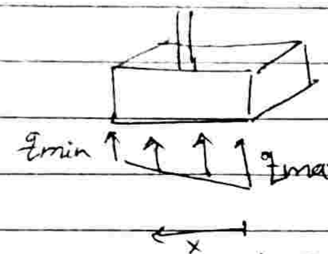
Eccentrically loaded spread footing

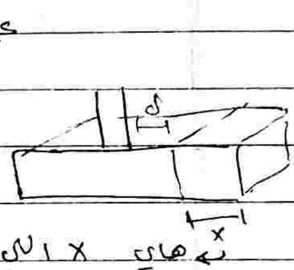
Col	Footing
0.5m × 0.5m	$f_y = 415$ MPa
DL = 420 kN.m	$f_c' = 21$ MPa
LL = 540 kN	$q_a = 150$ kPa
M = 480 kN.m	

* في حال افترضت إنه البرشر تحت القاعدة غير منتظم .الي بتغير هو إنه ما نطلع d



عال wide Beam ، الشير ما بساوي
البرشر × الايريا لا بساوي

$V_I = \int q \, dx$



$q(x) = q_{max} - slope(x)$

$= q_{max} - \left(\frac{q_{max} - q_{min}}{B}\right)(x)$

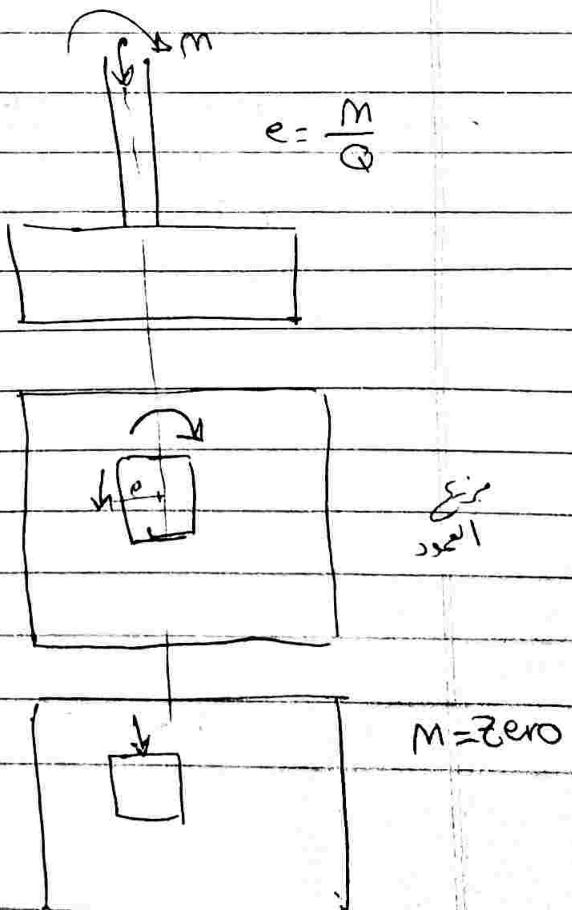
هاي الـ X الي بعوضع

$M = \int V$

* In our Example: Assum Uniform soil pressure squre footing: ⇒ عن طريق فرض مومنت مساوية لها في المقدار ومعاكسة لها في الاتجاه.

$e = \frac{M}{Q}$

"هاي المشكلة مرات ما بنقدر نعملها دائماً لأنه أحياناً بتحرك العمود صعبة ما بنقدر نكون فيها فبنرجع للحل الأول!!"



