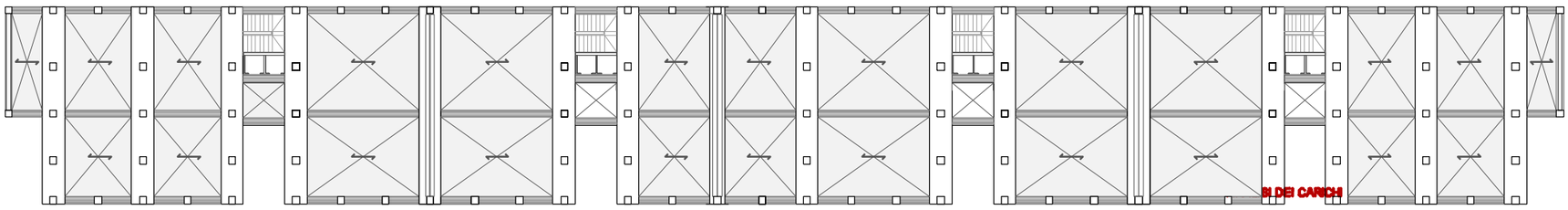


SI DEI CARICHI

ANALISI DEI CARICHI

PAVIMENTO	0.5 kN/m²	·	=	kN/m²
MASSETTO	11 kN/m²	0.02	0.17	kN/m²
PANNELLI RADIANTI		m	=	kN/m²
ISOLAMENTO	0.2 kN/m²	·	0.33	kN/m²
MASSETTO PER IMPIANTI	11 kN/m²	0.03	=	kN/m²
SOLAIO TRAVETTI E PIGNATTE	14 kN/m²	m	0.10	kN/m²
INTONACO	15 kN/m²	0.05	=	kN/m²
TRAMEZZI		m	0.01	kN/m²
		·	=	
		0.09	0.69	kN/m²
CARICHI PERMANENTI		m	0.79	kN/m²
CARICHI PER SLU			0.79 · 1.4	kN/m²
		0.09	2.40	kN/m²
		m	= 9.49	kN/m²
			2.5 · 1.5	kN/m²
		0.28	= 3.69	kN/m
		m	1.20 · 0.5	kN/m
		·	= 6.23	
		0.01		
		m		

As = 498400 / (0.9 · 391.3 · 2600) = 8.87 cm² ⇒ 3 Ø 20 ⇒ 9.42 cm²

RCK 500 Fcd = 25.9 N/mq
b = 12 cm
h = 28 cm
c = 2 cm
d = h - c - Ø2
d = 251
fc = 29.3 N/mm²
fs = 374 N/mm²

STADIO I

$X = \frac{As \cdot fs}{b} \cdot (-1 + \sqrt{1 + \frac{2b \cdot d}{n \cdot As}})$

X = 94.20 · 1.5 = 141.30 mm

$\sigma c = \frac{2M}{b \cdot X \cdot (d - X/3)}$

σc = 0,025 kN/mm² = 25 kN/mm² < 25.9 N/mm²

$\sigma s = \frac{M}{(d - X/3) \cdot As}$

σs = 0,28 kN/mm² = 280 kN/mm² < 374 N/mm²

STADIO II

$X = \frac{n \cdot As}{b \cdot 0.8\,b} = 117.4\ mm$

$\overline{X} = 0.8 \cdot X = 93.92\ mm$

z = d - X/2 = 209 mm

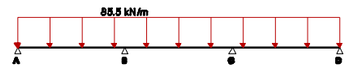
Mr = As · fs · z = 71918.5 kNmm

Mmax = 49849 kN mm < Mr = 71918.5 kNmm

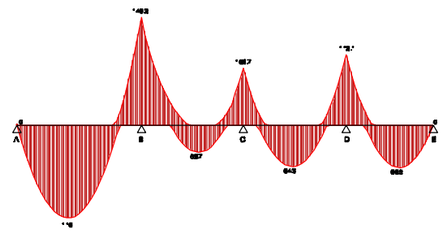
TRAVE 25 · 1000 · 280 · 1.4 = 9.8 kN/m
SOLAIO 6.79 · 8 · 1.4 = 75.7 kN/m
CARICHI VARIABILI 2 · 8 · 1.5 = 24 kN/m

