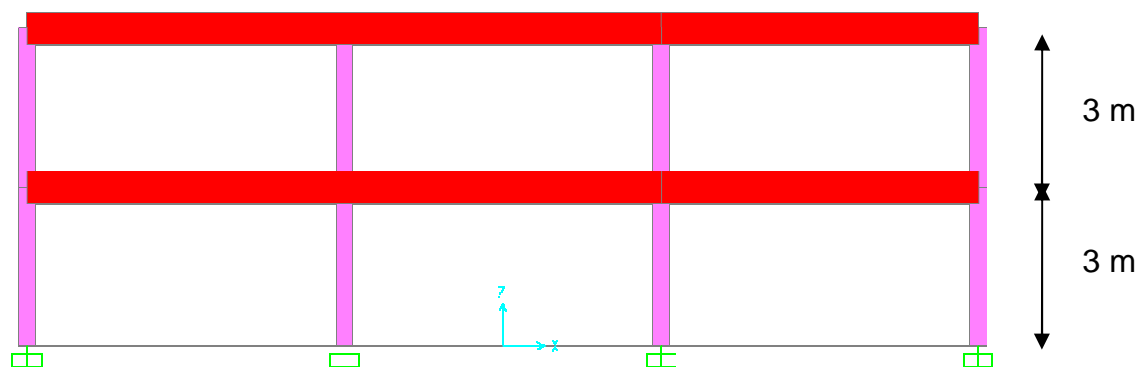
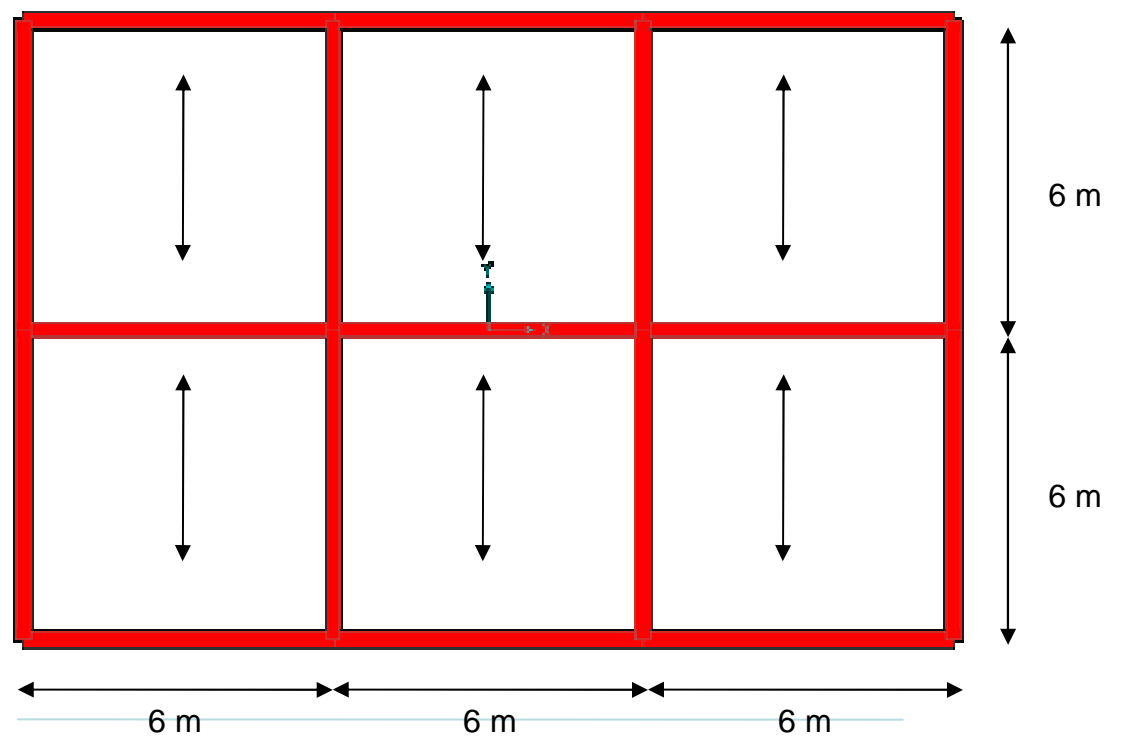