⇒ assume weight of the footing 9% of the load

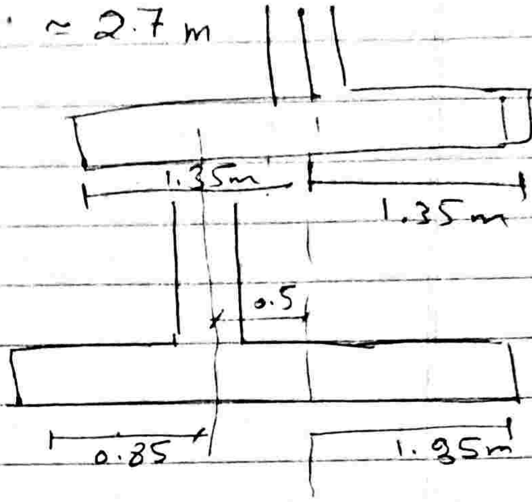
$= 0.09(420 + 540) = 86.4\ kN$

⇒ Total load $= 450 + 540 + 864 = 1064.4\ kN$

⇒ $A = \frac{1064.4}{150} = 7.1\ m^2$ ⇒ $B = 2.66\ m$

$\approx 2.7\ m$

⇒ $e = \frac{M}{P} = \frac{480}{420+540} = 0.5$



⇒ بنحرك العمود لحتى يصير البريشر uniform

• $P_{ult} = 1.2 \times 420 + 1.6 \times 540 = 1368\ kN$

• $q_{ult} = \frac{1368}{(2.7)^2} = 187.7\ kN/m^2$

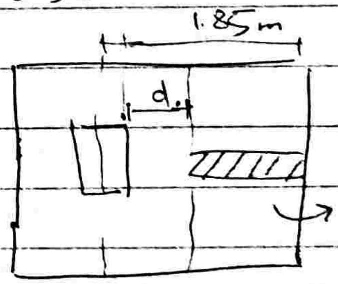
• $V_c = \frac{\phi}{3}\sqrt{f'_c} = 1145.6\ kN/m^2$

⇒ Find the depth of the footing :-

$$(2.7^2 - 0.5^2)\frac{187.7}{4} = d^2\left(1145.6 + \frac{187.7}{4}\right) + d(0.5)\left(1145.6 + \frac{187.7}{2}\right)$$

Solve the Equation ⇒ $d = 0.33\ m$

⇒ Check wide Beam :-



← بناخد الجهة الأطول عشان يكون حلها بالنسبة أي

$L = 1.85 - \frac{0.5}{2} - 0.33 = 1.27\ m$

$V = 1.277(1)(187.7) = 238.4\ kN$

$V_{actual} = \frac{238.4}{(1)(0.33)} = 722.4\ kN/m^2$

$V_{call} = \frac{1145.6}{2} = 572.8 < V_{act}$ not ok

$572.8 = \frac{238.4}{(1)(d)}$ ⇒ $d = 0.42$ use $0.45\ m$

weight of the footing $= 2.7 \times 2.7 \times 0.45 \times 24 = 78.7\ kN/m^2$ < 86.4 ok

• Moment In long direction:

$$\Rightarrow M_u = \frac{187.7\,[1.85-0.5]^2}{2} = 240.3 \text{ kN.m}$$

$$240.3 = 0.9\,A_s\,(415\times1000)\left[0.45-\frac{a}{2}\right]$$

$$\Rightarrow a = \frac{A_s(415)}{(0.85)(21)(1)} = 23.25\,A_s \rightarrow \frac{a}{2} = 11.62\,A_s$$

Solve Equation: $A_s = 1.49\times10^{-3}\ m^2$

$$\Rightarrow \rho = \frac{A_s}{bd} = \frac{1.49\times10^{-3}}{(1)(0.45)} = 0.0033$$

$$\Rightarrow \rho_{min} = \frac{1.4}{415} = 0.00337, \quad \rho < \rho_{min}$$

so use ρ_{min}

$$\Rightarrow B\times\rho_{min}\times bd = A_s = (2.7)(0.00337)(1)(0.45)$$
$$= 4.099\times10^{-3} \simeq 41\ cm^2$$

$\Rightarrow$ Using 20 mm bars $\rightarrow A_{s_{bar}} = 3.14\ cm^2$

$$\#\text{bars} = \frac{41}{3.14} = 13 \text{ bars}, \text{ Use 9cm cover}$$

$$\text{Spacing} = \frac{270-18}{12} = 21 \text{ cm c/c}$$

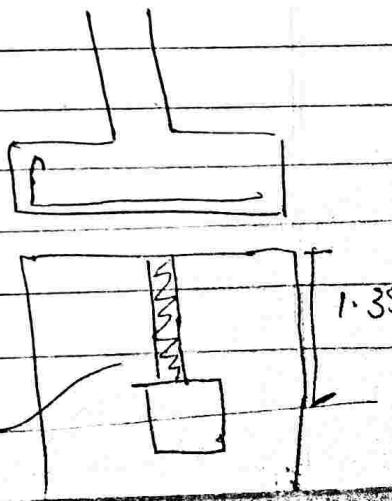
$\Rightarrow$ Check l_d:

$$w = \max \begin{cases} = 0.02(314)(415)/\sqrt{21} = 568.7 \text{ mm} \checkmark \\ = 0.06(20)(415) = 498 \text{ mm} \\ = 300 \text{ mm} \end{cases}$$

↳ Control

$\Rightarrow l_d$ av $= 850-250-90 = 510 \text{ mm} < 568.7 \text{ mm}$

$\Rightarrow$ OK



⇒ so provide hook for the left side.

