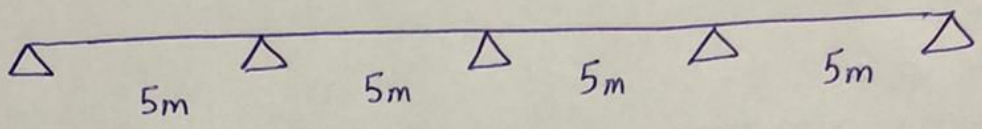
Design 1

HW 3

Name : Mohammad Al-Swaity

ID: 1181136



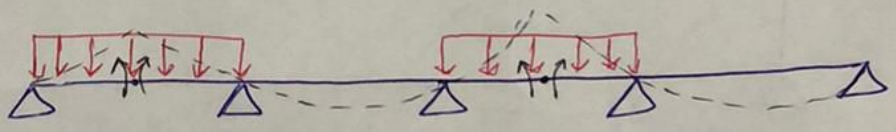
Live load = 40 KN/m

dead load = 100 KN/m

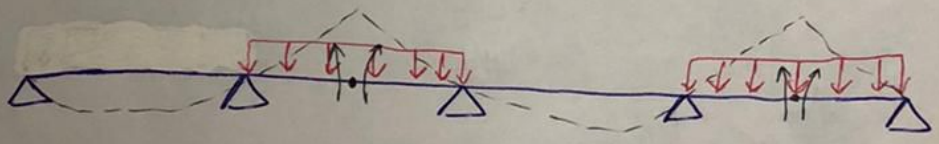
①: To maximize the positive and negative moment, we want to Apply load cases:-

Positive moment:

load case ①:

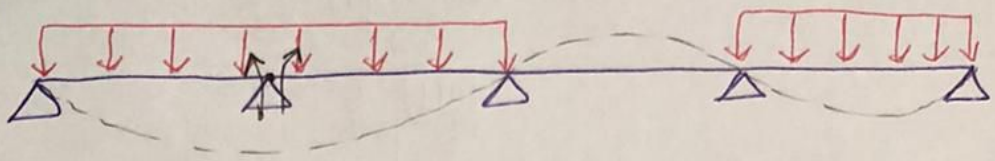


load case ②:

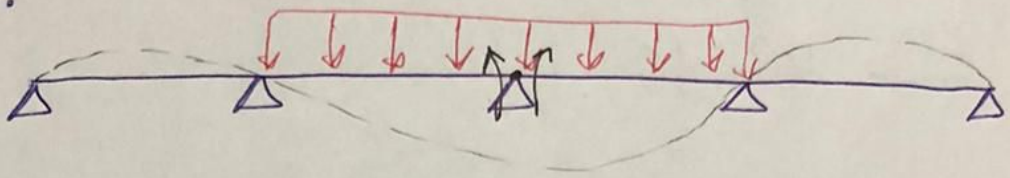


negative moment:

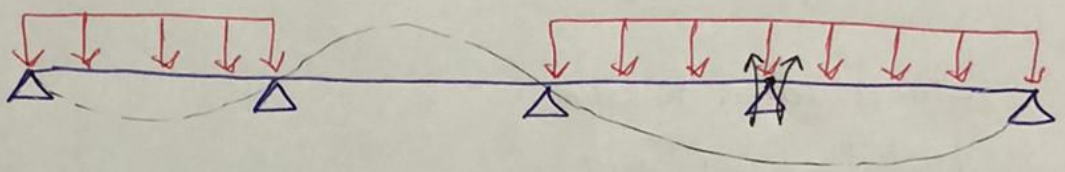
load case ③:



