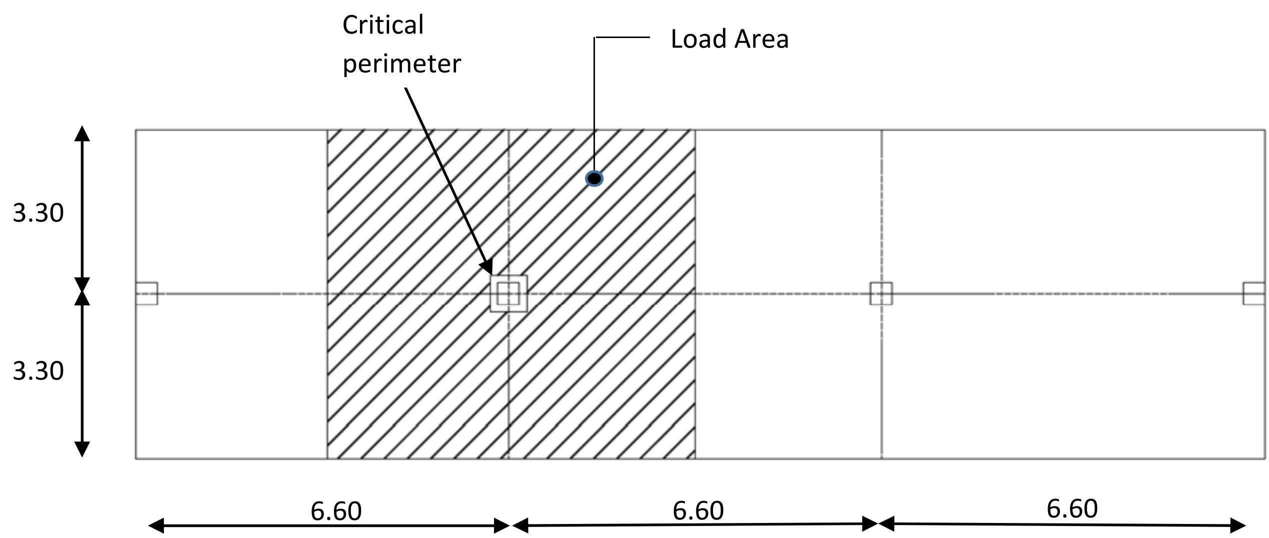
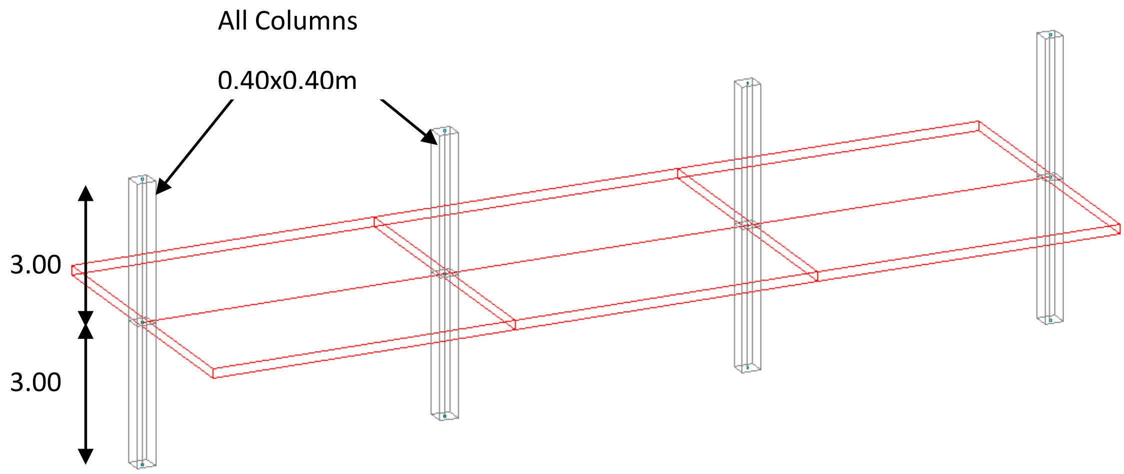
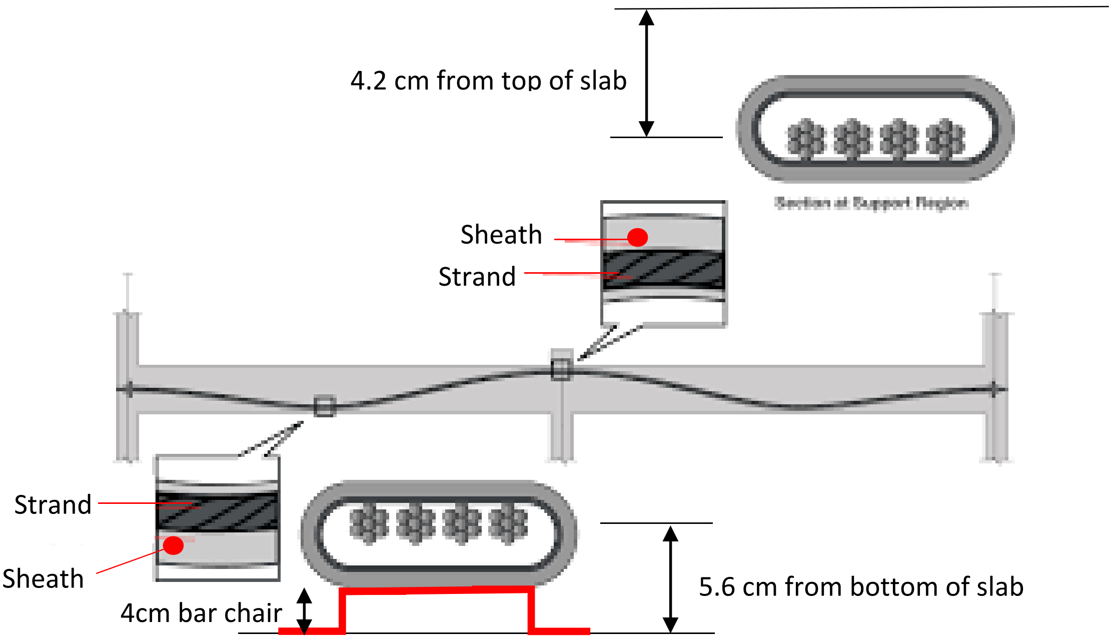
Example 1