ESERCITAZIONE 2

PROGETTO E VERIFICA DI UNA TRAVE IN CEMENTO ARMATO



ESERCITAZIONE 2

PROGETTO E VERIFICA ALLO SLE E SLU DI UNA TRAVE IN C.A.

1. ANALISI DEI CARICHI

| GP1 | GP2 | acc. | | neve | vento |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | | Qint. | Qint. | N | V |
| [kN/m ²] | [kN/m ²] | [kN/m ²] | [kN/m ²] | [kN/m ²] | [kN/m ²] |
| 3.00 | 2.00 | 2.00 | 0.50 | 1.00 | 0.45 |

| | | |
|---|-------------------|-------|
| LINEA INFLUENZA TELAIO PORTANTE | [m] | 6.00 |
| LUNGHEZZA TRAVE MAGGIORE | [m] | 6.00 |
| AREA INFLUENZA PILASTRO PIU' SOLLECITATO | [m ²] | 36.00 |
| LUNGHEZZA PILASTRO MAGGIORE | [m] | 3.00 |
| NUMERO DI PIANI GRAVANTI SUL PILASTRO PIU' SOLLECITATO | | 2 |

CARICHI SULLA TRAVE (sl_e)

| G _k | GP1 | GP2 | acc. | | neve |
|----------------|--------|--------|--------|--------|--------|
| | | | Qint. | Qint. | N |
| [kN/m] | [kN/m] | [kN/m] | [kN/m] | [kN/m] | [kN/m] |
| ? | 18.00 | 12.00 | 12.00 | 3.00 | 6.00 |

(*) considera: pavimento, massetto, impianti, tramezzi e tamponature

| | | |
|--|-----|------|
| per definire G_k (peso proprio della trave) si usi in questa fase una sezione di tentativo secondo la normativa $h > L/20$ in questo caso | [m] | 0.30 |
|--|-----|------|

| sezione di tentativo: | B | H | γ_{cls} | G _k |
|-----------------------|-------|-------|----------------------|----------------|
| | [cm] | [cm] | [kN/m ³] | [kN/m] |
| | 30.00 | 40.00 | 25.00 | 3.00 |

coefficienti di amplificazione sl_u

| G _k | GP1 | GP2 | acc. | | neve |
|----------------|--------|--------|--------|--------|--------|
| | | | Qint. | Qint. | N |
| [kN/m] | [kN/m] | [kN/m] | [kN/m] | [kN/m] | [kN/m] |
| 1.30 | 1.30 | 1.50 | 1.50 | 1.50 | 1.50 |

| Gk | GP1 | GP2 | Qint. | Qint. | N |
|--------|--------|--------|--------|--------|--------|
| [kN/m] | [kN/m] | [kN/m] | [kN/m] | [kN/m] | [kN/m] |
| 3.90 | 23.40 | 18.00 | 18.00 | 4.50 | 9.00 |

| | | | |
|---|--------|-------|-----|
| VALORE TOTALE PER IL PREDIMENSIONAMENTO (trave livello +1) | [kN/m] | 45.00 | sle |
| | [kN/m] | 63.30 | slu |

per definire Gk (peso proprio del pilastro) si usi in questa fase

una sezione di tentativo secondo la normativa $h > L/20$ in questo caso

| | |
|-----|------|
| [m] | 0.15 |
|-----|------|

| | | | | |
|-----------------------|-------|-------|----------------------|------|
| sezione di tentativo: | B | H | γ_{cls} | Gk |
| | [cm] | [cm] | [kN/m ³] | [kN] |
| | 30.00 | 30.00 | 25.00 | 6.75 |

