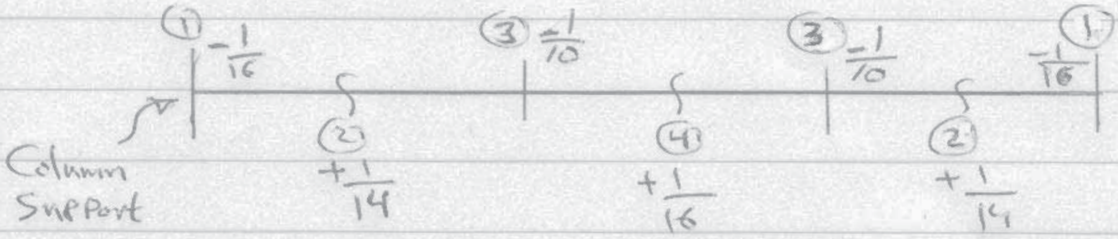
Solution :- (1) Moment

$W_u = 1.4\, W_D + 1.7\, W_L$

$= 1.4 * 35 + 1.7 * 15$

$= 74.5$ kN/m

$l_n = L - 0.3 = 5.7$ m



$M_i = C_i \cdot W_u l_n^2$

$M_1 = \frac{-1}{16} * (74.5)(5.7)^2 = -151.28$ kN.m

$M_2 = \frac{1}{14}(74.5)(5.7)^2 = 172.90$ kN.m

$M_3 = \frac{-1}{10}(74.5)(5.7)^2 = -242.05$ kN.m

$M_4 = \frac{1}{16}(74.5)(5.7)^2 = 151.28$ kN.m

The beam designed depending on maximum moment (Negative or Positive) ($M = 242.05$ kN.m)

Let $b = 300$ mm ;

$\rho_{min} = \frac{1.4}{f_y}$ or $\frac{\sqrt{f'_c}}{4 f_y}$

$= 0.0033$

$$\rho_{max.} = 0.75 * \left(0.85 * 0.85 * \frac{21}{420} * \frac{600}{600+420}\right)$$

$$= 0.016$$

assume $\rho = 0.01$

$$M_u = \phi \rho . b . d^2 f_y \left(1 - 0.59 \frac{\rho . f_y}{f'_c}\right)$$

$$242.05 * 10^6 = 0.9 * 0.01 * 300 * d^2 * 420 \left(1 - 0.59 * \frac{0.01 * 420}{21}\right)$$

$$\therefore d^2 = 242 * 10^3 \Rightarrow d = 492 \text{ mm}$$

use $d = 500$ mm

$$A_{s_3} = \rho . b . d = 0.01 * 300 * 500 = 1500 \text{ mm}^2$$

we can find the area of steel of the remaining regions by proportions ;

$$A_{s_1} = \frac{M_1}{M_3} * A_{s_3} = \frac{151.28}{242.05} * 1500$$

$$= 938 \text{ mm}^2$$

$$A_{s_2} = \frac{M_2}{M_3} * A_{s_3} = \frac{172.90}{242.05} * 1500$$

$$= 1072 \text{ mm}^2$$

$$A_{s_4} = \frac{M_4}{M_3} * A_{s_3} = \frac{151.28}{242.05} * 1500$$

$$= 938 \text{ mm}^2$$

If we use ϕ 25 mm bars
$A_b = 491\ mm^2$

* Reinforcements for Positive Moment

① for $A_{s2} = 1072\ mm^2$
No. of bars $= \frac{1072}{491} = 2.18$
use $3\phi25$ bars
As provided $= 1473\ mm^2 > As_{req.}$ OK.

