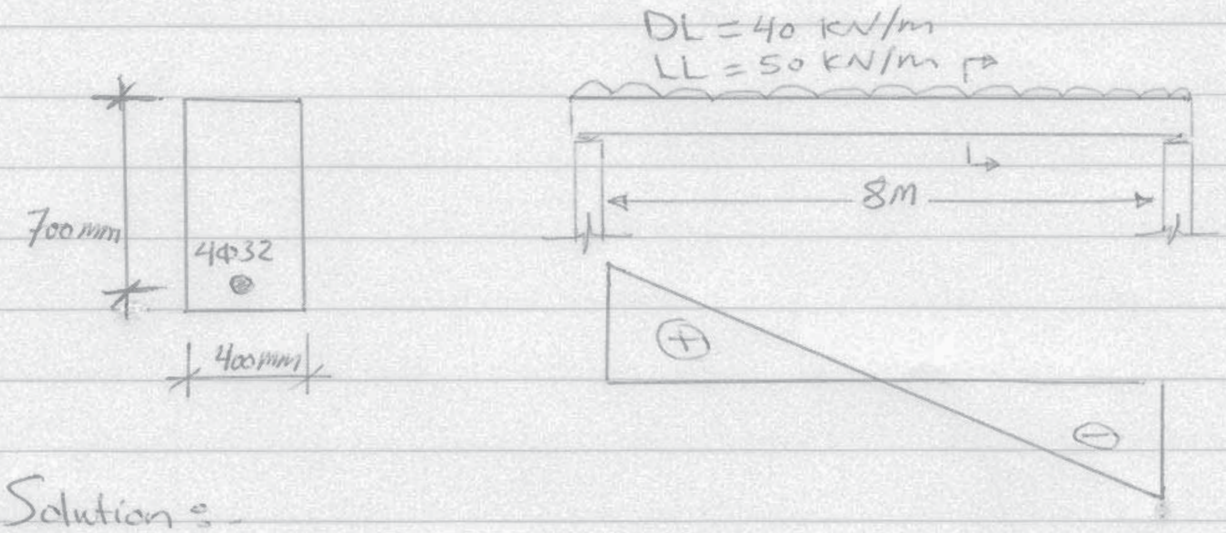
Example:

A simply supported rectangular beam 400 mm (b), having an effective depth of 700 mm, carries a total dead load of 40 kN/m and service live load of 50 kN/m on a 8 m clear span. The beam reinforced with 4 Φ32 bars. Using $f'_c = 21$ MPa, $f_y = 420$ MPa. Design the web reinforcement.



Solution:

$W_u = 1.4\,DL + 1.7\,LL$

$= 1.4 * (40) + 1.7 * (50) = 141$ kN/m

$V_u = \dfrac{W_u * l}{2} = \dfrac{141 * 8}{2} = 564$ kN at face of the support

At the critical section (at a distance d from the face of the support)

$V_{u,d} = 564 - 141 * (0.70) = 465.3$ kN

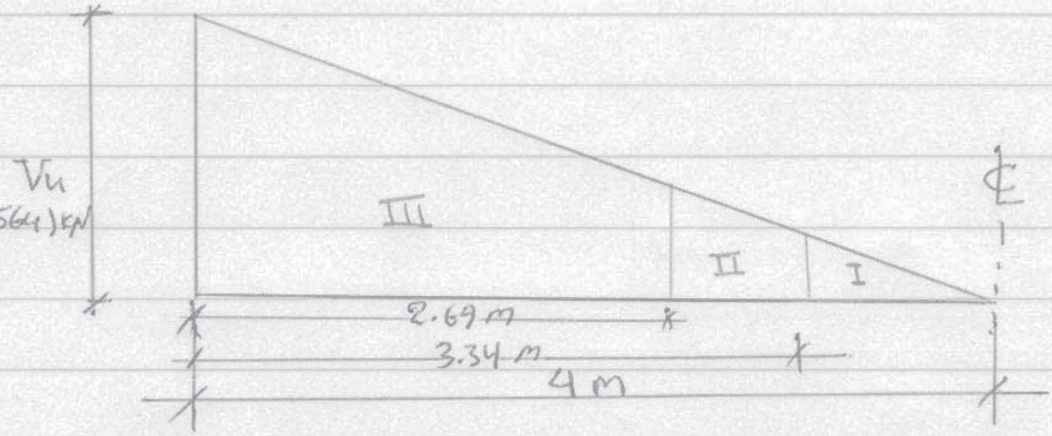
Shear force provided by concrete is,

$\Phi V_c = 0.85 * 0.17 \sqrt{f'_c} \cdot b_w \cdot d$

$= 0.85 * 0.17 \sqrt{21} * 400 * 700 * 10^{-3} = 185.41$ kN

$V_{u,d} \gg \phi V_c$

$$\frac{\phi V_c}{2} = \frac{185.41}{2} = 92.71 \text{ KN}$$



(I) The region at which web reinforcement theoritically is no longer required.

(II) According to the ACI code at least a minimum amount of web reinforcement is required wherever the shear force exceeds $\frac{\phi V_c}{2}$ and less ϕV_c and this distance is located at

$$\frac{564}{4} = \frac{92.71}{X_1} \Rightarrow X_1 = 0.66 \text{ m from the center line.}$$

&

$$\frac{564}{4} = \frac{185.41}{X_2} \Rightarrow X_2 = 1.31 \text{ m from the center line.}$$

$V_{u,d} = \phi V_s + \phi V_c$

$\phi V_s = V_{u,d} - \phi V_c$

$= 465.3 - 185.41 = 279.9 \text{ KN}$

$$\frac{\Phi}{3}\sqrt{f'_c}\cdot b_w\cdot d = \frac{\Phi}{3}\sqrt{21} * 400 * 700 * 10^{-3}$$

$$= 363.55\ kN > \Phi V_s$$

So that region (IV) not exist.