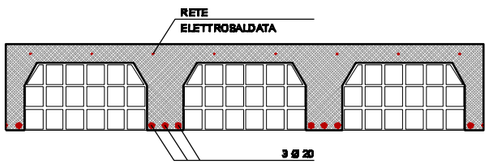
TOTALE CARICHI 86.5 kN/m

SCHEMA STATICO

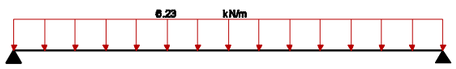


MOMENTO

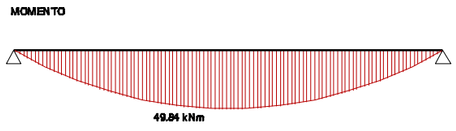




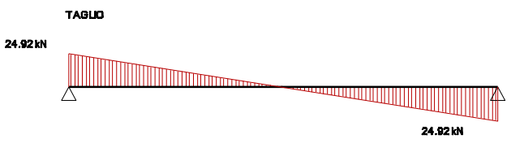
SCHEMA STATICO



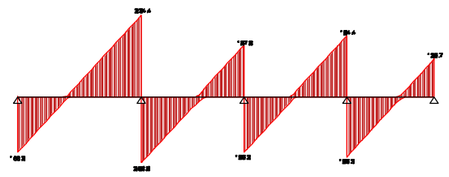
MOMENTO



TAGLIO



TAGLIO



b = 100 cm
h = 28 cm
d = 251
c' = 20 mm
fc = 25.9 N/mm²
fs = 374 N/mm²

ARMATURA A TRAVE NON COMPRESA

W = 0.352

fc · b · c {(0.156 − 0.776 · c − 0.776 · c')/(1.13 · 0.6 · 25.9 · 1000 · 251²)} ≥ 1.13 · 10⁻⁶

8650.6 c² − 91156 c − 1,16 · 10⁻⁶

c = 11.15 mm

As = (W · b · c · fc)/fs = 2550 mm² = 25.50 cm² ⇒ 12 Ø 16 ⇒ 30.64

As' = 0.5 · As = 14.40 cm² ⇒ 6 Ø 16 cm² ⇒ 15.27

ρ = As/b·d = 0.01 ⇒ 1.09 % > 0.5%

S^ADIO I

$x = \frac{As \cdot fs}{b} \cdot (-1 + \sqrt{1 + \frac{2b \cdot c}{f \cdot As}})$

X = 45.51 · 4.61 = 220.36 mm

$\sigma c = \frac{2M}{b \cdot X \cdot (d - X/3)}$

σc = 0,0095 kN/mm² = 9.49 kN/mm² < 25.9 N/mm²

$\sigma s = \frac{M}{(d - X/3) \cdot As}$

σs = 0,35 kN/mm² = 350 kN/mm² < 374 N/mm²

S^ADIO II

$x = \frac{f \cdot As}{b \cdot 0.8\,fc} = 95.12\ mm$

$\overline{X} = 0.8 \cdot X = 44.10\ mm$

z = d - X/3 = 235.69 mm

Mr = As · fs · z = 38.5 kNm

Mmax = 16.8 kNm < Mr = 38.5 kNm

6 Ø 16
12 Ø 16

ARMATURA A TRAVE NON COMPRESA

W = 0.352

fc · b · c {(0.156 − 0.776 · c − 0.776 · c')/(1.45 · 0.6 · 25.9 · 1000 · 251²)} ≥ 1.45 · 10⁻⁶

8650.6 c² − 91156 c − 1.45 · 10⁻⁶

c = 11.37 mm

As = (W · b · c · fc)/fs = 3260.64 mm² = 32.61 cm² ⇒ 16 Ø 22 ⇒ 34.21 cm² ⇒ 19.01

As' = 0.5 · As = 16.30 cm² ⇒ 8 Ø 22 cm² ⇒ 15.21

ρ = As/b·d = 0.01 ⇒ 1.1 % > 0.5%

S^ADIO I

$x = \frac{As \cdot fs}{b} \cdot (-1 + \sqrt{1 + \frac{2b \cdot c}{f \cdot As}})$

