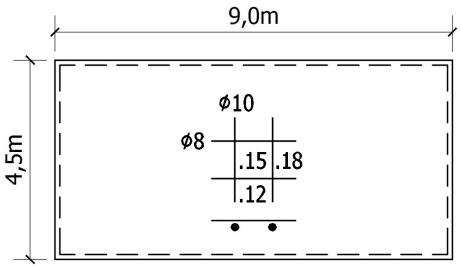
Ejercicio 1

a)

$M_{d,y}^{+} = 31{,}80\ kNm/m \rightarrow A_{s,nec} = 6{,}26\ cm^2/\text{m} \rightarrow \text{Ø}10/12$

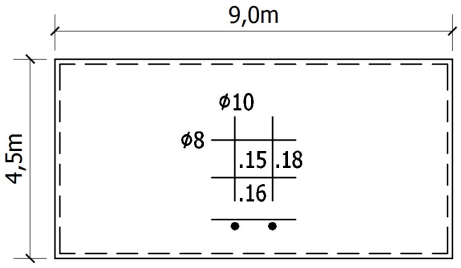
$M_{d,x}^{+} = 7{,}95\ kNm/m \rightarrow A_{s,nec} = 1{,}62\ cm^2/\text{m}$
$A_{s,nec} = 2{,}70\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \text{Ø}8/18$



b)

$M_{d,y}^{+} = 25{,}18\ kNm/m \rightarrow A_{s,nec} = 4{,}88\ cm^2/\text{m} \rightarrow \text{Ø}10/16$

$M_{d,x}^{+} = 8{,}14\ kNm/m \rightarrow A_{s,nec} = 1{,}66\ cm^2/\text{m}$
$A_{s,nec} = 2{,}70\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \text{Ø}8/18$



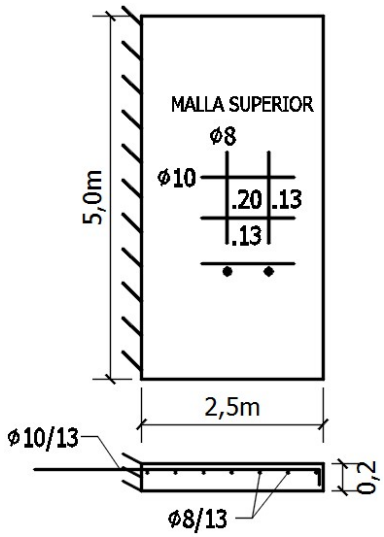
Ejercicio 2

i.

$M_{d,y}^{-} = 39{,}84\ kNm/m \rightarrow A_{s,nec} = 5{,}77\ cm^2/\text{m} \rightarrow \text{Ø}10/13$

$M_{d,x}^{-} = 9{,}96\ kNm/m \rightarrow A_{s,nec} = 1{,}49\ cm^2/\text{m}$
$A_{s,nec} = 3{,}60\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \text{Ø}8/13$

$V_d = 31{,}9\ kN/m < V_{Rd,c} = 89{,}47\ kN/m\ (verifica)$

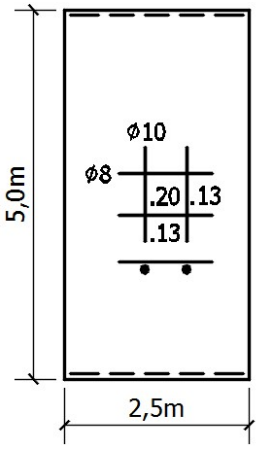


ii.

$M_{d,x}^{+} = 39{,}84\ kNm/m \rightarrow A_{s,nec} = 5{,}77\ cm^2/\text{m} \rightarrow \text{Ø}10/13$

$M_{d,y}^{+} = 9{,}96\ kNm/m \rightarrow A_{s,nec} = 1{,}49\ cm^2/\text{m}$
$A_{s,nec} = 3{,}60\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \text{Ø}8/13$

$V_d = 31{,}9\ kN/m < V_{Rd,c} = 89{,}47\ kN/m\ (verifica)$



Ejercicio 3

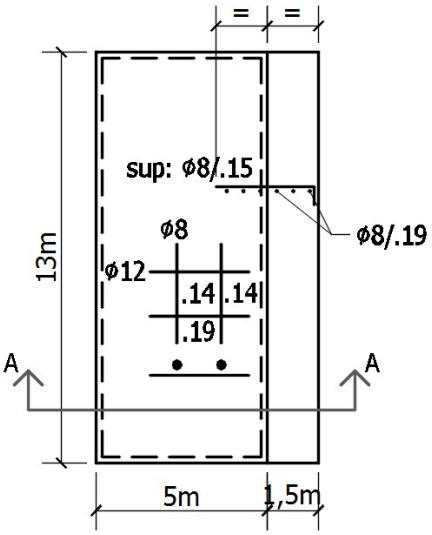
i.