CARICHI SUL PILASTRO

valori di 1 piano

| Gk | GP1 | GP2 | acc. | | neve |
|------|--------|-------|-------|-------|-------|
| | | | Qint. | Qint. | N |
| [kN] | [kN] | [kN] | [kN] | [kN] | [kN] |
| 6.75 | 108.00 | 72.00 | 72.00 | 18.00 | 36.00 |

DISTRIBUITO

| |
|----------------------|
| vento |
| V |
| [kN/m ²] |
| 2.70 |

| | | |
|---|------|----|
| incidenza travi (ipotizzando 4 travi sul pilastro per piano) | [kN] | 36 |
|---|------|----|

| | | | |
|--|--------|--------|-----|
| VALORE TOTALE PER IL PREDIMENSIONAMENTO | [kN/m] | 589.50 | sle |
| | [kN/m] | 823.95 | slu |

2. PREDIMENSIONAMENTO SEZIONI

PILASTRO (sezione quadrata) (slu)

Area acciaio utilizzata (1 per vertice)

| Ac,min | L | As,min | As,min |
|--------------------|-------|--------------------|--------------------|
| [cm ²] | [cm] | [cm ²] | [cm ²] |
| 567.26 | 23.82 | 4.54 | 2.01 |

TRAVE

si usa il modello di trave appoggiata

| | | slu | sle |
|---|-------|--------|--------|
| momento flettente massimo (PL²/8) | [kNm] | 284.85 | 202.50 |
| base della trave | [cm] | 30.00 | 30.00 |

| b | r | slu | sle | slu | sle |
|-------|------|-------|-------|--------------------|--------------------|
| | | h,min | h,min | As | As |
| [cm] | | [cm] | [cm] | [cm ²] | [cm ²] |
| 30.00 | 0.20 | 61.63 | 51.96 | 13.12 | 11.07 |

RIEPILOGO SEZIONI INIZIALI DA VERIFICARE:

