30	30	226	678	42.43	43.24	66.67	2.73E+08	50.94	38.20	33.75
12	5.65	1000	240	30	30	226	678	25.46	44.77	54.69	3.02E+08	68.72	51.54	34.47

**POSITIVI**

Sezioni	z (m)	b (mm)	b <sub>0</sub> (mm)	h (mm)	d <sub>tesa</sub> (mm)	d <sub>compr</sub> (mm)	A <sub>s</sub> (mm) <sup>2</sup>	A <sub>s</sub> (mm) <sup>2</sup>	γ <sub>c,SLU</sub> (mm)	M <sub>Rd</sub> (kNm)	γ <sub>c,SLS</sub> (mm)	I <sub>n</sub> (mm) <sup>4</sup>	M <sub>rc,r</sub> (kNm)	M <sub>rc,qp</sub> (kNm)	M <sub>rs,r</sub> (kNm)
1	0.00	1000	1000	240	30	30	678	226	8.49	15.43	33.53	1.18E+08	43.91	32.93	11.88
2	0.30	1000	600	240	30	30	678	226	8.49	15.43	33.70	1.18E+08	43.70	32.78	11.90
3	0.80	1000	200	240	30	30	678	226	8.49	15.43	33.85	1.18E+08	43.52	32.64	11.91
4	1.18	1000	200	240	30	30	452	452	16.97	30.35	45.27	2.16E+08	59.53	44.65	23.30
5	2.78	1000	200	240	30	30	0	452	16.97	30.35	47.42	2.15E+08	56.35	42.27	23.41
6	3.33	1000	200	240	30	30	0	452	16.97	30.35	47.42	2.15E+08	56.35	42.27	23.41
7	4.47	1000	200	240	30	30	452	452	16.97	30.35	45.27	2.16E+08	59.53	44.65	23.30
8	5.05	1000	200	240	30	30	678	226	8.49	15.43	33.85	1.18E+08	43.52	32.64	11.91
9	5.30	1000	600	240	30	30	678	226	8.49	15.43	33.70	1.18E+08	43.70	32.78	11.90
10	5.65	1000	1000	240	30	30	678	226	8.49	15.43	33.53	1.18E+08	43.91	32.93	11.88

**CAMPATA CD**

**NEGATIVI**

Sezioni	z (m)	b (mm)	h (mm)	d <sub>tesa</sub> (mm)	d <sub>compr</sub> (mm)	A <sub>s</sub> (mm) <sup>2</sup>	A <sub>s</sub> (mm) <sup>2</sup>	γ <sub>c,SLU</sub> (mm)	M <sub>Rd</sub> (kNm)	γ <sub>c,SLS</sub> (mm)	I <sub>n</sub> (mm) <sup>4</sup>	M <sub>rc,r</sub> (kNm)	M <sub>rc,qp</sub> (kNm)	M <sub>rs,r</sub> (kNm)
1	0.00	1000	240	30	30	226	678	25.46	44.77	54.69	3.02E+08	68.72	51.54	34.47
2	0.35	200	240	30	30	226	678	127.29	35.64	96.43	2.06E+08	26.59	19.94	32.15
3	1.00	200	240	30	30	226	678	127.29	35.64	96.43	2.06E+08	26.59	19.94	32.15
4	1.50	200	240	30	30	452	452	84.86	26.30	76.66	1.65E+08	26.85	20.14	21.99
5	2.22	200	240	30	30	452	226	42.43	14.41	57.50	9.66E+07	20.93	15.69	11.24
6	3.50	200	240	30	30	226	226	42.43	14.41	62.46	9.36E+07	18.66	13.99	11.25
7	3.85	200	240	30	30	226	226	42.43	14.41	62.46	9.36E+07	18.66	13.99	11.25
8	4.20	1000	240	30	30	226	226	8.49	15.43	34.12	1.18E+08	43.11	32.33	11.91