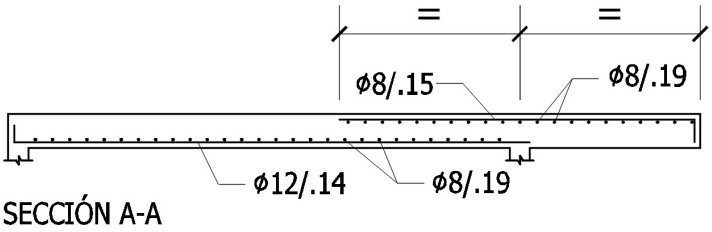
$M_{d,y}^{-} = 15{,}69\ kNm/m \rightarrow A_{s,nec} = 3{,}22\ cm^2/\text{m} \rightarrow \text{Ø}8/15$

$M_{d,x}^{-} = 3{,}92\ kNm/m \rightarrow A_{s,nec} = 0{,}87\ cm^2/\text{m}$
$A_{s,nec} = 2{,}52\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \text{Ø}8/19$

$M_{d,y}^{+} = 36{,}10\ kNm/m \rightarrow A_{s,nec} = 7{,}78\ cm^2/\text{m} \rightarrow \text{Ø}12/14$

$M_{d,x}^{+} = 9{,}02\ kNm/m \rightarrow A_{s,nec} = 2{,}03\ cm^2/\text{m}$
$A_{s,nec} = 2{,}52\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \text{Ø}8/19$





SECCIÓN A-A

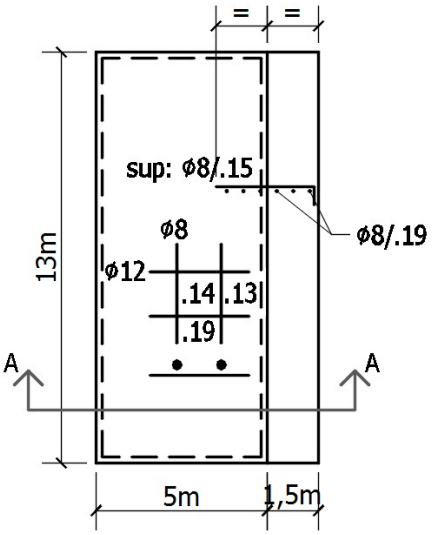
ii.

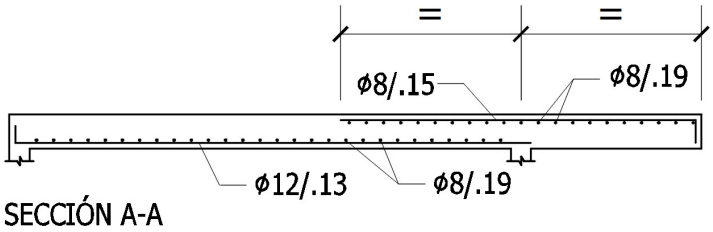
$M_{d,y}^{-} = 15{,}69\ kNm/m \rightarrow A_{s,nec} = 3{,}22\ cm^2/\text{m} \rightarrow \text{Ø}8/15$

$M_{d,x}^{-} = 3{,}92\ kNm/m \rightarrow A_{s,nec} = 0{,}87\ cm^2/\text{m}$
$A_{s,nec} = 2{,}52\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \text{Ø}8/19$

$M_{d,y}^{+} = 38{,}44\ kNm/m \rightarrow A_{s,nec} = 8{,}32\ cm^2/\text{m} \rightarrow \text{Ø}12/13$

$M_{d,x}^{+} = 9{,}61\ kNm/m \rightarrow A_{s,nec} = 2{,}17\ cm^2/\text{m}$
$A_{s,nec} = 2{,}52\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \text{Ø}8/19$



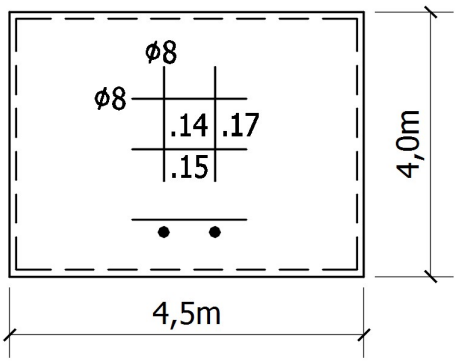


SECCIÓN A-A

Ejercicio 4

$M_{d,y}^{+} = 13{,}32\ kNm/m \ \rightarrow \ A_{s,nec} = 3{,}27\ cm^2/\text{m} \rightarrow \emptyset 8/15$