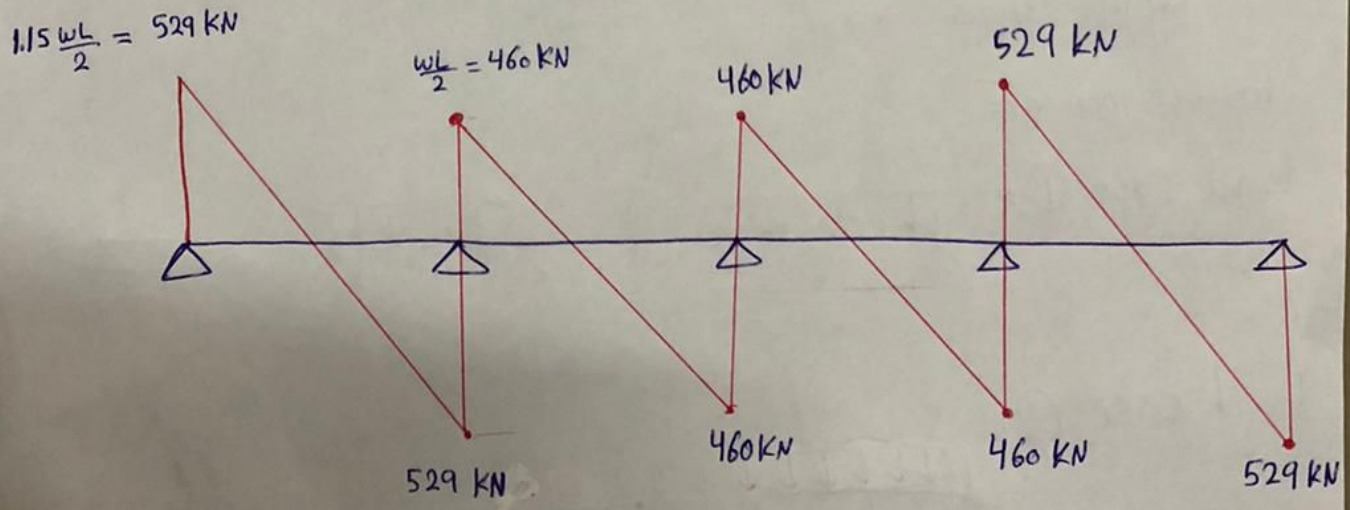
load case ④:



load case ⑤:

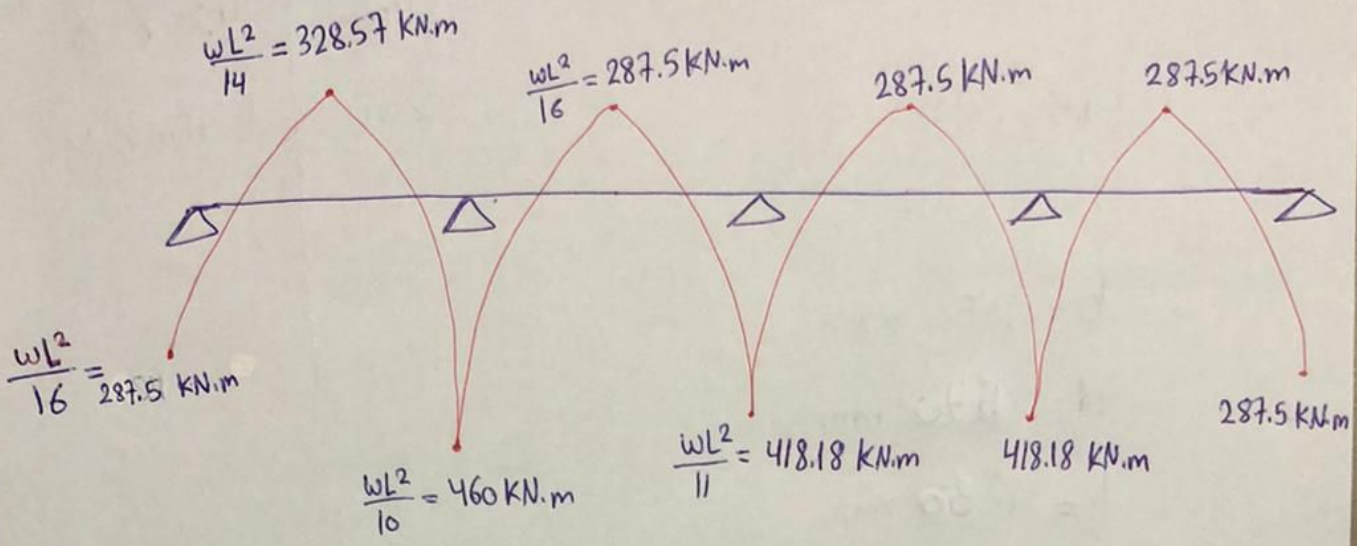


② : $W = 1.2d + 1.6L = 184$ KN/m



Shear Diagram

* Moment Diagram:



