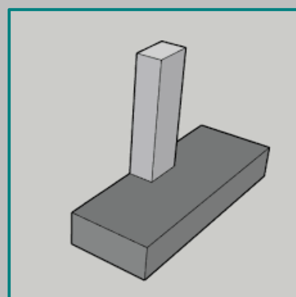
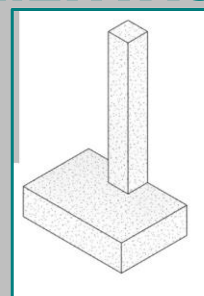
INGENERÍA DE CIMENTACIONES





CAPÍTULO III: ANALISIS Y DISEÑO DE ZAPATA EXCENTRICA

2024-I

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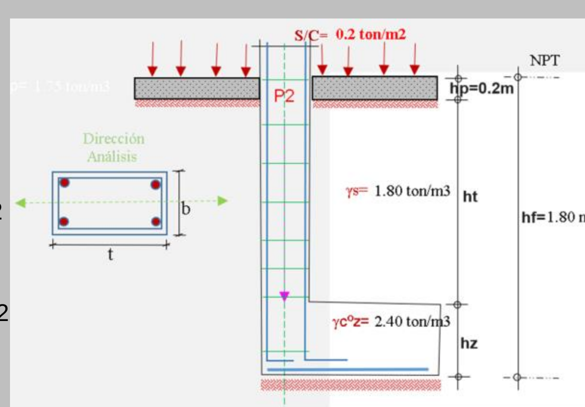
Problema 03

Diseñe el espesor y distribución de refuerzo de la zapata excéntrica; para las solicitaciones que se adjunta:

- Carga muerta = 32 tn
- Carga viva = 12 tn
- Mom. Carga Muerta = 6.00 tn – m
- Mom. Carga Viva = 4.00 tn – m
- Sección de columna = 30×25 cm2
- Capacidad portante = 2.00 kg/cm2
- f'_c zapata = 210 kg/cm2
- f'_c columna = 210 kg/cm2
- f_y acero = 4200 kg/cm2
- γ_s suelo = 1800 kg/m3
- Acero de la Columna = 4 ϕ 5/8”
- s/c = 200 kg/m2



SOLUCIÓN:

1. DIMENSIONAMIENTO

1.1. CALCULO DEL ESFUERZO NETO DEL TERRENO

$$\boldsymbol{\sigma_n = \sigma_t - h_p\gamma_{cs} - h_t\gamma_s - h_z\gamma_{ca} - s/c}$$

El peralte de la zapata, debe ser capaz de permitir el desarrollo del refuerzo a compresión de la columna:

Acero de la Columna: ϕ 5/8“
Øb = 1.59 cm
Ab = 1.98 cm2

Acero asumido de la zapata: Ø3/4”
Øb = 1.91cm
Ab = 2.85 cm2

$$L_d \geq d \begin{cases} 0.075 \times db \times f_y/\sqrt{f'_c} & = 0.075 \times 1.59 \times \dfrac{4200}{\sqrt{210}} = \mathbf{34.56\ cm} \\ 0.0044 \times db \times f_y & = 0.0044 \times 1.59 \times 4200 = \mathbf{29.38\ cm} \\ 20\ cm \end{cases}$$

$$\therefore \boldsymbol{h_z = d + r + 2db(zab) + db(col) = 34.56 + 7.5 + 2x1.91 + 1.59 = 47.47cm \approx 50.00\ cm}$$

$$h_t = h_f - h_p - h_z = 1.80 - 0.20 - 0.50 = \mathbf{1.10\ m}$$

$$\sigma_n = 20 - 0.20x2.30 - 1.10x1.80 - 0.50x2.40 - 0.2 = \mathbf{16.16\ tn/m^2}$$