X = 51.51 · 2.37 = 136.42 mm

$\sigma c = \frac{2M}{b \cdot X \cdot (d - X/3)}$

σc = 0,0189 kN/mm² = 18.9 kN/mm² < 25.9 N/mm²

$\sigma s = \frac{M}{(d - X/3) \cdot As}$

σs = 0,33 kN/mm² = 330 kN/mm² < 374 N/mm²

S^ADIO II

$x = \frac{f \cdot As}{b \cdot 0.8\,fc} = 61.76\ mm$

$\overline{X} = 0.8 \cdot X = 49.39\ mm$

z = d - X/3 = 230.54 mm

Mr = As · fs · z = 37.7 kNm

Mmax = 16.8 kNm < Mr = 37.7 kNm

8 Ø 22
16 Ø 22

ARMATURA A TRAVE NON COMPRESA

W = 0.352

fc · b · c {(0.156 − 0.776 · c − 0.776 · c')/(1.65 · 0.6 · 25.9 · 1000 · 251²)} ≥ 1.65 · 10⁻⁶

8650.6 c² − 91156 c − 1.65 · 10⁻⁶

c = 11.54 mm

As = (W · b · c · fc)/fs = 2197 mm² = 21.97 cm² ⇒ 7 Ø 20 ⇒ 21.99 cm² ⇒ 11.57

As' = 0.5 · As = 10.99 cm² ⇒ 4 Ø 20 ⇒ 12.57

ρ = As/b·d = 0.009 ⇒ 7.8 % > 0.5%

S^ADIO I

$x = \frac{As \cdot fs}{b} \cdot (-1 + \sqrt{1 + \frac{2b \cdot c}{f \cdot As}})$

X = 32.65 · 3.61 = 99.55 mm

$\sigma c = \frac{2M}{b \cdot X \cdot (d - X/3)}$

σc = 0,0079 kN/mm² = 7.9 kN/mm² < 25.9 N/mm²

$\sigma s = \frac{M}{(d - X/3) \cdot As}$

σs = 0,13 kN/mm² = 130 kN/mm² < 374 N/mm²

S^ADIO II

$x = \frac{f \cdot As}{b \cdot 0.8\,fc} = 39.69\ mm$

$\overline{X} = 0.8 \cdot X = 31.75\ mm$

z = d - X/3 = 239.42 mm

Mr = As · fs · z = 20.5 kNm

Mmax = 6.6 kNm < Mr = 20.5 kNm

4 Ø 20
7 Ø 20

ARMATURA A TRAVE NON COMPRESA

W = 0.352

fc · b · c {(0.156 − 0.776 · c − 0.776 · c')/(1.82 · 0.6 · 25.9 · 1000 · 251²)} ≥ 1.82 · 10⁻⁶

8650.6 c² − 91156 c − 1.82 · 10⁻⁶

c = 11.63 mm

As = (W · b · c · fc)/fs = 3295 mm² = 32.95 cm² ⇒ 16 Ø 22 ⇒ 34.21 cm² ⇒ 19.01

As' = 0.5 · As = 16.48 cm² ⇒ 8 Ø 22 cm² ⇒ 15.21

ρ = As/b·d = 0.01 ⇒ 1.1 % > 0.5%

S^ADIO I

$x = \frac{As \cdot fs}{b} \cdot (-1 + \sqrt{1 + \frac{2b \cdot c}{f \cdot As}})$

X = 46.61 · 2.45 = 114.19 mm

$\sigma c = \frac{2M}{b \cdot X \cdot (d - X/3)}$

σc = 0,0144 kN/mm² = 14.4 kN/mm² < 25.9 N/mm²

$\sigma s = \frac{M}{(d - X/3) \cdot As}$

σs = 0,18 kN/mm² = 180 kN/mm² < 374 N/mm²

S^ADIO II

$x = \frac{f \cdot As}{b \cdot 0.8\,fc} = 84.89\ mm$

$\overline{X} = 0.8 \cdot X = 63.9\ mm$

z = d - X/3 = 227.69 mm

Mr = As · fs · z = 28.1 kNm

Mmax = 16.8 kNm < Mr = 28.1 kNm

8 Ø 22
16 Ø 22

ARMATURA A TRAVE NON COMPRESA

W = 0.352

fc · b · c {(0.156 − 0.776 · c − 0.776 · c')/(1.69 · 0.6 · 25.9 · 1000 · 251²)} ≥ 1.69 · 10⁻⁶

8650.6 c² − 91156 c − 1.69 · 10⁻⁶

c = 11.58 mm

As = (W · b · c · fc)/fs = 2343 mm² = 23.43 cm² ⇒ 8 Ø 20 ⇒ 25.12 cm² ⇒ 12.57

As' = 0.5 · As = 11.71 cm² ⇒ 4 Ø 20 cm² ⇒ 12.57

ρ = As/b·d = 0.009 ⇒ 0.89 % > 0.5%

S^ADIO I

$x = \frac{As \cdot fs}{b} \cdot (-1 + \sqrt{1 + \frac{2b \cdot c}{f \cdot As}})$