Material	Concrete	fc' slab	320	ksc
		fc' Column	240	ksc
	Rebar SD40	fy	4000	ksc
	Strand diameter 12.7mm Low relaxation			
		fpu	18,975	ksc
Design code	ACI318-99	ϕD = 1.4, ϕL = 1.7		
Load	SDL	200	kg/m^2	
	LL	200	kg/m^2	

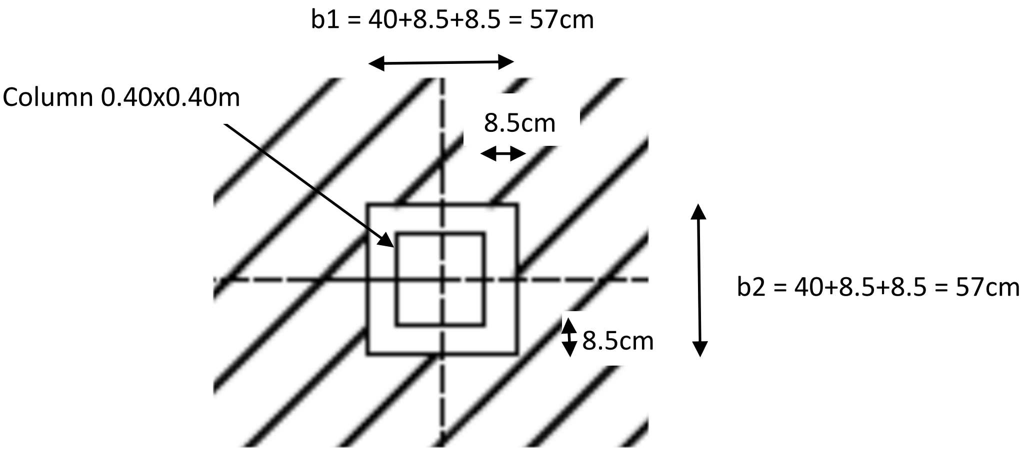
Slab thickness 0.20m



w = (SW+SDL)+LL =(480+200)+200 = 880 kg/m^2

wu =1.4x(SW+SDL)+1.7x200 = 1,292 kg/m^2

- **Check Punching Shear**



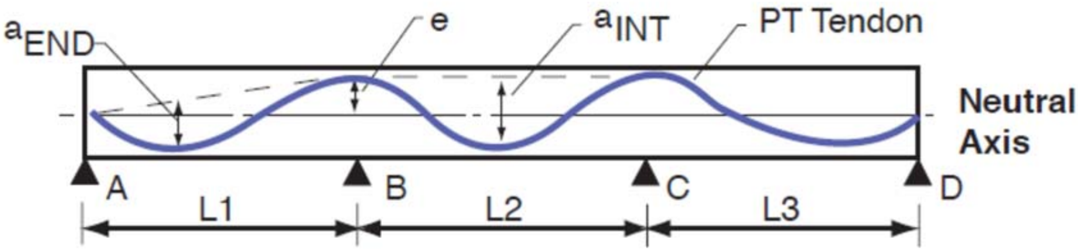
Vu = 1,292x(6.60x6.60-0.57x0.57) = 55,860 kg