If we use $\Phi 12$ as stirrup ; $A_b = 113\ mm^2$

$A_v = 2\ A_b = 226\ mm^2$

$$S_d = \frac{\Phi\ A_v \cdot f_y \cdot d}{\Phi\ V_s} = \frac{0.85 * 226 * 420 * 700}{279.9 * 10^3}$$

$$= 201.77\ mm$$

Check with max. spacing :

$S_{max} = \frac{d}{2}$ or $600\ mm$ ACI Code 318

$\frac{d}{2} = 350\ mm$

also the max. spacing to provide the minimum web reinforcement is

$$S_{max.} = \frac{3\ A_{v_{min.}} f_y}{b_w} = \frac{3 * 226 * 420}{400}$$

$$= 712\ mm.$$

Therefore $S_{max} = \frac{d}{2} = 350\ mm$

Arrangement of stirrups

$\Phi 12$ @ 200 mm c/c $< \frac{d}{2} = 350\ mm$ ok

Continuous Beams :-

There are many methods to analyze the continuous beams and finds the moments at different regions.

The famous method is ACI moment coefficients which can be used with the following conditions satisfied.

1- Maximum allowable ratio of live to dead 3:1
2- The larger of two adjacent spans not exceed the short by more than 20%.
3- The R.C. beams should be continuous.
4- The load is U.D.L.

- Moment calculation :-

$$M_i = C_i . w . l_n^2$$

where :-

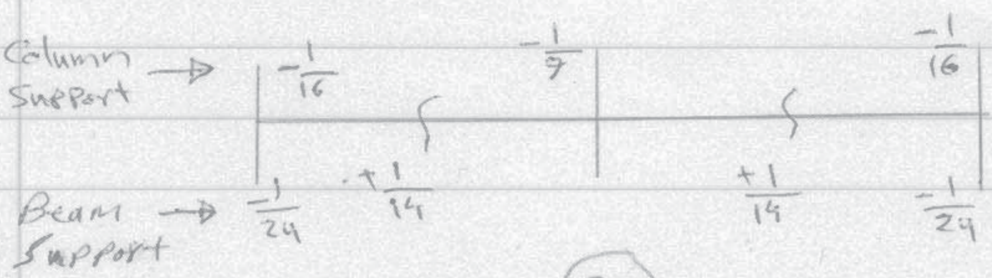
M_i = moment at the specified point.

C_i = moment coefficient at that point.

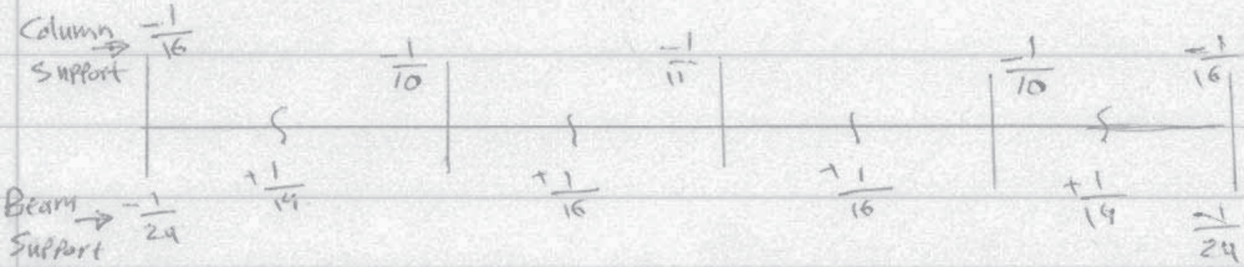
w = the uniformly distributed load (UDL)

l_n = clear span.

① For two spans :-



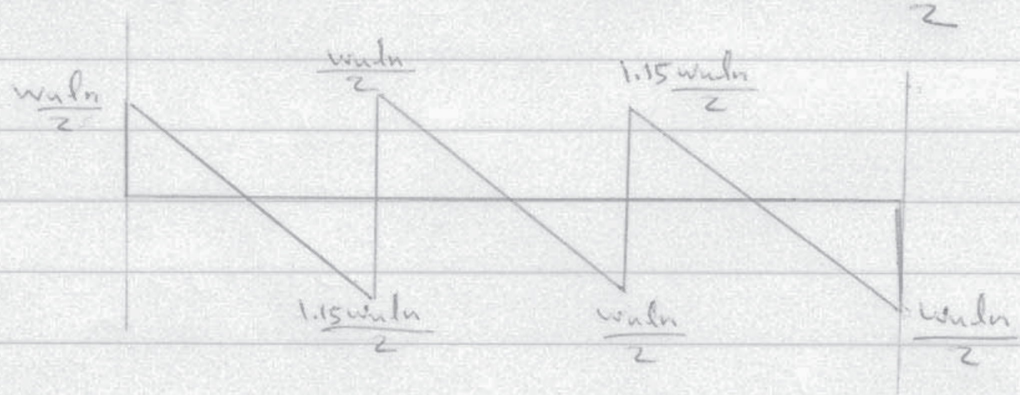
② More than two spans ;



— Shear Calculation :-

① Shear in the end members at face of first interior support $= 1.15 \frac{W_u l_n}{2}$

② Shear at face of all other supports $= \frac{W_u l_n}{2}$



Example :-

Design the following continuous beam for moment & shear, the loads are $W_L = 15$ KN/m , $W_D = 35$ KN/m including self weight ; $f'_c = 21$ MPa , $f_y = 420$ MPa