③ Smallest moment = 287.5 KN.m $= M_u$

let $\phi = 0.9$

let $\rho = 0.5\,\rho_{max} = 0.0103$

$$\frac{0.0105 - 0.0100}{4 - 3.83} = \frac{0.0103 - 0.0100}{R - 3.83}$$

$$R = 3.93 = \frac{M_u}{\phi\, bd^2}$$

$$bd^2 = \frac{287.5 * 10^6}{(0.9)(3.93)} = 81.3 * 10^6$$

$\longrightarrow bd^2 = 81.3 * 10^6$

$(1.5-3)b = d$

b	d
400	450.8 ✗
250	570.3 ✓

$\therefore$ b = 250 mm

d = 600 mm

h = 660 mm

(4): b = 300 mm

h = 500 mm

d = 450 mm for M_u = 287.5 KN.m

(I) Take M_u = 287.5 KN.m

Iterations for (a): assume $a = \frac{d}{3} = 150$

* $M_u = \phi A_s f_y \left(d - \frac{a}{2}\right) \longrightarrow A_s = 2028.2\ mm^2$

$a = \frac{A_s f_y}{0.85 f_c' b} \longrightarrow a = 119.3$ mm ✗

* take a = 115 mm

$A_s = \frac{M_u}{\phi f_y (d - \frac{a}{2})} \longrightarrow A_s = 1938\ mm^2$ ✓

$a = \frac{A_s f_y}{23.8\, b} = 114$ mm

$\therefore a = 115$ mm , $A_s = 1938$ mm^2

from Design Aid:

$4\phi 25 \longrightarrow 2040$ mm^2

$3S = 300 - 4(25) - 100$

$S = 33.3$ mm ✓

$\longrightarrow A_s = 2040$ mm^2

Checks: ① $\rho = \frac{2040}{(300)(450)} = 0.01511$

$(0.0033)\rho_{min} < \rho < \rho_{max}(0.0206)$

② $\phi M_n = (0.9)(420)(2040)\left(450 - \frac{a}{2}\right)$

$a = \frac{(2040)(420)}{(23.8)(300)} = 120$ mm

$\phi M_n = 300.7$ kN.m $\geq M_u$

(II) Take $M_u = 328.5$ KN.m :

$h = 500$ mm / $b = 300$ mm

assume $D_B = 25$mm $\longrightarrow$ $d = 437.5$ mm

* $R = \frac{M}{\phi b d^2} = 6.356$ MPa

$\therefore \frac{6.36 - 6.22}{6.356 - 6.22} = \frac{0.0180 - 0.0175}{\rho - 0.0175}$

$\longrightarrow \rho = 0.01798 < \rho_{max}$
$> \rho_{min}$

* $A_s = \rho b d = (0.01798)(300)(437.5) = 2359.9\ mm^2$

$\therefore 3\ \phi 32 \rightarrow 2457\ mm^2$

new $\rho = \frac{A_s}{bd} = \frac{2457}{(300)(437.5)} = 0.01872 > \rho_{max}$

$\longrightarrow$ Doubly Reinforcement

* 2 layers : $d = 412.5$ mm / $d' = 62.5$ mm

$\phi M_{n_1} = (0.9)(6.356)(300)(412.5)^2 = 292$ KN.m

$\phi M_{n_2} = 328.5 - 292 = 36.5$ KN.m

* $\rho = \rho_{a005} = 0.0181$

$$A_{s_1} = \rho bd = 2239.9 \text{ mm}^2$$

$$a = \frac{A_{s_1} f_y}{(23.8)(300)} = 131.8 \text{ mm}$$

$$\bar{y} = \frac{a}{B_1} = 155.06 \text{ mm}$$

$$\epsilon_s' = 0.00179 \longrightarrow f_s' = 358 \text{ mpa}$$

* $\phi M_{n_2} = \phi A_s' f_s' (d - d') \longrightarrow A_s' = 323.7 \text{ mm}^2$