PILASTRO

| b | h |
|-------|-------|
| [cm] | [cm] |
| 30.00 | 30.00 |

TRAVE

| b | h |
|-------|-------|
| [cm] | [cm] |
| 30.00 | 60.00 |

3. DEFINIZIONE DEI MATERIALI

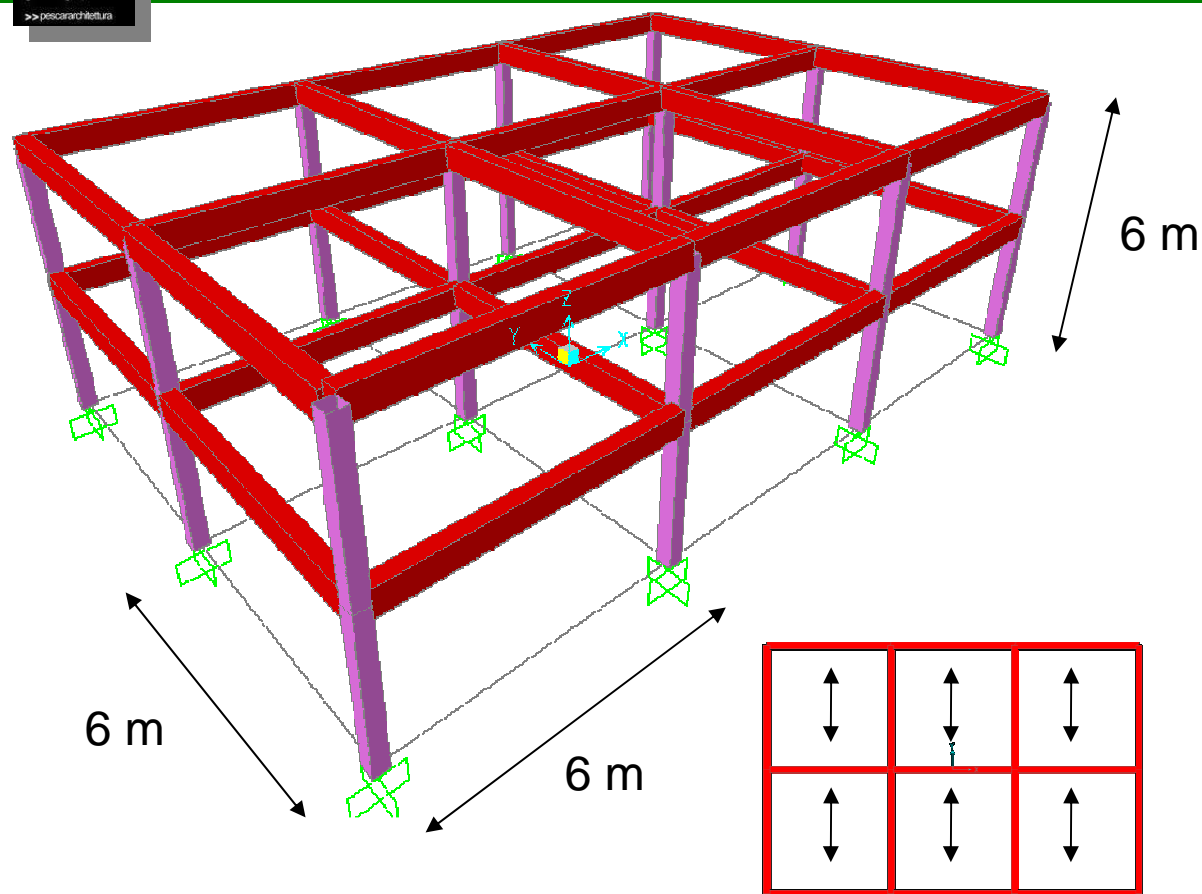
CARATTERISTICHE MECCANICHE DELLA SEZIONE

calcestruzzo

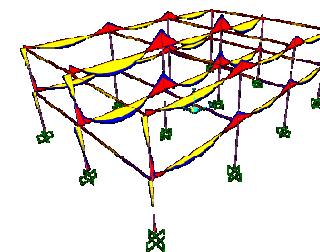
| compressione | | | | | | | | | | | trazione | | | | |
|--------------|----------|-------|------------|------------|------------|----------|----------------|-------------------------|-------------------------|-----------------|-----------------|---------------|---------------|---------------|--------------|
| Rck | Ec | fck | γ_c | slu fcd | sle fcd | α | α_{fcd} | D.M. 2005 σ_c | D.M. 1996 σ_c | ϵ_{c1} | ϵ_{cu} | a flessione | | | |
| [Mpa] | [Mpa] | [Mpa] | | [Mpa] | [Mpa] | | [Mpa] | [Mpa] | [Mpa] | [‰] | [‰] | fctm [Mpa] | fctk [Mpa] | fctd [Mpa] | fck [Mpa] |
| 25.00 | 28500.00 | 20.75 | 1.50 | 13.83 | 20.75 | 0.85 | 11.76 | 7.81 | 8.50 | 2.00 | 3.50 | 2.31 | 1.62 | 1.08 | 1.94 |

acciaio

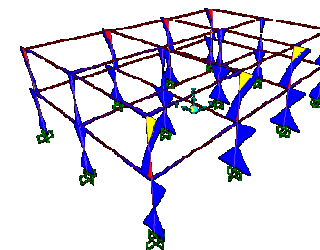
| fyk | Es | γ_c | fyd | ϵ_{s1} | ϵ_{su} | D.M. 1996 σ_s |
|--------|-----------|------------|--------|-----------------|-----------------|-------------------------|
| [Mpa] | [Mpa] | | [Mpa] | [‰] | [‰] | [Mpa] |
| 450.00 | 206000.00 | 1.15 | 391.30 | 2.50 | 10.00 | 255.00 |