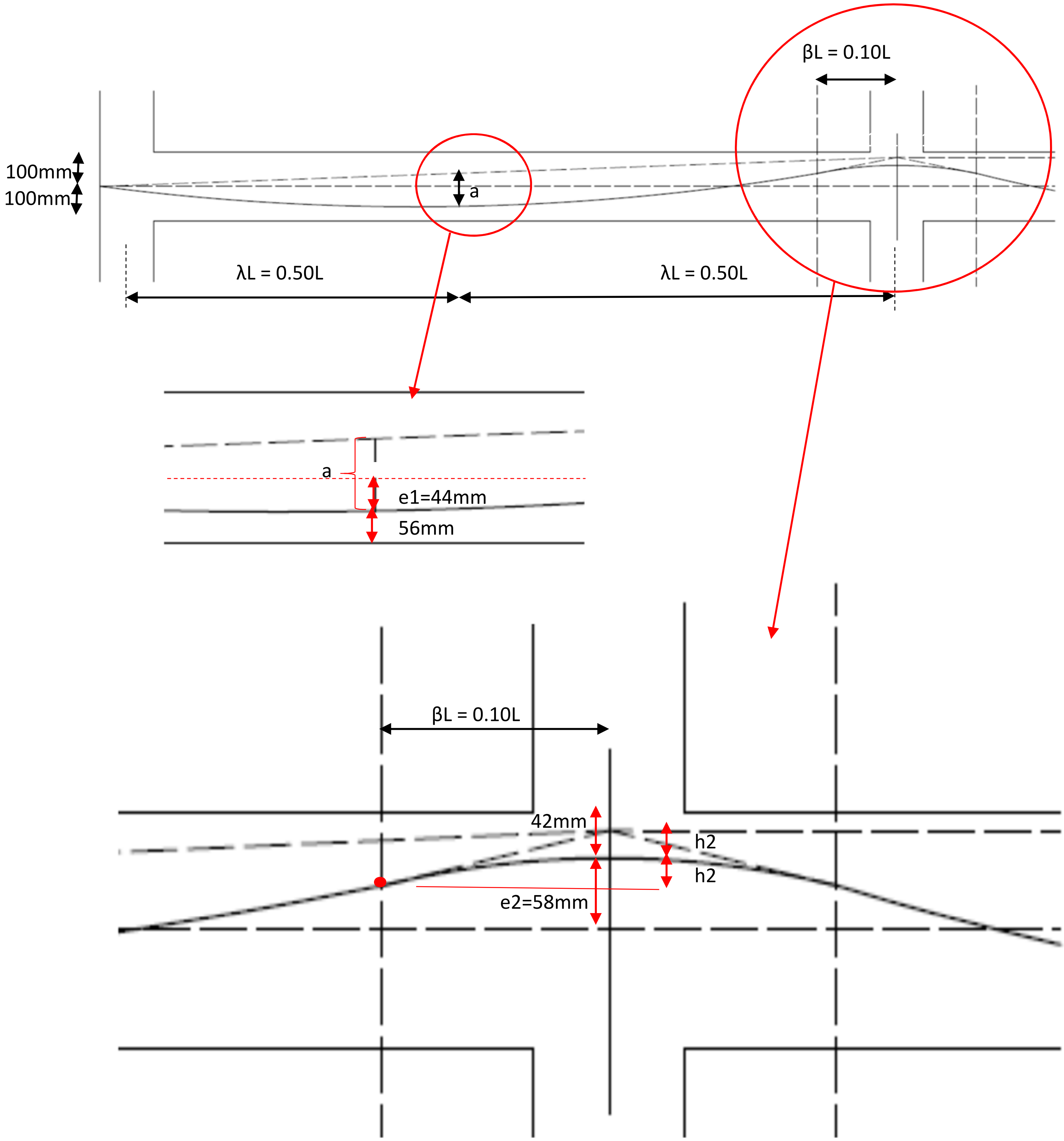
ϕVc = $0.85 \times 1.06\sqrt{fc'}\, b_o d$ ACI Code 11.11.2

= $0.85 \times 0.85 \times 1.06\sqrt{320}$ (4x57) x 17 = 62,471 kg > 55,860 kg OK

SPAN#1

- **Calculate drape distance, a**





$$h2 = \frac{\beta}{\lambda}(e1+e2) = \frac{0.10}{0.50}(44+58) = 20.4 \text{ mm}$$

$$a = \left[\frac{100+(100+58+20.4)}{2}\right] - 56 \qquad = 83.2 \text{ mm}$$

- **Calculate number of strand**

Try balanced load, wb, 80% of slab selfweight = 0.80x480 = 384 kg/m^2

Effective forces = 10,800 kg/strand

Pe . a = (wb . L^2)/8

Pe = (6.6*384) . (6.6^2) / (8 x 0.0832) = 165,863 kg

No. of strand = 165,863 / 10,800 = 15.36 ~ 16 strands

- **Calculate actual balanced load**
-

$$wb = \frac{8 \text{ x Pe x a}}{L^2} = \frac{8 \text{ x } 16 \text{ x } 10{,}800 \text{ x } 0.0832}{6.6^2} \qquad = 2{,}640 \text{ kg/m}$$

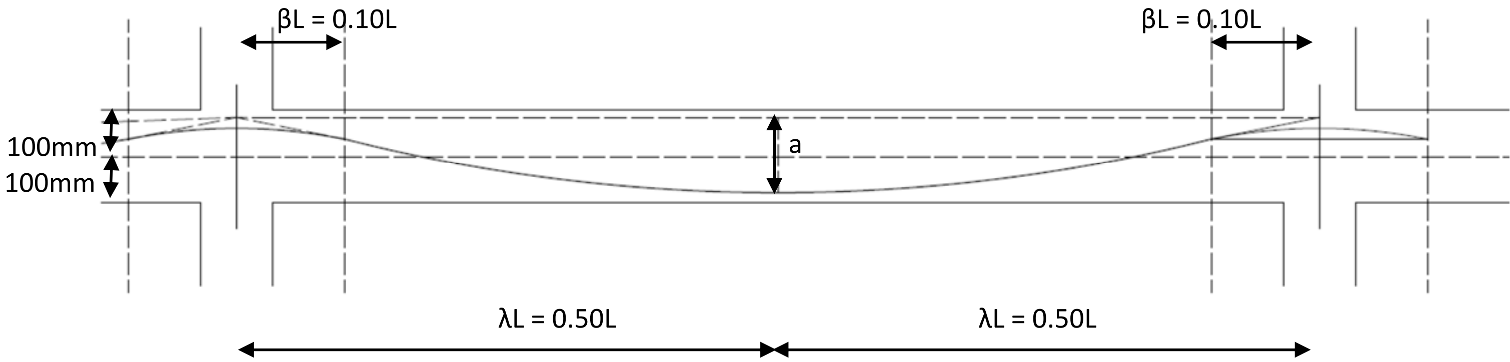
For bay width 6.6m wb = 2640/6.6 = 400 kg/m^2 (83.3%SW)