1.2. AREA DE ZAPATA

$$\boldsymbol{A_z = \frac{P}{\sigma_n}} \qquad \text{Donde } P = P_D + P_L = 32.00 + 12.00 = \mathbf{44.00\ tn}$$

$$A_z = \frac{44.00}{16.16} = \mathbf{2.72 \approx 2.75\ m^2}$$

$$*\ Por\ excentricidad\ A_z > 2.75m^2$$

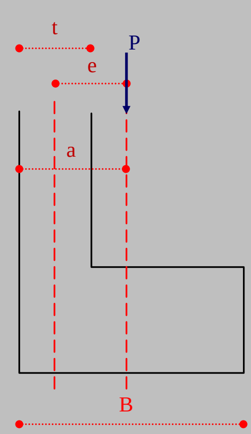
$$e = \frac{M}{P};$$

$$donde\ M = M_D + M_L$$

$$M = 6.00 + 4.00$$

$$M = \mathbf{10.00\ tn - m}$$

$$e = \frac{10.00}{44.00} = 0.227\ m$$



$$B_{MIN} = 3e = 3x0.227 = 0.68\ m$$

$$B_{MAX} = 2a;$$

$$donde\ a = e + \frac{t}{2} = 0.227 + \frac{0.30}{2} = 0.377\ m$$

$$B_{MAX} = 2x0.377 = 0.75\ m$$

$$A_z = AxB; \quad A = 2.B \rightarrow B = \sqrt{\frac{A_z}{2}}$$

$$B = \sqrt{\frac{2.75}{2}} = 1.17 \approx 1.20\ m$$

$$A = 2x1.20 = 2.40m$$

$$\therefore \boldsymbol{A_Z = AxB = 2.40x1.20 = 2.88\ m^2}$$

1.3. VERIFICACION DE PRESION$(\boldsymbol{\sigma_{max}} < \boldsymbol{\sigma_t})$

$$\boldsymbol{\sigma_{max}} = \frac{P}{A_z} + \frac{Mc}{I}; \qquad donde\ c = \frac{B}{2} = \frac{1.20}{2} = 0.60\ m$$

$$\boldsymbol{\sigma_{max}} = \frac{44.00}{2.88} + \frac{10.00x0.60}{0.35} \qquad I = \frac{A.B^3}{12} = \frac{2.40x1.20^3}{12} = 0.35\ m^4$$

$$\boldsymbol{\sigma_{max}} = 32.42\ tn/m^2$$

$$\therefore \boldsymbol{\sigma_{max}} = 32.42\ tn/m^2 > \boldsymbol{\sigma_t} = 20.00\ tn/m^2 \ldots \text{¡no cumple!}$$

Redimensionar Area

$$\left.\begin{array}{r} B = 1.40\ m \\ A = 2.80\ m \\ A_z = 3.92\ m^2 \\ I = 0.64\ m^4 \\ c = 0.70\ m \end{array}\right\} \quad \sigma_{max} = \frac{44.00}{3.92} + \frac{10.00x0.70}{0.64} = 22.16\ tn/m^2$$

$$\boldsymbol{\sigma_{max} = 22.16\ tn/m^2 > \sigma_t = 20.00\ tn/m^2} \ldots\ldots\ldots \text{¡No cumple!}$$

$$\left.\begin{array}{r} B = 1.50\ m \\ A = 3.00\ m \\ A_z = 4.50\ m^2 \\ I = 0.84\ m^4 \\ c = 0.75\ m \end{array}\right\} \quad \sigma_{max} = \frac{44.00}{4.50} + \frac{10.00x0.75}{0.84} = 18.71\ tn/m^2$$

$$\boldsymbol{\sigma_{max} = 18.71\ tn/m^2 < \sigma_t = 20.00\ tn/m^2} \ldots\ldots\ldots \boldsymbol{OK}$$