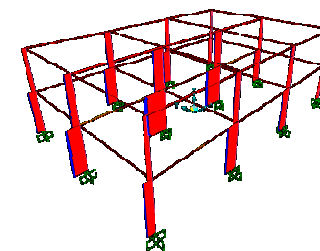
M3
3



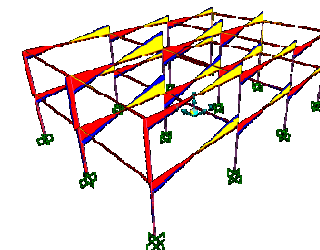
M2
2



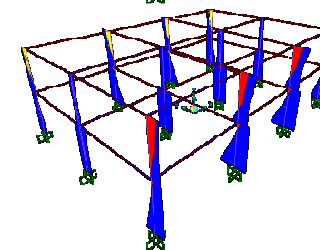
N



V22



V33



4. ANALISI STATICA LINEARE SU MODELLO FEM

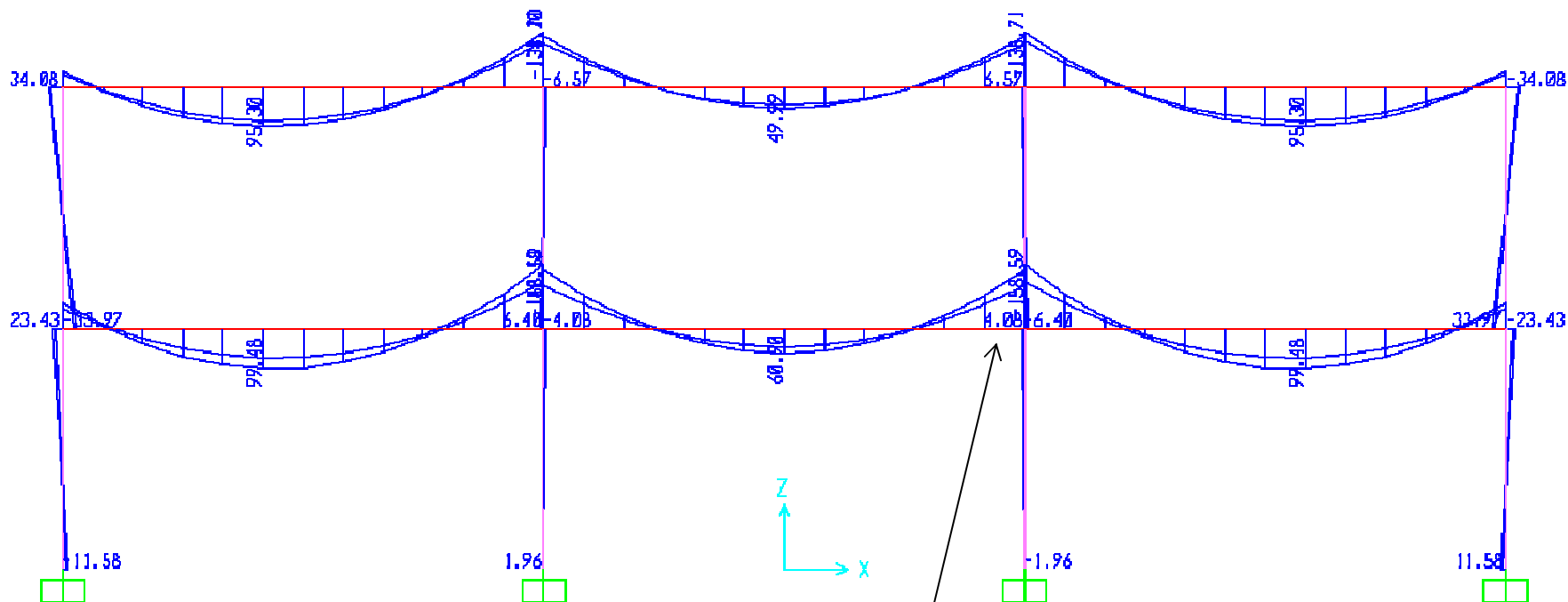
SOLLECITAZIONI (sle)

| M22 | M33 | V22 | V33 | N |
|-------|--------|--------|------|------|
| [kNm] | [kNm] | [kN] | [kN] | [kN] |
| 0.00 | 147.18 | 226.00 | 0.00 | 0.00 |