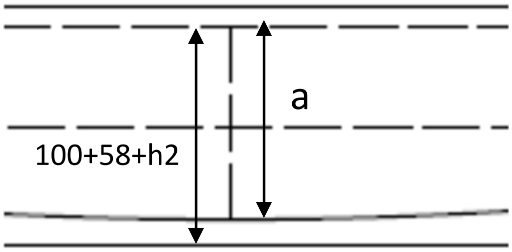
w,net = wDL + wLL –wb

= (480 + 200) + 200 -400 = 480 kg/m^2

SPAN#2

- **Calculate drape distance, a**





a = [100+58+20.4] - 5.6 = 122.4mm

- **Calculate number of strand**

Try balanced load, wb, 80% of slab selfweight = 0.80x480 = 384 kg/m^2

Effective forces = 10,800 kg/strand

Pe . a = (wb . L^2)/8

Pe = (6.6*384) . (6.6^2) / (8 x 0.1224) = 112,928 kg

No. of strand = 112,928 / 10,800 = 10.46 ~ 11 strands

- **Calculate actual balanced load**

wb = $\frac{8 \text{ x Pe x a}}{L^2} = \frac{8 \text{ x } 11 \text{ x} 10{,}800 \text{ x } 0.1224}{6.6^2}$ = 2,670 kg/m

For bay width 6.6m wb = 2670/6.6 = 404.5 kg/m^2

w,net = wDL + wLL –wb

= (480 + 200) + 200 -404.5 = 475.5 kg/m^2

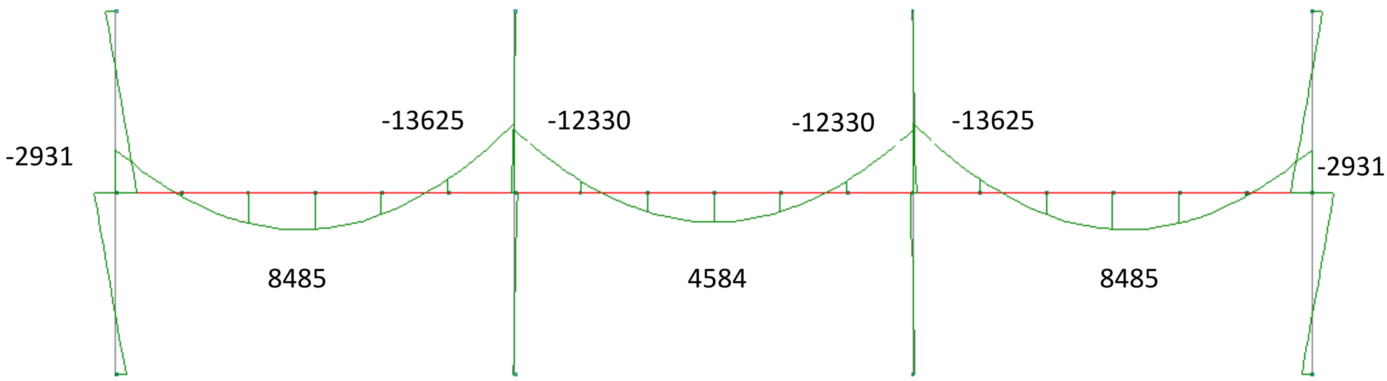
- **Calculate stress at transfer**

From ACI 18.5.1

Tensile stress in strand after force transfer = 0.70fpu = 13,283 ksc

Force at transfer = 13,283 x 0.9871 = 13,111 kg/strand

Moment due to selfweight



- **Check stresses at top and bottom fibers**

From basic stress summation s = Pi/A ± Pi.e/S ± M/S

Let compression is positive

A	= Sectional area	= 13,200 cm^2
I	= Moment of Inertia	= 440,000 cm^4
c,top	= c,bottom	= 10 cm
S	= Section modulus	= 44,000 cm^3

fci’ = 240 ksc

Allowable tensile stress at service	$= -0.795\sqrt{fci'}$	= -12.32 ksc
Allowable compressive stress at service	= 0.60fci’	= 144 ksc

Stress at point A

Pi	= 16x13,111	= 209,776 kg
A	= 13,200	cm^2
Pi/A	= 15.89	ksc
e	= 0	cm
S	= 44,000	cm^3
M	= -2,931	kg-m

σ,top = 15.89 + 0 + (-2,931)x100/44,000 = 9.23 ksc

σ,bottom = 15.89 + 0 - (-2,931)x100/44,000 = 22.55 ksc

Stress at point B left

Pi	= 16x13,111	=	209,776 kg
A	= 13,200	cm^2	
Pi/A	= 15.89	ksc	
e	= +5.8	cm	
S	= 44,000	cm^3	
M	= -13,625	kg-m	