$M_{d,x}^{+} = 10{,}96\ kNm/m \ \rightarrow \ A_{s,nec} = 2{,}95\ cm^2/m \rightarrow \emptyset 8/17$



Descargas a los apoyos:

- Apoyos cortos: $CM = 3{,}5\ kN/m\ , SCU = 7{,}5\ kN/m$
- Apoyos largos: $CM = 3{,}9\ kN/m\ , SCU = 8{,}3\ kN/m$

$V_d = 17{,}7\ kN/m < V_{Rd,c} = 57{,}42\ kN/m\ (verifica)$

Ejercicio 5

$$M_{d,y}^{+} = 10{,}84\ kNm/m \ \rightarrow \ A_{s,nec} = 3{,}78\ cm^2/\text{m} \rightarrow \emptyset 10/20$$

$$M_{d,x}^{+} = 3{,}90\ kNm/m \ \rightarrow \ A_{s,nec} = 1{,}54\ cm^2/m$$

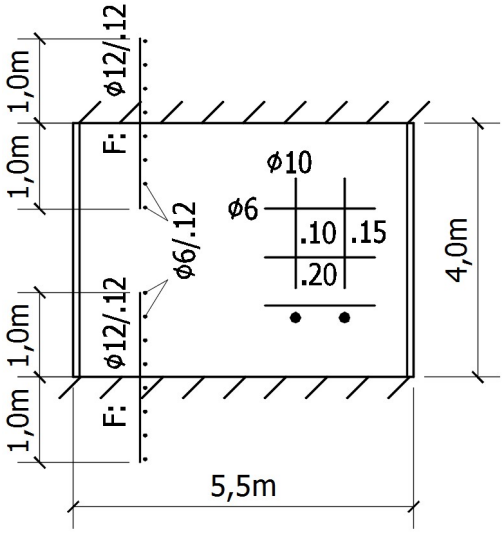
$$A_{s,nec} = 1{,}84\ cm^2/\text{m}\ (cuantía\ mecánica) \rightarrow \emptyset 6/15$$

$$M_{d,y}^{-} = 22{,}82\ kNm/m \ \rightarrow \ A_{s,nec} = 8{,}84\ cm^2/\text{m} \rightarrow \emptyset 12/12$$

$$M_{d,x}^{-} = 5{,}71\ kNm/m \ \rightarrow \ A_{s,nec} = 2{,}28\ cm^2/m \rightarrow \emptyset 6/12$$

Descargas a los apoyos:

- Ap. empotrados: $CM = 3{,}95\ kN/m\ , SCU = 15{,}0\ kN/m$
- Ap. articulados: $CM = 1{,}4\ kN/m\ , SCU = 5{,}5\ kN/m$



Ejercicio 6

$$M_{y,u} = 22{,}61\ kNm/m\ , M_{x,u} = 10{,}19\ kNm/m \ \rightarrow \ SCU_u = 11{,}94\ \text{kN}/m^2$$

Ejercicio 7

$$M_{d,y}^{+} = 14{,}13\ kNm/m \ \rightarrow \ A_{s,nec} = 2{,}92\ cm^2/\text{m} \rightarrow \emptyset 8/17$$

$$M_{d,x}^{+} = 7{,}99\ kNm/m \ \rightarrow \ A_{s,nec} = 1{,}79\ cm^2/m$$

$$A_{s,nec} = 2{,}52\ cm^2/\text{m}\ (cuantía\ geométrica) \rightarrow \emptyset 8/19$$

$$M_{d,y}^{-} = 31{,}03\ kNm/m \ \rightarrow \ A_{s,nec} = 6{,}79\ cm^2/\text{m} \rightarrow \emptyset 12/16$$

$$M_{d,x}^{-} = 7{,}76\ kNm/m \ \rightarrow \ A_{s,nec} = 1{,}74\ cm^2/m \rightarrow \emptyset 6/16$$

Descargas a los apoyos:

- Apoyo intermedios: $CM = 12{,}6\ kN/m\ , SCU = 34{,}7\ kN/m$

$$V_d = 34{,}5\ kN/m < V_{Rd,c} = 67{,}31\ kN/m\ (verifica)$$