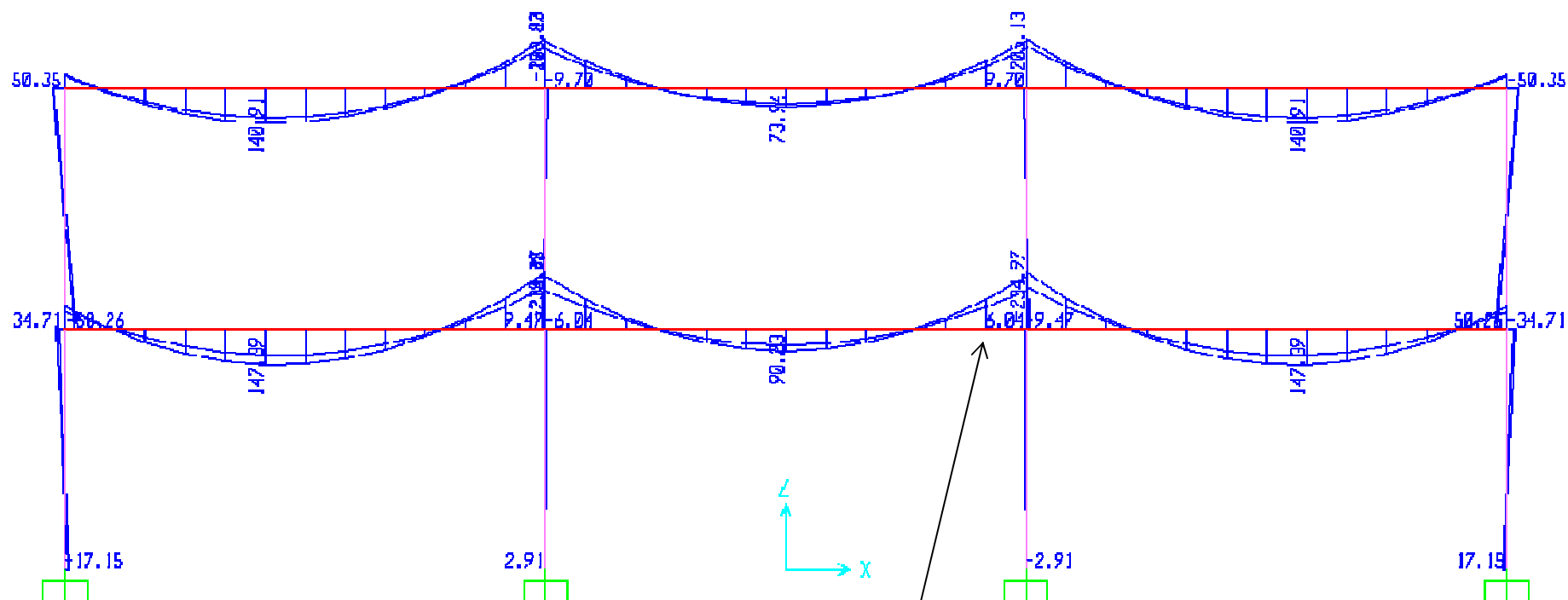
SOLLECITAZIONI (slu)

| M22 | M33 | V22 | V33 | N |
|-------|--------|--------|------|------|
| [kNm] | [kNm] | [kN] | [kN] | [kN] |
| 0.00 | 218.70 | 226.00 | 0.00 | 0.00 |