σ,top = 15.89 + 209,776x(+5.8)/44,000 + (-13,625)x100/44,000 = 12.58 ksc (Comp.<144)

σ,bottom = 15.89 – 209,776x(+5.8)/44,000 –(-13,625)x100/44,000 = 19.2ksc(Comp.<144)

Stress at mid span A-B

Pi	= 16x13,111	=	209,776 kg
A	= 13,200	cm^2	
Pi/A	= 15.89	ksc	
e	= -4.4	cm	
S	= 44,000	cm^3	
M	= 8,485 kg-m		

σ,top = 15.89 + 209,776x(-4.4)/44,000 + (+8,485)x100/44,000 = 14.2 ksc (Comp.<144)

σ,bottom = 15.89 – 209,776x(-4.4)/44,000 – (+8,485)x100/44,000 = 17.6 ksc (Comp.<144)

Stress at point B right

Pi	= 16x13,111	=	209,776 kg
A	= 13,200	cm^2	
Pi/A	= 15.89	ksc	
e	= +5.8	cm	
S	= 44,000	cm^3	
M	= -12,330	kg-m	

σ,top = 15.89 + 209,776x(+5.8)/44,000 + (-12,330)x100/44,000 = 15.52 ksc (Comp.<144)

σ,bottom = 15.89 – 209,776x(+5.8)/44,000 –(-12,330)x100/44,000 = 16.23 ksc (Comp.<144)

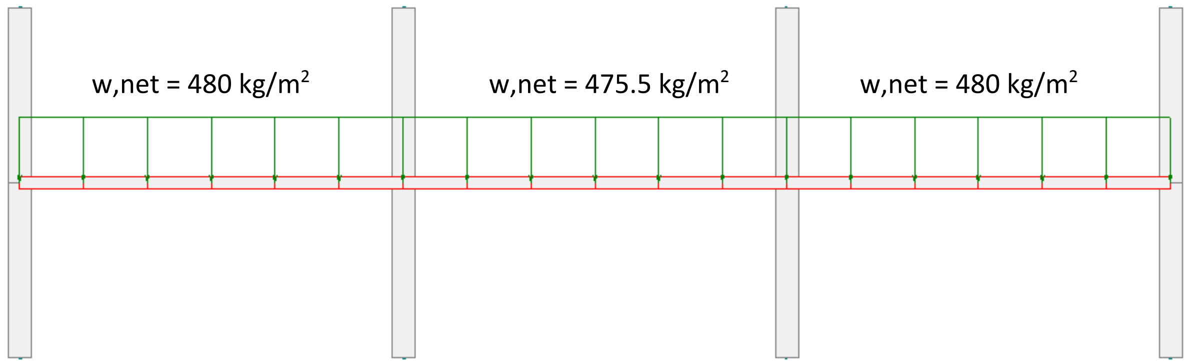
Stress at mid span B-C

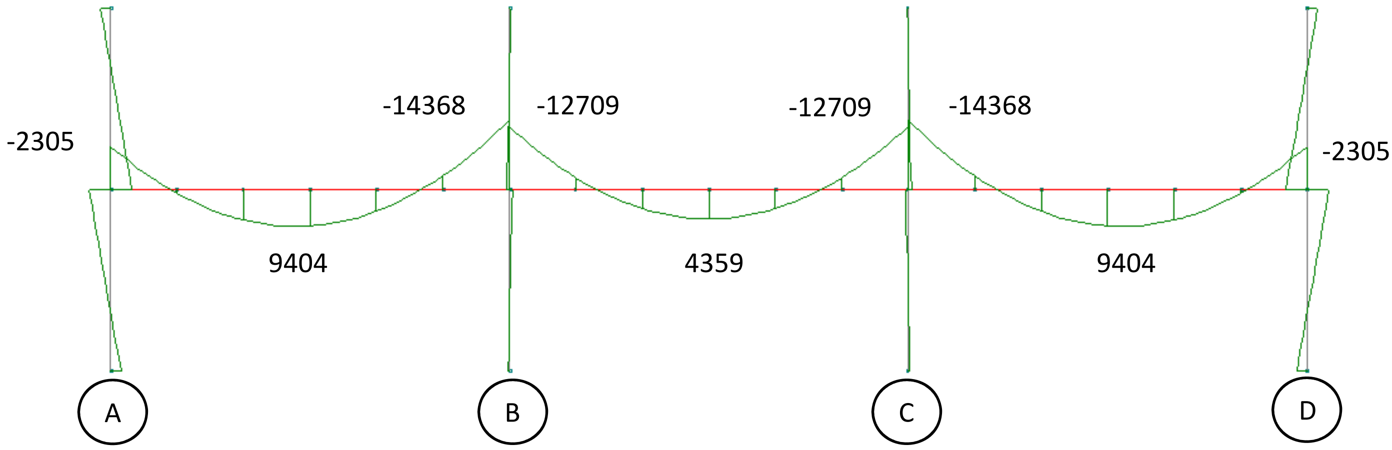
Pi	= 11x13,111	=	144,221 kg
A	= 13,200	cm^2	
Pi/A	= 10.92	ksc	
e	= -4.4	cm	
S	= 44,000	cm^3	
M	= 4,584 kg-m		

σ,top = 10.92 + 144,221x(-4.4)/44,000 + (+4,584)x100/44,000 = 6.92 ksc (Comp.<144)