X = 37.99 · 2.77 = 105.63 mm

$\sigma c = \frac{2M}{b \cdot X \cdot (d - X/3)}$

σc = 0,0095 kN/mm² = 9.5 kN/mm² < 25.9 N/mm²

$\sigma s = \frac{M}{(d - X/3) \cdot As}$

σs = 0,11 kN/mm² = 110 kN/mm² < 374 N/mm²

S^ADIO II

$x = \frac{f \cdot As}{b \cdot 0.8\,fc} = 121.5\ mm$

$\overline{X} = 0.8 \cdot X = 97.08\ mm$

z = d - X/3 = 204.69 mm

Mr = As · fs · z = 23.9 kNm

Mmax = 16.8 kNm < Mr = 23.9 kNm

4 Ø 20
5 Ø 20

ARMATURA A TRAVE NON COMPRESA

W = 0.352

fc · b · c {(0.156 − 0.776 · c − 0.776 · c')/(1.121 · 0.6 · 25.9 · 1000 · 251²)} ≥ 1.121 · 10⁻⁶

8650.6 c² − 91156 c − 1.121 · 10⁻⁶

c = 11.40 mm

As = (W · b · c · fc)/fs = 3056 mm² = 30.56 cm² ⇒ 10 Ø 20 ⇒ 31.42 cm² ⇒ 12.57

As' = 0.5 · As = 15.28 cm² ⇒ 4 Ø 20 cm² ⇒ 12.57

ρ = As/b·d = 0.011 ⇒ 1.1 % > 0.5%

S^ADIO I

$x = \frac{As \cdot fs}{b} \cdot (-1 + \sqrt{1 + \frac{2b \cdot c}{f \cdot As}})$

X = 47.13 · 2.46 = 115.1 mm

$\sigma c = \frac{2M}{b \cdot X \cdot (d - X/3)}$

σc = 0,0143 kN/mm² = 14.4 kN/mm² < 25.9 N/mm²

$\sigma s = \frac{M}{(d - X/3) \cdot As}$

σs = 0,18 kN/mm² = 183 kN/mm² < 374 N/mm²

S^ADIO II

$x = \frac{f \cdot As}{b \cdot 0.8\,fc} = 98.71\ mm$

$\overline{X} = 0.8 \cdot X = 80.57\ mm$

z = d - X/3 = 227.2 mm

Mr = As · fs · z = 28.5 kNm

Mmax = 16.8 kNm < Mr = 28.5 kNm

4 Ø 20
10 Ø 20

ARMATURA A TRAVE NON COMPRESA

W = 0.352

fc · b · c {(0.156 − 0.776 · c − 0.776 · c')/(1.82 · 0.6 · 25.9 · 1000 · 251²)} ≥ 1.82 · 10⁻⁶

8650.6 c² − 91156 c − 1.82 · 10⁻⁶

c = 11.63 mm

As = (W · b · c · fc)/fs = 3295 mm² = 32.95 cm² ⇒ 12 Ø 20 ⇒ 34.13 cm² ⇒ 18.85

As' = 0.5 · As = 16.48 cm² ⇒ 6 Ø 20 cm² ⇒ 18.85

ρ = As/b·d = 0.013 ⇒ 0.86 % > 0.5%

S^ADIO I

$x = \frac{As \cdot fs}{b} \cdot (-1 + \sqrt{1 + \frac{2b \cdot c}{f \cdot As}})$

X = 36.19 · 2.64 = 103.69 mm

$\sigma c = \frac{2M}{b \cdot X \cdot (d - X/3)}$

σc = 0,0135 kN/mm² = 8.6 kN/mm² < 25.9 N/mm²

$\sigma s = \frac{M}{(d - X/3) \cdot As}$

σs = 0,12 kN/mm² = 122 kN/mm² < 374 N/mm²

S^ADIO II

$x = \frac{f \cdot As}{b \cdot 0.8\,fc} = 43.95\ mm$

$\overline{X} = 0.8 \cdot X = 34.54\ mm$

z = d - X/3 = 234.48 mm

Mr = As · fs · z = 28.8 kNm

Mmax = 6.6 kNm < Mr = 28.8 kNm

6 Ø 20
12 Ø 20

VERIFICA A TAGLIO

b = 100 cm
h = 28 cm
c = 2 cm
d = h - c - Ø2
d = 251
fc = 29.3 N/mm²
fs = 374 N/mm²
Vedu = 467.9 KN