Momento flettente (comb_tot_envelope) (M33) sle



Momento flettente (comb_tot_envelope) (M33) slu



Valore massimo (M33) = 218.70 kNm

5. VERIFICHE STRUTTURALI

5.1 VERIFICA A FLESSIONE DELLA TRAVE

CARATTERISTICHE GEOMETRICHE DELLA SEZIONE

| b | h | d | c | As' | As |
|-------|-------|-------|------|--------------------|--------------------|
| [cm] | [cm] | [cm] | [cm] | [cm ²] | [cm ²] |
| 30.00 | 60.00 | 56.00 | 4.00 | 4.00 | 20.60 |

1° STADIO

coefficiente di omogeneizzazione

| effettivo | di calcolo |
|-----------|------------|
| 7.23 | 15 |

Si fessura



| A,sez | Sx | dG,sup | dG,inf | Ix | Mcr | $\sigma_{c,sup}$ | $\sigma_{c,inf}$ | $\sigma_{s,sup}$ | $\sigma_{s,inf}$ |
|--------------------|--------------------|--------|--------|--------------------|-------|------------------|------------------|------------------|------------------|
| [cm ²] | [cm ³] | [cm] | [cm] | [cm ⁴] | [kNm] | [Mpa] | [Mpa] | [Mpa] | [Mpa] |
| 2169.00 | 62453.95 | 28.79 | 31.21 | 670602.27 | 23.15 | 8.59 | 9.31 | 110.92 | 121.71 |

2° STADIO

| | effettivo | di calcolo |
|----------------------------------|-----------|------------|
| coefficiente di omogeneizzazione | 7.23 | 15 |

| asse neutro | | controllo | | | | | | | |
|-------------|--------------------|--------------------|--------------------|--------------------|------------|-------------|------------|--------|--------|
| x | Sx | Ac | A,sez | Ix | σ_c | σ_s' | σ_s | Mrc | Mrs |
| [cm] | [cm ³] | [cm ²] | [cm ²] | [cm ⁴] | [Mpa] | [Mpa] | [Mpa] | [kNm] | [kNm] |
| 24.04 | 0.00 | 721.32 | 1090.32 | 478653.89 | 10.05 | 125.63 | 200.29 | 169.21 | 149.59 |

3° STADIO

| α | β | k | u | γ | compresso | | compresso | teso | compresso | teso | ξ | γ |
|----------|---------|------|------|-----------|---------------|--------------|-------------|------------|-----------|------|------------|----------|
| | | | | | ϵ_s' | ϵ_s | σ_s' | σ_s | s' | s | | |
| 0.85 | 0.81 | 0.42 | 0.19 | -0.000154 | 0.002884175 | -0.0051216 | -391.30 | 391.30 | -1.00 | 1.00 | 0.40 60 | 0.07 |

| ω | ω' | ρ | ρ' |
|----------|-----------|--------|---------|
| 0.41 | 0.79 | 0.0114 | 0.0022 |

| campo 2-3 | | campo 3-4 | |
|-----------|------------|-----------|------------|
| s=s'=1 | | s=s'=1 | |
| ξ_2 | ω_2 | ξ_3 | ω_3 |
| 0.26 | 0.26 | 0.65 | 0.66 |