σ,bottom = 10.92 – 144,221x(-4.4)/44,000 – (+4,584)x100/44,000 = 14.92 ksc (Comp.<144)

- **Calculate net moment**





Net moments in kg-m unit

- **Check stresses at top and bottom fibers**

From basic stress summation s = Pe/A ± Pe.e/S ± M/S

Let compression is positive

A	= Sectional area	= 13,200 cm^2
I	= Moment of Inertia	= 440,000 cm^4
c,top	= c,bottom	= 10 cm
S	= Section modulus	= 44,000 cm^3

Allowable tensile stress at service	$= -1.59\sqrt{fc'}$	= -28.44 ksc
Allowable compressive stress at service	= 0.45fc'	= 144 ksc

Stress at point A

Pe = 16x10,800 = 172,800 cm^4
A = 13,200 cm^2
Pe/A = 13.09 ksc
e = 0 cm
S = 44,000 cm^3
M = -2,305 kg-m

σ,top = 13.09 + 0 + (-2,305)x100/44,000 = 7.85 ksc

σ,bottom = 13.09 + 0 - (-2,305)x100/44,000 = 18.33 ksc

Stress at point B right

Pe/A = 13.09 ksc
e = +5.8 cm
S = 44,000 cm^3
M = -14,368 kg-m

σ,top = 13.09 + 172,800x(+5.8)/44,000 + (-14,368)x100/44,000 = 3.21 ksc (Comp.<144)

σ,bottom = 13.09 – 172,800x(+5.8)/44,000 –(-14,368)x100/44,000 = 22.97ksc(Comp.<144)

Stress at mid span A-B

Pe/A = 13.09 ksc
e = -4.4 cm
S = 44,000 cm^3
M = 9,404 kg-m

σ,top = 13.09 + 172,800x(-4.4)/44,000 + (+9,404)x100/44,000 = 17.182 ksc (Comp.<144)

σ,bottom = 13.09 – 172,800x(-4.4)/44,000 – (+9,404)x100/44,000 = 8.997 ksc (Comp.<144)

Stress at point B left

Pe/A = 13.09 ksc
e = +5.8 cm
S = 44,000 cm^3
M = -12,709 kg-m

σ,top = 13.09 + 172,800x(+5.8)/44,000 + (-12,709)x100/44,000 = 6.984 ksc (Comp.<144)

σ,bottom= 13.09 – 172,800x(+5.8)/44,000 –(-12,709)x100/44,000 = 19.196 ksc (Comp.<144)

Stress at mid span B-C

Pe/A = 11 x 10800 / 13,200 = 9.0 ksc

e = -4.4 cm

S = 44,000 cm^3

M = 4,359 kg-m

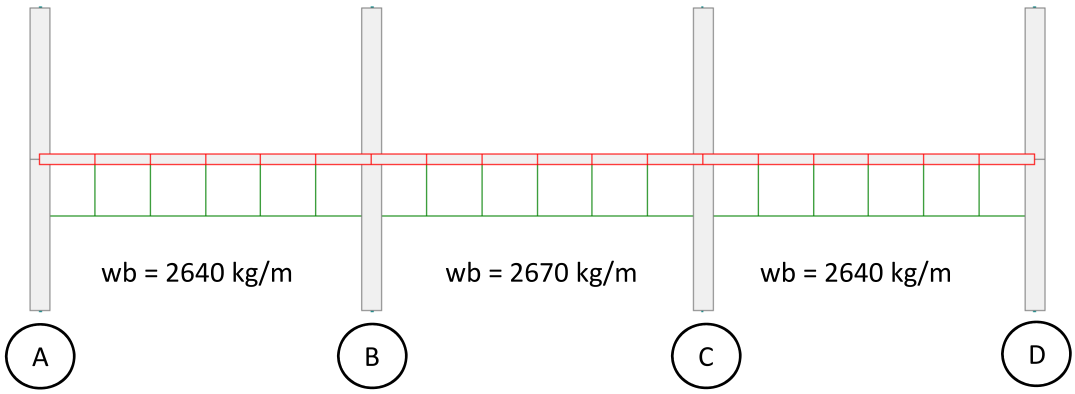
σ,top = 9.0 + 118,800x(-4.4)/44,000 + (+4,359)x100/44,000 = 7.03 ksc (Comp.<144)

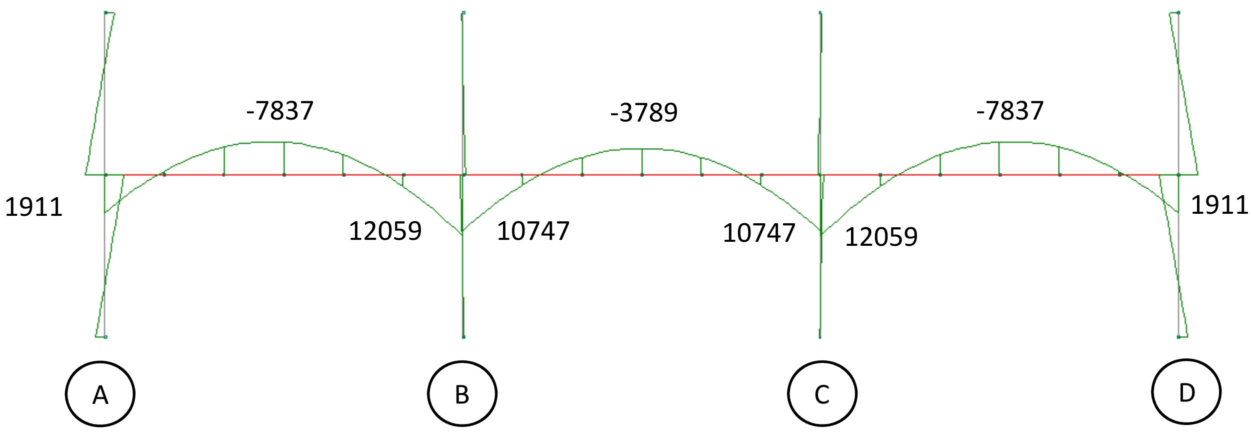
σ,bottom = 9.0 – 118,800x(-4.4)/44,000 – (+4,359)x100/44,000 = 10.97 ksc (Comp.<144)