$$A_{s_2} = A_s' \left(\frac{f_s'}{f_y}\right) = 275.9 \text{ mm}^2$$

$$A_s = 2515.8 \text{ mm}^2$$

* Check ϕ: $T = C$: $A_s f_y = A_s' f_s' + 23.8\, a\, b$

$a = 131.75$ mm

$\bar{y} = 155$ mm

$\epsilon_s' = 0.00179 \longrightarrow f_s' = 358$ mpa

$\epsilon_s = 0.005 \longrightarrow \phi = 0.9$

* $A_s = 2515.8\ mm^2 \longrightarrow 7\phi 22 \rightarrow 2709\ mm^2$

$A_s' = 323.7\ mm^2 \longrightarrow 2\phi 16 \longrightarrow 398\ mm^2$

new d = 417 / new d' = 58

Assume $f_s' = 385$ mpa

$\rightarrow a = 137.9$ mm

$\bar{y} = 162.2$ mm

$E_s' = 0.00193$

$f_s' = 385.4$ mpa

$E_s = 0.0047$

$\phi = 0.875$

$$\Sigma M_n = \phi M_{n_1} + \phi M_{n_2}$$

$$= (0.875)(0.85)(28)(300)(137.9)\left(417 - \frac{137.9}{2}\right) + (0.875)(398)(385.4)\left(417 - \frac{58}{2}\right)$$

$\rightarrow \Sigma M_n = 348.3\ KN.m \geq M_4$

(III) $M_u = 418.18$ KN.m

assume 9

$h = 500$ mm / $b = 300$ mm / $D_B = 25$ $\rightarrow d = 437.5$ mm

$R = 8.09$ Mpa (not exist in Design Aid)

∴ Doubly Reinforcement : $d = 412.5$ mm (2 layers)

$d' = 62.5$ mm

let $\phi = 0.9$ / $R = 6.36$

* $\phi M_{n1} = 292.2$ KN.m

$\phi M_{n2} = 125.98$ KN.m

$\rho = \rho_{0.005} = 0.0181$

$A_{s1} = 2239.9$ mm^2

$a = 131.8$ mm

$\bar{y} = 155.06$ mm

$\epsilon_s' = 0.00179 \rightarrow f_s' = 358$ mpa

* $\phi M_{n2} = \phi A_s' f_s' (d - d') \rightarrow A_s' = 1005.4$ mm^2

$A_{s2} = A_s' \left(\frac{f_s'}{f_y}\right) = 857$ mm^2

* Check ϕ: $A_s f_y = A_s' f_s' + 23.8\, ab$

$a = 131.75$ mm

$\bar{y} = 155$ mm

$\epsilon_s' = 0.00179$

$f_s' = 358$

$\epsilon_s = 0.005 \rightarrow \phi = 0.9$

* $A_s = 3096.9\ mm^2 \longrightarrow 5\phi 29\ (3225\ mm^2)$

$A_s' = 1005.4\ mm^2 \longrightarrow 4\phi 19\ (1136\ mm^2)$

new $d = 407$ / new $d' = 60$

let $f_s' = 365$ mpa

$a = 131.6$ mm

$\bar{y} = 154.8$ mm

$\epsilon_s' = 0.00184$

$f_s' = 368$

$\epsilon_s = 0.00489 \rightarrow \phi = 0.89$

$\phi M_n = 425.6$ kN.m $\geq M_u$

(IV) take $M_u = 460\ KN.m$

$h = 500\ mm$ / $b = 300\ mm$ / $d = 437.5\ mm$

$R = 8.9\ MPa$ (Does'nt Exist in Design Aid)