non si trova in campo 3

si trova tra il campo 3 e il campo 4

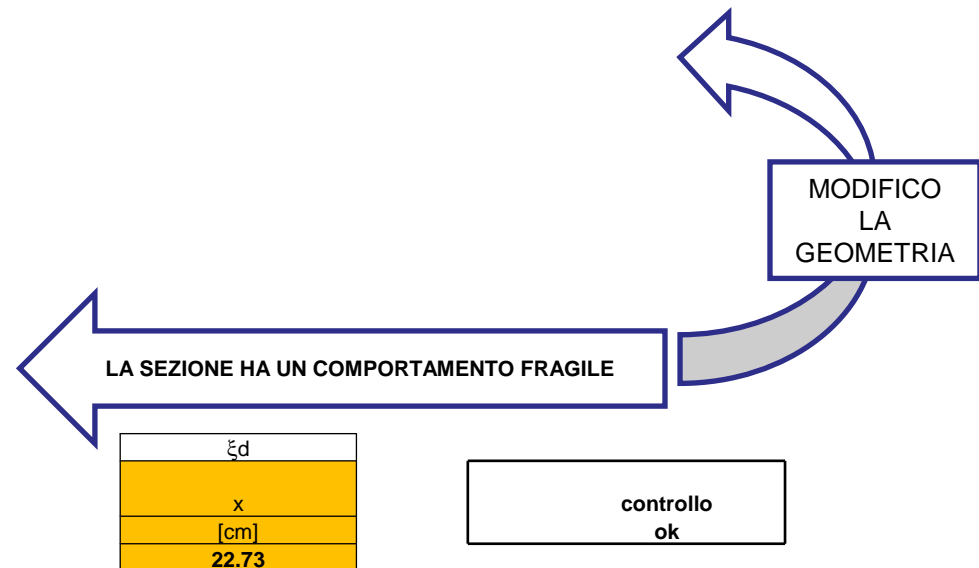
| Nc | Ns' | Ns |
|---------|---------|--------|
| [kN] | [kN] | [kN] |
| -649.57 | -156.52 | 806.09 |

| Nc+Ns'+Ns |
|-----------|
| 0.00 |

| | |
|-----------------------------|-------|
| equilibrio alla traslazione | -0.16 |
|-----------------------------|-------|

| | | | |
|---------------------------|-----|-------|--------|
| equilibrio alla rotazione | Mrd | [kNm] | 366.63 |
|---------------------------|-----|-------|--------|

Residuo numerico



| ξd |
|---------|
| x |
| [cm] |
| 22.73 |

controllo ok

MODIFICO LA GEOMETRIA => riduco l'area dell'acciaio teso

CARATTERISTICHE GEOMETRICHE DELLA SEZIONE

| b | h | d | c | As' | As |
|-------|-------|-------|------|--------------------|--------------------|
| [cm] | [cm] | [cm] | [cm] | [cm ²] | [cm ²] |
| 30.00 | 60.00 | 56.00 | 4.00 | 4.02 | 12.06 |

3° STADIO

| α | β | k | u | χ | compresso | teso | compresso | teso | compresso | teso | ξ | γ |
|----------|---------|------|------|------------|---------------|--------------|-------------|------------|-----------|------|--------|----------|
| | | | | | $\epsilon s'$ | ϵs | $\sigma s'$ | σs | s' | s | | |
| 0.85 | 0.81 | 0.42 | 0.33 | -0.0003179 | 0.002228521 | -0.0143007 | [Mpa] | [Mpa] | -1.00 | 1.00 | 0.1966 | 0.07 |
| | | | | | | | -391.30 | 391.30 | | | | |

| ω | ω' | ρ | ρ' |
|-------------|-----------|--------|---------|
| 0.24 | 0.80 | 0.0067 | 0.0022 |

| campo 2-3 | | campo 3-4 | |
|-------------------------|-------------|-------------------------|-------------|
| s=s'=1 | | s=s'=1 | |
| ξ_2 | ω_2 | ξ_3 | ω_3 |
| 0.26 | 0.32 | 0.65 | 0.79 |
| non si trova in campo 3 | | non si trova in campo 4 | |
| si trova nel campo 2 | | | |

| Nc | Ns' | Ns | Nc+Ns'+Ns |
|---------|---------|--------|-------------|
| [kN] | [kN] | [kN] | [kN] |
| -314.61 | -157.30 | 471.91 | 0.00 |

LA SEZIONE HA UN COMPORTAMENTO DUTTILE

| ξd |
|--------------|
| x |
| [cm] |
| 11.01 |

controllo
ok

equilibrio alla traslazione **-0.16**

equilibrio alla rotazione Mrd [kNm] **241.74**