- **Calculate Secondary moment**

Msec = Mb – Pe . e

Find Mb



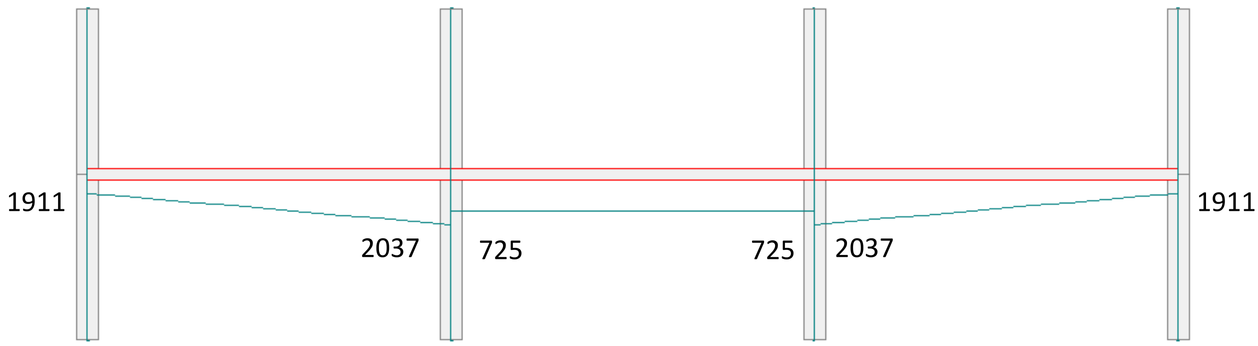


Balanced moments, Mb in kg-m unit

Calculate Pe . e

A	B	C	D
e = 0cm	e = 5.8cm	e = 5.8cm	e = 0cm
Pe = 16x10,800 kg			
Pe . e = 0 kg-m	Pe . e = 10,022 kg-m	Pe . e = 10,022 kg-m	Pe . e = 0 kg-m