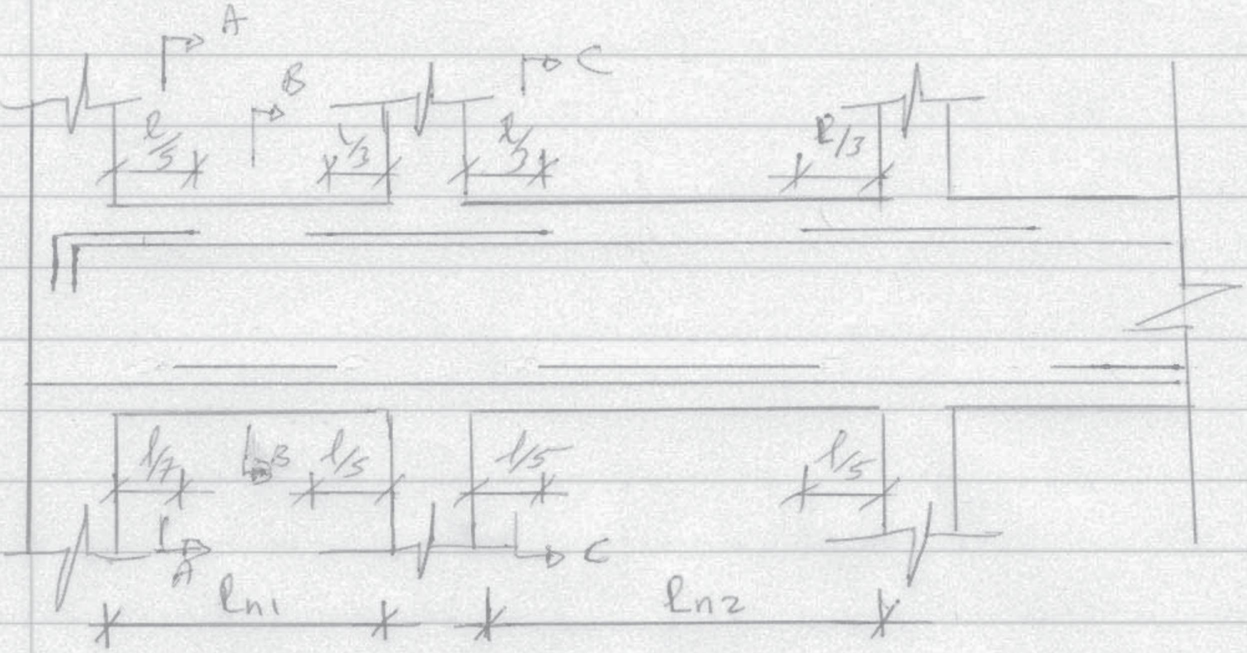
② for $A_4 = 938\ mm^2$
No. of bars $= \frac{938}{491} = 1.91$

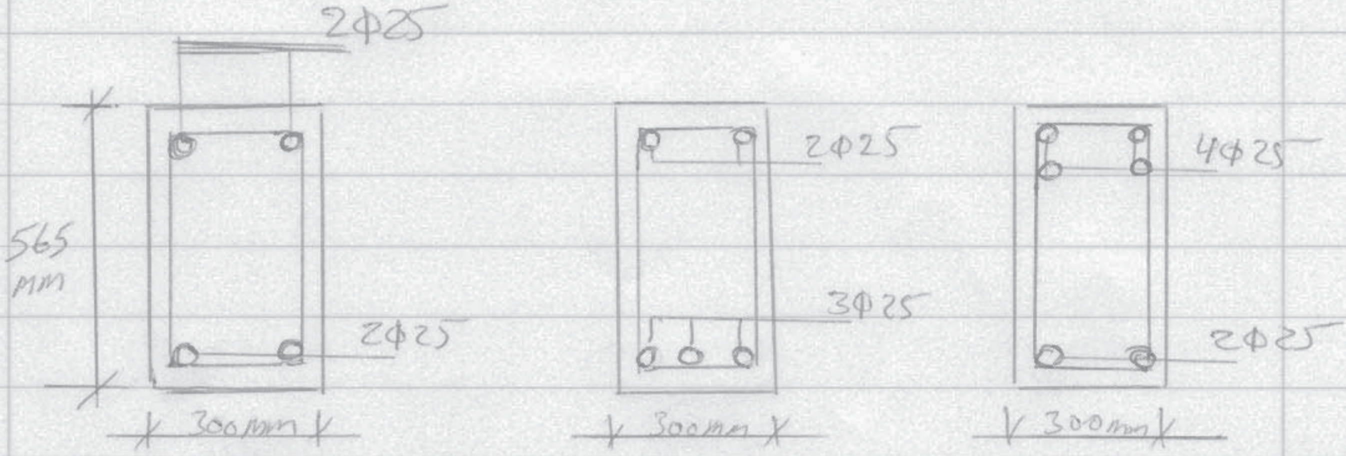
use $2\phi25$ bars
$As_{provided} = 982\ mm^2 > As_{req.}$ OK.