2. REACCION AMPLIFICADA DEL SUELO

2.1. ESFUERZOS PRODUCIDOS POR EL SUELO $(\boldsymbol{Max\ y\ Min})$

$$\sigma_{1,2} = \frac{P_u}{A_z} \pm \frac{M_{uc}}{I};$$

$$\sigma_{1,2} = \frac{65.20}{4.50} \pm \frac{15.20x0.75}{0.84}$$

$$\sigma_1 = 28.06\ tn/m^2$$

$$\sigma_2 = 0.92\ tn/m^2$$

donde:

$$P_u = 1.4P_D + 1.7P_L$$

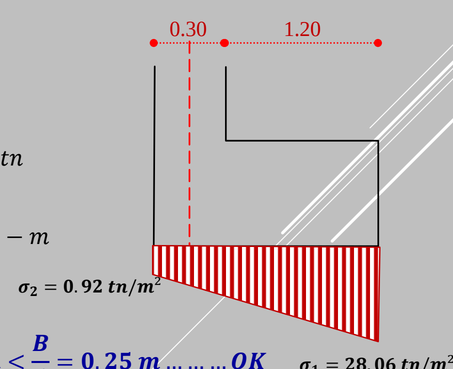
$$P_u = 1.4(32.00) + 1.7(12.00) = 65.20\ tn$$

$$M_u = 1.4M_D + 1.7M_L$$

$$M_u = 1.4(6.00) + 1.7(4.00) = 15.20 tn - m$$

$$e_u = \frac{M_u}{P_u} = \frac{15.20}{65.20} = 0.233m$$

$$\frac{B}{6} = \frac{1.50}{6} = 0.25 \qquad \therefore\ \boldsymbol{e_u = 0.233\ m < \frac{B}{6} = 0.25\ m} \ldots\ldots\ldots \boldsymbol{OK}$$

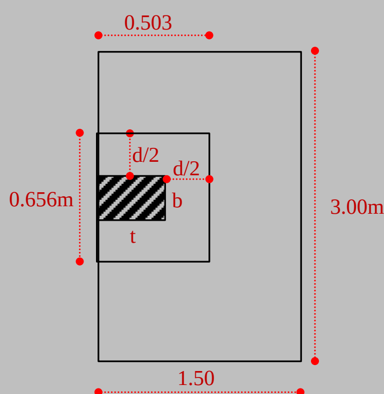


2.2. VERIFICACION POR PUNZONAMIENTO($V_c \geq V_u$)

$dprom = hz - r - \phi b;$ $\quad$ $se\ asume\ \phi\ 3/4" \rightarrow \phi b = 1.91\ cm$

$dprom = 50 - 7.5 - 1.91 = 40.59 \approx 0.4059\ m$

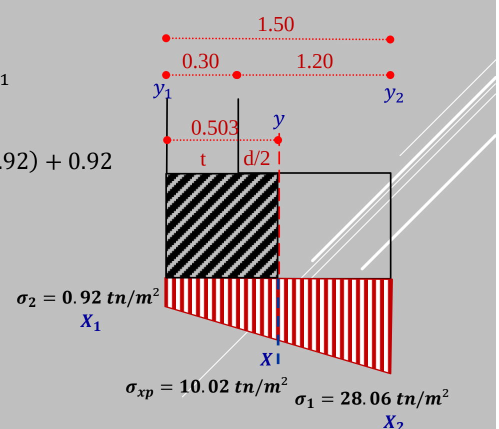
$*$ ***ACCION EN 2 DIRECCIONES A UNA DISTANCIA*** $^{d}/_{2}$ ***DE LA CARA DE APOYO***