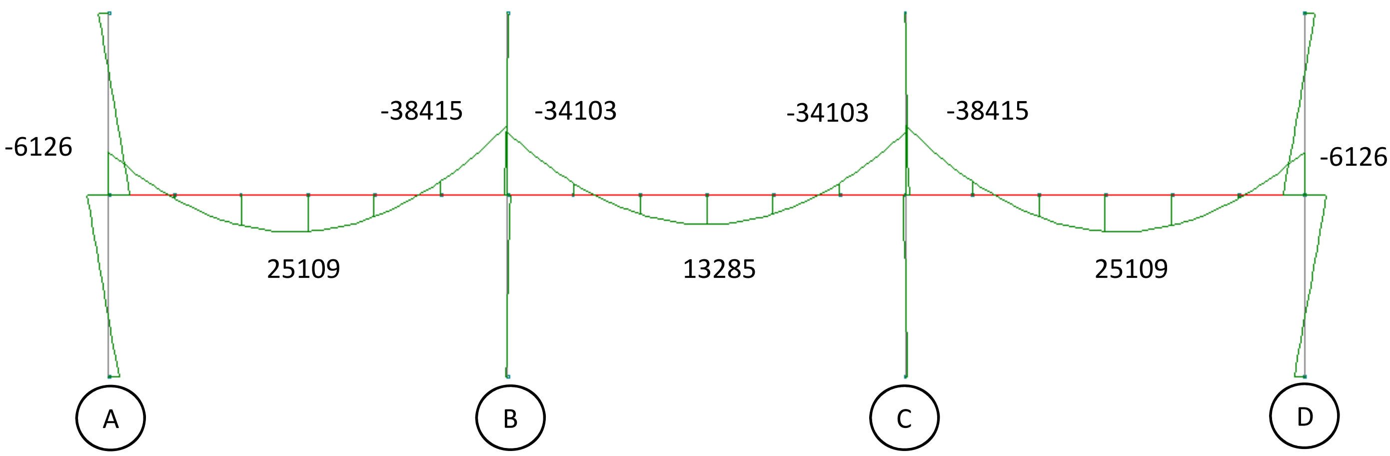
Msec = Mb – Pe . e



- **Calculate factored moment**

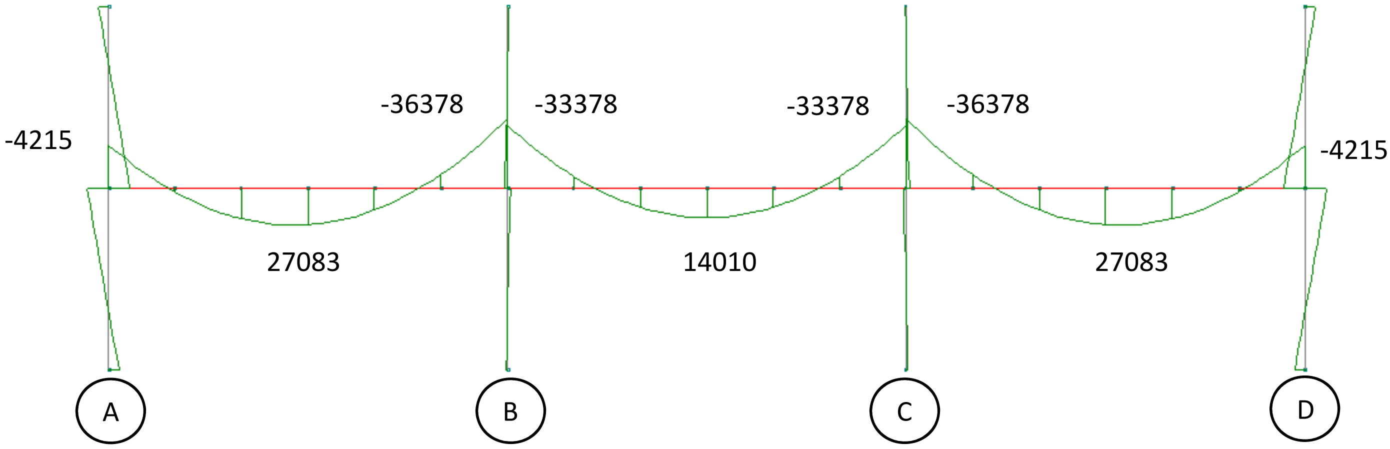
Mu = 1.4MD + 1.7 ML +1.0Msec

Find BMD of 1.4MD + 1.7 ML

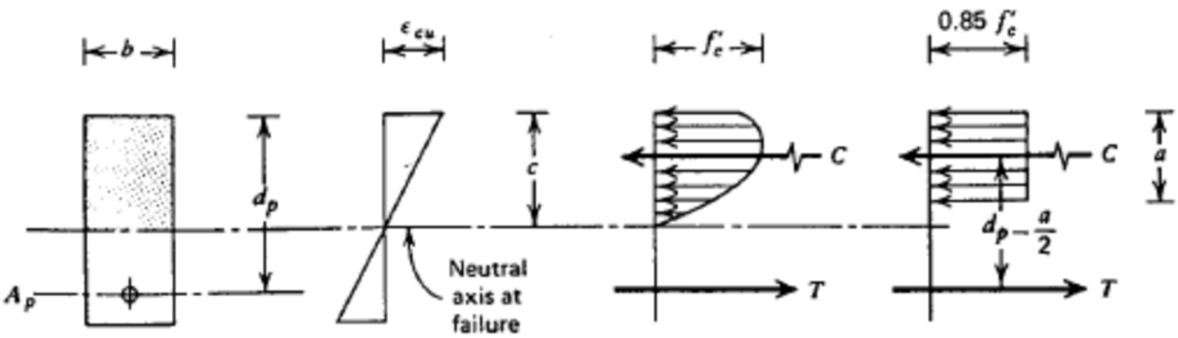


Moments from 1.4MD+1.7ML in kg-m unit

Find BMD of 1.4MD + 1.7 ML + 1.0 Msec



- **Calculate moment capacity of section**



Compression, C = Tension, T

0.85fc' a b = As.fy + Aps.fps

$$f_{ps} = f_{pu}\left\{1 - \frac{\gamma_p}{\beta_1}\left[\rho_p \frac{f_{pu}}{f_c'} + \frac{d}{d_p}(\omega - \omega')\right]\right\}$$

where γ_p = 0.55 for deformed bars $\left(f_{py} / f_{pu} \geq 0.80\right)$

= 0.40 for stress-relieved wire and strands, and plain bars $\left(f_{py} / f_{pu} \geq 0.85\right)$

= 0.28 for low-relaxation wire and strands $\left(f_{py} / f_{pu} \geq 0.90\right)$

where ω is $\rho f_y / f_c'$, ω' is $\rho' f_y / f_c'$

If any compression reinforcement is taken into account when calculating f_{ps} by Eq. (18-3), the term

$$\left[\rho_p \frac{f_{pu}}{f_c'} + \frac{d}{d_p}(\omega - \omega')\right]$$

shall be taken not less than 0.17 and d' shall be no greater than $0.15d_p$.

$\beta 1$ = 0.85 – 0.05 (fc'-280)/70 = 0.82

γ_p = 0.28

d_p = 15.8 cm

d' = 2.5 cm , 0.15dp = 2.16 cm   use d' = 2.16 cm

ρ_p = (16x0.9871)/(660x15.8) = 0.00151

d = 17.5cm

$$\left[\rho_p \frac{f_{pu}}{f_c'} + \frac{d}{d_p}(\omega - \omega')\right]$$ = 0.098 < 0.17 use 0.17

fps = 18975 x (1 - (0.28/0.82) x 0.17) = 17,873 ksc

a = (fps . Aps) / (0.85fc' b) = 1.27cm

ϕMn = ϕ Aps.fps (dp – a/2) =0.90x16x0.9871x17873 (15.8-1.27/2) = 38,526 kg-m