⇒ Steel In short direction

$L = 1.35 - 0.25 = 1.1\ m$

$M_u = 187.7 \dfrac{(1.1)^2}{2} = 113.55\ kN\cdot m$

$d = 45 - 2 = 0.43\ m$ الزلمة فيكم بوت شوهاي .. دقيقي لاني نعست

$113.55 = 0.9\ A_s\ (415 \times 1000) \left[0.43 - 11.62 A_s\right]$

solve Equation → $A_s = 7.2 \times 10^{-4}$

⇒ $\rho = \dfrac{7.2 \times 10^{-4}}{(1)(0.43)} = 0.00167 < \rho_{min}$ use ρ_{min}

$A_{st} = \dfrac{1.4}{f_y} \left[(1)(0.43)(2.7)\right] = 3.92 \times 10^{-3}\ m^2 = 39.17$

using ϕ 20mm → # of bars = 12.5 use 13 bars

spacing = $\dfrac{270 - 18}{12} = 21$ c/c

⇒ $l_{d\,av} = 1.35 - 0.25 - 0.09 = 1.01 > l_{d\,req}$ OK

Design of wall Footing

Wall

$DL = 300\ kN/m$

$LL = 300\ kN/m$

$b = 0.4\ m$

R.C

Footing

$f_y = 415\ MPa$

$f_c' = 21\ MPa$

$q_a = 300\ kPa$

← بنحل لواحد متر طولي

⇒ Assume $W.\ Footing = 0.06(600) = 36\ kN/m$

⇒ $A = \dfrac{300 + 300 + 36}{300} = 2.12\ m^2$

$1 \times B = 2.12$

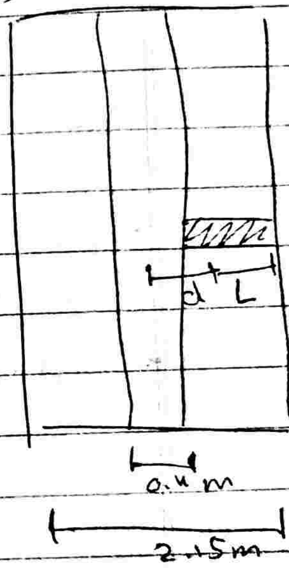
$B = 2.12$ Use $2.15m$

⇒ $P_{ult} = 1.2 \times 300 + 1.6 \times 300 = 840\ kN/m$

$q_{ult} = \dfrac{840}{2.15} = 390.7$

فقط، لإنه مستحيل يعمل Punching على أطوال كبيرة

⇒ Find d from **Wide Beam Shear**



$L = \dfrac{2.15}{2} - \dfrac{0.4}{2} - d = (0.875 - d)\ m$

⇒ $V_{at\ d} = \dfrac{(0.875 - d)(1)(840)}{2.15(1)} = (341.9 - 390.7d)$

$= \dfrac{735 - 840d}{2.15(1)}$

⇒ $V_{c\ act} = \dfrac{735 - 840d}{(1)d(2.15)}$

$= \dfrac{341.9 - 390.7d}{d}$

⇒ $V_{c\ all} = \dfrac{\phi}{6}\sqrt{f_c'} = 572.8$

$V_{c\ all} = V_{c\ act}$ ⇒ solve Equation

$d = 0.35m$

cover $= 10\ cm$

$H = 45\ cm$

• weight of the footing = $2.15 \times 24 \times (0.45) = 27 < 36$ ok

d [0.55] ← assumed

⇒ $Mu = 0.9 As (415) \times 1000 \ [0.55 - 11.62 As]$

solve Equation : $As = 1.62 \times 10^{-3} m^2$

⇒ $\rho = \frac{1.62 \times 10^{-3}}{(1)(0.55)} = 0.00295 < \rho_{min}$ use ρ_{min}

⇒ $As = \frac{1.4}{415} (1)(0.55) = 1.86 \times 10^{-3} m^2$

$= 18.55 \ cm^2/m$

using 20 mm bar ⇒ $As = 3.14 \ cm^2$

bars = 6 bars

⇒ spacing = $\frac{100}{5} = 20$ cm c/c

⇒ $Ld = 568.7$ mm , $Ld = 498$, $Ld = 300$

↓ control

⇒ Ld vernish = $\left(\frac{2.15}{2} - 0.08\right) = 995 mm > 568.7$ O.K

※ long direction:- use Temp. (shrinkage) steel

$= 0.002 A_{gross}$

$= 0.002 (1)(0.63)$

$= 12.6 cm^2$

use 16 mm bars $A_{s\,bar} = 2 cm^2$

# of bar = 6.3 /m

$6.3 \times 2.15 = 15.75 \simeq 16$ bars

spacing = $\frac{2.5 \times 100 - 16}{15} = 15.6$ use 15 cm