$A_{staffe} = 0.1 \cdot (1 - 0.15 \cdot d/b) \cdot b = 12.37\ cm^2/m$
passo min = 0.8 · d = 200 mm = 20 cm ⇒ 5 staffe in un metro
passo max ≤ 12 · $\emptyset_{armatura}$ = 22 cm

Staffe a 2 bracci

$A_{staffa} = \frac{A_{staffe}}{n_{bracci}} = 1.237\ cm^2$ ⇒ Ø 12
113 mm²

VERIFICA A COMPRESSIONE DEL CLS

Vedu ≤ 0.3 · f_{cd} · b · d = Vrdu

Vrdu = 0.3 · 25.9 · 1000 · 251 = 1950.2 KN > 467.9 KN VERIFICATO

VERIFICA A COMPRESSIONE RISPETTO ALL'ARMATURA

Vedu ≤ V_{sd} + V_{rd} = Vrdu

V_{rd} = 0.9 · f_{yd} · b · d · δ= con δ=1

V_{rd} = 247.08 KN

$V_{sd} = A_{sw} \cdot f_{yd} \cdot \frac{0.9 \cdot d}{s} \cdot (\sin\beta + \cos\beta)$ (con β = 90 angolo tra staffe e armatura)

V_{sd} = 98.5 KN

Vrdu = 222 − 95 = 345.59 KN > 171.4 KN VERIFICATO PER CAMPATE AB E GH
< 467.9 KN NON VERIFICATO PER LE ALTRE CAMPATE

NUOVA STAFFATURA PER CAMPATE BC E CD

$\frac{A_{sw}}{s} \geq \frac{V_{sd} - V_{rd}}{f_{yd} \cdot 0.9 \cdot d} = 2.31\ mm$

$\frac{A_{sw}}{s} \geq 2.31\ mm$

con Ø 16

$s \leq \frac{2 \cdot 113}{2.31}$

s ≤ 97 mm

VERIFICA STAFFATURA PER CAMPATE BC E CD

$V_{rd} = A_{sw} \cdot f_{yd} \cdot \frac{0.9 \cdot d}{s}$ = 212.15 KN

Vrdu = 247.08 + 212.15 = 459.23 KN > 442.20 KN VERIFICATO

NUOVA STAFFATURA PER CAMPATE DE E EF

$\frac{A_{sw}}{s} \geq \frac{V_{sd} - V_{rd}}{f_{yd} \cdot 0.9 \cdot d} = 1.54\ mm$

$\frac{A_{sw}}{s} \geq 1.54\ mm$

con Ø 16

$s \leq \frac{2 \cdot 113}{1.54}$

s ≤ 146 mm

VERIFICA STAFFATURA PER CAMPATE DE E EF

$V_{rd} = A_{sw} \cdot f_{yd} \cdot \frac{0.9 \cdot d}{s}$ = 1272.93 KN

Vrdu = 247.08 + 1272.93 = 1520 KN > 442.20 KN VERIFICATO

NUOVA STAFFATURA PER CAMPATE EF E FG

$\frac{A_{sw}}{s} \geq \frac{V_{sd} - V_{rd}}{f_{yd} \cdot 0.9 \cdot d} = 1.66\ mm$

$\frac{A_{sw}}{s} \geq 1.66\ mm$

con Ø 16

$s \leq \frac{2 \cdot 113}{1.66}$

s ≤ 136 mm

VERIFICA STAFFATURA PER CAMPATE BC E CD

$V_{rd} = A_{sw} \cdot f_{yd} \cdot \frac{0.9 \cdot d}{s}$ = 1363.85 KN

Vrdu = 247.08 + 1363.85 = 1610.93 KN > 442.20 KN VERIFICATO

POLITECNICO DI MILANO - Facoltà di Architettura Civile - Corso di Laurea Specialistica in Architettura delle Costruzioni
Laboratorio di Progettazione e Costruzione dell'Architettura - Anno Accademico 2009 - 2010
Docenti: R. Neri, S. Sirtl, E. Genvaglia, S. Croce, S. La Mura

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