$$\sigma_{xp} = \frac{y - y_1}{y_2 - y_1}(x_2 - x_1) + x_1$$

$$\sigma_{xp} = \frac{0.503 - 0}{1.50 - 0}(28.06 - 0.92) + 0.92$$

$$\sigma_{xp} = 10.02\ tn/m^2$$



$*$ ***FUERZA POR PUNZONAMIENTO***

$$Fpu = \left(\frac{\sigma_{xp} + \sigma_2}{2}\right) A_0;$$

$$Fpu = \left(\frac{10.92 + 0.92}{2}\right) x0.33$$

$$Fpu = 1.95\ tn$$

$$Donde:\ A_0 = (t + d/2)(b + d)$$

$$A_0 = \left(0.30 + \frac{0.4059}{2}\right)(0.25 + 0.4059)$$

$$A_0 = 0.33\ m^2$$

$*$ ***CORTANTE ULTIMA POR PUNZONAMIENTO***

$$Vu = Pu - Fpu = 65.20 - 1.95 = 63.25\ tn$$

$*$ ***CORTANTE RESISTENTE DE PUNZONAMIENTO***

$$V_c = \phi 1.06 \sqrt{f'_c}\ x\ b_o\ x\ d$$

$$V_c = 0{,}85\ \text{x}\ 1.06\ x\ \sqrt{210} * 2.32\ x\ 0.4059$$

$$Vc = 122.95\ \text{tn}$$

$$donde: bo = 2\left(t + {}^{d}/_{2}\right) + 2(b + d)$$

$$b_0 = 2\left(0.30 + \frac{0.4059}{2}\right) + 2(0.25 + 0.4059)$$

$$bo = 2.32$$

$$\therefore\ \boldsymbol{V_c = 122.95tn > V_u = 63.25tn \ldots\ldots\ldots OK}$$

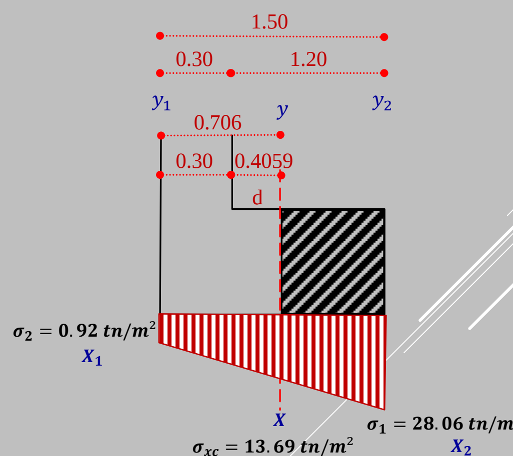
3. VERIFICACION POR *CORTANTE*

$* \ ACCION\ DE\ VIGA\ A\ LA\ DISTANCIA\ "d"\ DE\ LA\ CARA\ DE\ APOYO$

$$\sigma_{xc} = \frac{y - y_1}{y_2 - y_1}(x_2 - x_1) + x_1$$

$$\sigma_{xc} = \frac{0.706 - 0}{1.50 - 0}(28.06 - 0.92) + 0.92$$

$$\sigma_{xc} = 13.69\ tn/m^2$$



$* \ Vu = CORTANTE\ FACTORIZADO$

$$Vu = \left(\frac{\sigma_{xc} + \sigma_1}{2}\right) x\left(A(L_v - d)\right)$$

$$Vu = \left(\frac{13.69 + 28.06}{2}\right) x\left(3.00(1.20 - 0.4059)\right)$$

$$Vu = 49.73\ tn$$

$* \ CORTE\ NOMINAL\ REQUERIDO\ "Vn"$

$$Vn = \frac{Vu}{\phi}; \qquad \phi = 0.85$$

$$Vn = \frac{49.73}{0.85}$$

$$Vn = 58.51\ tn$$

$* \ RESISTENCIA\ AL\ CORTANTE\ DISPONIBLE\ DEL\ CONCRETO\ EN\ LA\ ZAPATA$

$$Vc = 0.53\sqrt{f'c}\ x\ A\ x\ d$$

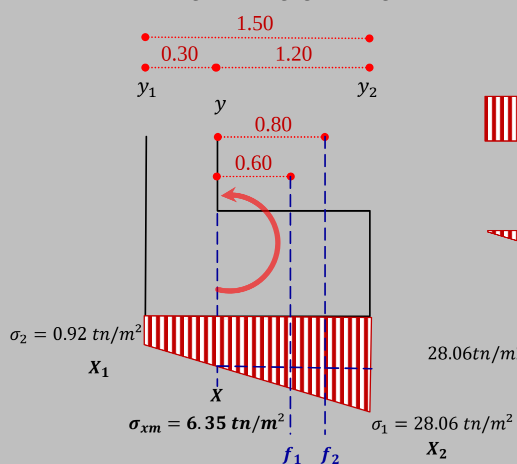
$$Vc = 0.53\sqrt{210}\ x\ 10\ x\ 3.00\ x\ 0.4059 = 93.52\ tn$$

$$\therefore\ \boldsymbol{V_c = 93.52\ tn > V_n = 58.51tn \ldots\ldots\ldots\ OK}$$