**POSITIVI**

Sezioni	z (m)	b (mm)	b <sub>0</sub> (mm)	h (mm)	d <sub>tesa</sub> (mm)	d <sub>compr</sub> (mm)	A <sub>s</sub> (mm) <sup>2</sup>	A <sub>s</sub> (mm) <sup>2</sup>	γ <sub>c,SLU</sub> (mm)	M <sub>Rd</sub> (kNm)	γ <sub>c,SLS</sub> (mm)	I <sub>n</sub> (mm) <sup>4</sup>	M <sub>rc,r</sub> (kNm)	M <sub>rc,qp</sub> (kNm)	M <sub>rs,r</sub> (kNm)
1	0.00	1000	1000	240	30	30	678	226	8.49	15.43	33.53	1.18E+08	43.91	32.93	11.88
2	1.18	1000	200	240	30	30	452	452	16.97	30.35	45.27	2.16E+08	59.53	44.65	23.30
3	3.32	1000	200	240	30	30	0	452	16.97	30.35	47.42	2.15E+08	56.35	42.27	23.41
4	4.20	1000	1000	240	30	30	226	226	8.49	15.43	34.12	1.18E+08	43.11	32.33	11.91

**SBALZO**

**NEGATIVI**

Sezioni	z (m)	b (mm)	h (mm)	d <sub>tesa</sub> (mm)	d <sub>compr</sub> (mm)	A <sub>s</sub> (mm) <sup>2</sup>	A <sub>s</sub> (mm) <sup>2</sup>	γ <sub>c,SLU</sub> (mm)	M <sub>Rd</sub> (kNm)	γ <sub>c,SLS</sub> (mm)	I <sub>n</sub> (mm) <sup>4</sup>	M <sub>rc,r</sub> (kNm)	M <sub>rc,qp</sub> (kNm)	M <sub>rs,r</sub> (kNm)
1	0.00	1000	200	30	30	226	226	8.49	12.44	30.66	7.54E+07	30.63	22.97	9.60
2	0.20	200	200	30	30	226	226	42.43	11.43	55.15	5.80E+07	13.10	9.83	8.96
3	0.80	200	200	30	30	226	452	84.86	20.32	72.15	9.60E+07	16.56	12.42	17.39
4	1.30	1000	200	30	30	226	452	16.97	24.38	40.94	1.36E+08	41.42	31.07	18.72

**VERIFICA ALLO SLU PER TAGLIO****CAMPATA AB**

Sezioni	z (m)	b (mm)	h (mm)	A' <sub>S</sub> (mm) <sup>2</sup>	A <sub>S</sub> (mm) <sup>2</sup>	V <sub>Rd</sub> (kN)
1	0.00	1000	240	226	452	81.63
2	0.30	200	240	226	452	22.67
3	0.64	200	240	452	226	18.71
4	1.68	200	240	452	226	18.71
5	2.78	200	240	452	226	18.71
6	3.65	200	240	452	452	22.67
7	4.05	200	240	452	678	26.64
8	4.30	200	240	452	678	26.64
9	4.85	600	240	226	678	56.12
10	5.15	1000	240	226	678	85.60

**CAMPATA BC**

Sezioni	z (m)	b (mm)	h (mm)	A' <sub>S</sub> (mm) <sup>2</sup>	A <sub>S</sub> (mm) <sup>2</sup>	V <sub>Rd</sub> (kN)
1	0.00	1000	240	226	678	85.60
2	0.30	600	240	226	678	56.12
3	0.80	200	240	226	678	26.64
4	1.00	200	240	226	678	26.64
5	1.50	200	240	452	452	22.67
6	2.60	200	240	452	226	18.71
7	3.51	200	240	452	226	18.71
8	4.15	200	240	452	452	22.67
9	4.65	200	240	226	678	26.64
10	5.05	200	240	226	678	26.64
11	5.30	600	240	226	678	56.12
12	5.65	1000	240	226	678	85.60

**CAMPATA CD**

Sezioni	z (m)	b (mm)	h (mm)	A' <sub>S</sub> (mm) <sup>2</sup>	A <sub>S</sub> (mm) <sup>2</sup>	V <sub>Rd</sub> (kN)
1	0.00	1000	240	226	678	85.60
2	0.35	200	240	226	678	26.64
3	1.00	200	240	226	678	26.64
4	1.50	200	240	452	452	22.67
5	2.22	200	240	452	226	18.71
6	3.50	200	240	226	226	18.71
7	3.85	200	240	226	226	18.71
8	4.20	1000	240	226	226	77.67

**SBALZO**

Sezioni	z (m)	b (mm)	h (mm)	A' <sub>S</sub> (mm) <sup>2</sup>	A <sub>S</sub> (mm) <sup>2</sup>	V <sub>Rd</sub> (kN)
1	0.00	1000	200	226	226	65.46
2	0.20	200	200	226	226	16.36
3	0.80	200	200	226	452	20.44
4	1.30	1000	200	226	452	69.54