∴ Doubly Reinforcement : 2 layers : $d = 412.5\ mm$

$d' = 62.5\ mm$

let $\phi = 0.9 \rightarrow R = 8.36\ mpa$

$\phi M_{n_1} = 292.2\ KN.m$

$\phi M_{n_2} = 167.8\ KN.m$

$\rho = \rho_{0.005} = 0.0181$ / $A_{s_1} = 2239.9\ mm^2$ / $a = 131.8\ mm$

$\bar{y} = 155.06\ mm$ / $\varepsilon_s' = 0.00179 \rightarrow f_s' = 358 mpa$

$\phi M_{n_2} = \phi A_s' f_s' (d - d') \rightarrow A_s' = 1339.2\ mm^2$

$A_{s_2} = 1141.5\ mm^2$

Check ϕ: $T = C$: $A_s f_y = A_s' f_s' + 23.8 ab$

$a = 131.75\ mm \rightarrow \bar{y} = 155\ mm$

$\varepsilon_s' = 0.00179 \rightarrow f_s' = 358 mpa$

$\varepsilon_s = 0.005 \rightarrow \phi = 0.9$ ✓

* $A_s = 3381.4 \longrightarrow 7\phi 25\ (3570\ mm^2)$

$A_s' = 1339.2 \longrightarrow 5\phi 19\ (1420\ mm^2)$

new $d = 412.5\ mm$ / new $d' = 60\ mm$

let $f_s' = 370 mpa$

$a = 136.4\ mm$

$\bar{y} = 160.5\ mm$

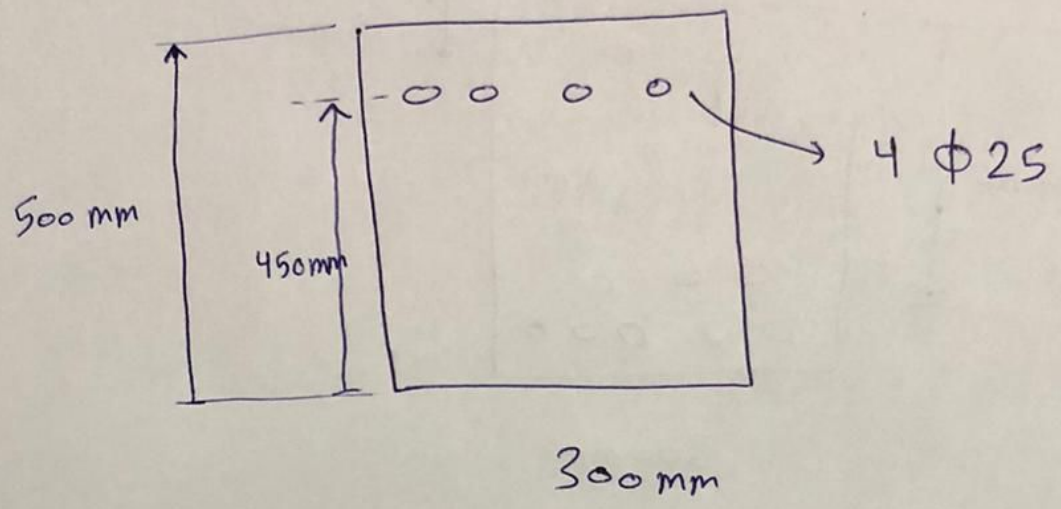
$\epsilon_s' = 0.00188$

$f_s' = 376\ Mpa$

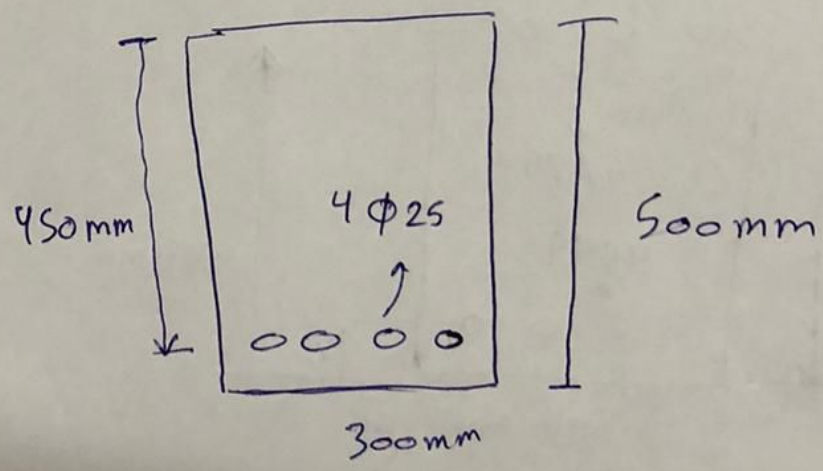
$\epsilon_s = 0.00471 \rightarrow \phi = 0.8758$

$\Sigma M_n = 472.53\ KN.m \geqslant M_u$

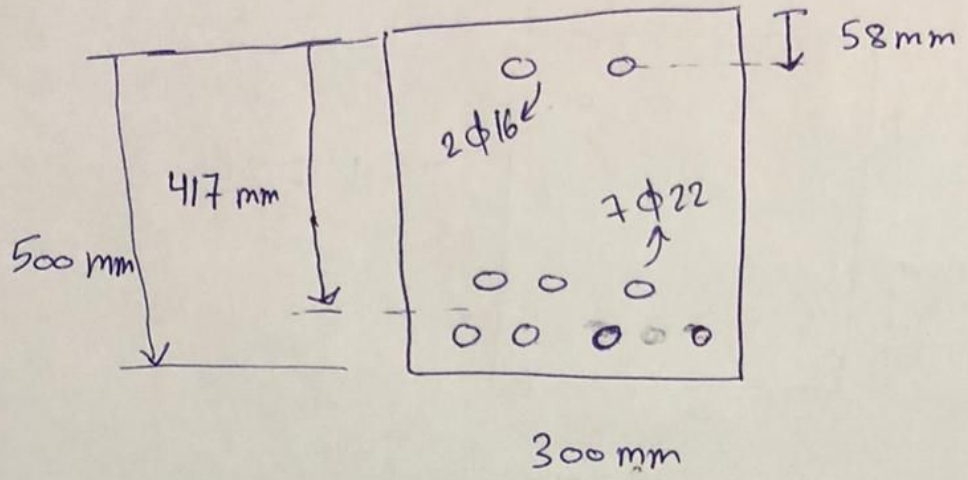
(5) : Negative moment = 287.5 KN.m



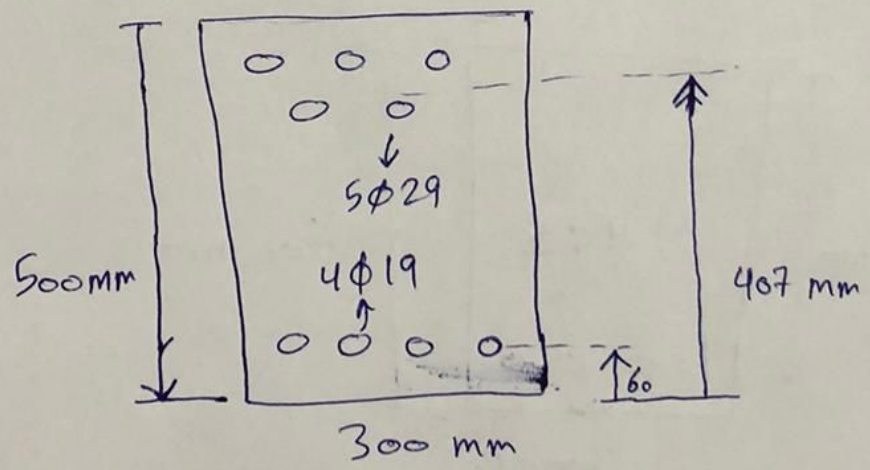
Positive moment = 287.5 KN.m



* Positive moment = 328.57 KN.m



* Negative moment = 418.18 KN.m



✱ negative moment = 460 kN.m