* Reinforcement for Negative moment

① for $As_1 = 938\ mm^2$
No. of bars $= \frac{938}{491} = 1.91$

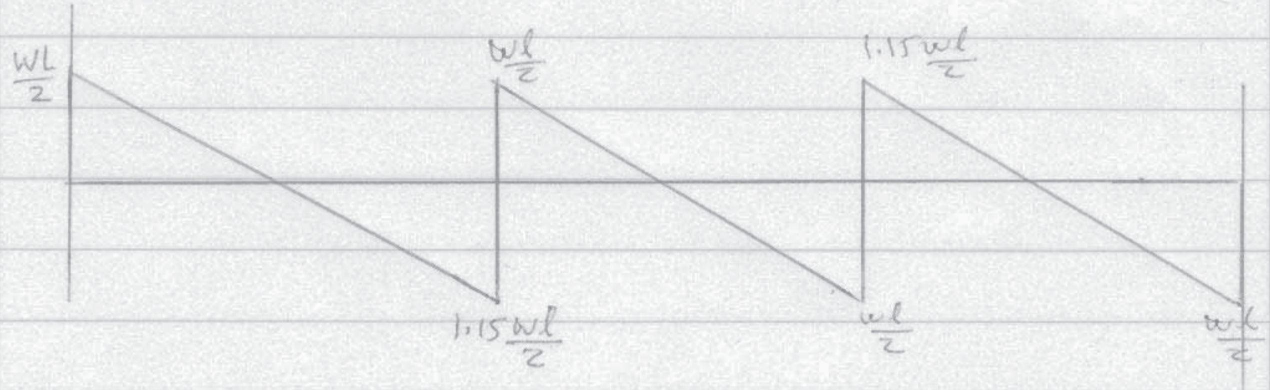
use $2\phi25$ bars
$As_{prov.} = 982\ mm^2 > A_{req.}$ OK.
② for $As_3 = 1500\ mm^2$
No. of bars $= \frac{1500}{491} = 3.05$
use $4\phi25$ bars
$As_{prov.} = 1964\ mm^2 > As_{req.}$ OK.





Section A-A   Section B-B   Section C-C

② Shear ;



$W = W_u = 74.5 \ kN/m$

$$V_u = \frac{1.15\,\omega L}{2}$$
$$= 1.15 * \frac{74.5 * 6}{2} = 257.0 \text{ KN}$$

$$V_{u_{max}} = V_{u,d} = V_u - \omega d$$
$$= 257.0 - 74.5 * 0.50$$
$$= 219.80 \text{ KN}$$
$$V_c = 0.17\sqrt{f'_c}\, b_w \cdot d = 0.17\sqrt{21} * 300 * 500 * 10^{-3}$$
$$= 116.85 \text{ KN} < V_{u,max}$$
Let use ϕ 10 mm Stirrups.
$$\therefore S_{max} = \frac{d}{2} = \frac{500}{2} = 250 \text{ mm}$$

$$S_{max} = \frac{A_v \cdot f_y}{0.34\, b} = \frac{158 * 420}{0.34 * 300} = 664 \text{ mm}$$

$S_{max} = 600$ mm

To check S_{max}.
$$V_{umax} - V_c < 0.33\sqrt{f'_c}$$
$$219.8 - 116.85 = 102.95 \text{ KN}$$
$$0.33\sqrt{21} * 300 * 500 * 10^{-3} = 226.84 \text{ KN}$$

$$\therefore (V_{umax} - V_c) < 0.33\sqrt{f'_c}$$

$\therefore S_{max} = 250$ mm.

From Calculations : Part (1)

$$S_1 = \frac{A_v \cdot f_y \cdot d}{(V_{umax} - V_c)} = \frac{158 * 420 * 500}{102.95 * 10^3}$$
$$= 322.3 \text{ mm.}$$

$\therefore$ use $\phi 10$ @ 250 mm c/c Stirrups.