4. *DISEÑO POR FLEXION*

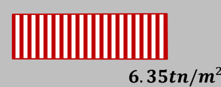
4.1. *ACERO LONGITUDINAL*

4.1.1. *MOMENTO ULTIMO*



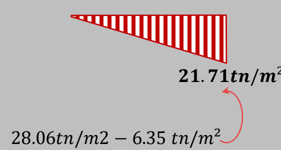
$$\sigma_{xm} = \frac{y - y_1}{y_2 - y_1}(x_2 - x_1) + x_1$$

$$\sigma_{xm} = \frac{0.30 - 0.0}{1.50 - 0.0}(28.06 - 0.92) + 0.92 = 6.35\ tn/m^2$$



$$f1 = 6.35\ t/m2\ x\ 1.20\ m\ x\ 3.00\ m = 22.86\ tn$$

$$Lv_1 = \frac{1.2}{2} = 0.60m$$



$$f2 = 21.71\ t/m2\ x \frac{1.20\ m}{2} x\ 3.00\ m = 39.08\ tn$$

$$Lv_2 = 1.2 \times \frac{2}{3} = 0.80\ m$$

$$Mu = f1\ x\ 0.60 + f2\ x\ 0.80$$

$$Mu = 22.86\ x\ 0.60 + 39.08\ x\ 0.80$$

$$\mathbf{Mu = 44.98\ tn - m}$$

CAPÍTULO III: ANALISIS Y DISEÑO DE ZAPATA EXCENTRICA

4.1.2. MOMENTO NOMINAL (Mn)

$$M_n = \frac{Mu}{\phi}; \qquad \phi = 0.90 \quad (flexión)$$

$$M_n = \frac{44.98}{0.90} = 49.98\ tn - m$$

4.1.3. AREA DE ACERO

$$A_s = \left(0.85 - \sqrt{0.7225 - \frac{1.7\ x\ Mn\ x\ 10^5}{f'c\ x\ A\ x\ d^2}}\right) x\ \frac{f'c}{fy}\ x\ A\ x\ d$$

$$A_s = \left(0.85 - \sqrt{0.7225 - \frac{1.7\ x\ 49.98\ x\ 10^5}{210\ x\ 300\ x\ 40.59^2}}\right) x\ \frac{210}{4200}\ x\ 300\ x\ 40.59$$

$$\mathbf{A_s = 22.76\ cm^2}$$

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4.1.4. VERIFICACION DE CUANTIA

Debe cumplir: $\rho > \rho_{min}$ $\;$ $si\;\; \rho < \rho_{min}\;\; entonces\; tomar\;\; \rho_{min} = \mathbf{0.0018}$

$$\rho = \frac{A_s}{A\;x\;d} = \frac{22.76}{(300\;x\;40.59)} = \mathbf{0.0019}$$

$$\therefore \boldsymbol{\rho = 0.0019 > \rho_{min} = 0.0018 \ldots\ldots\ldots OK}$$

4.1.5. DISTRIBUCION DE ACERO (n)

Numero de varillas longitudinales en $A = 3.00\; m.$

Si elegimos $\phi = 5/8"$

$$\left.\begin{matrix} \emptyset b = 1.59 cm \\ Ab = 1.98\; cm^2 \end{matrix}\right\} n = \frac{As}{Ab} = \frac{22.76}{1.98} = 11.49 \approx 12\; varillas$$

4.1.6. ESPACIAMIENTO DE LAS BARRAS (s)

Distribucion en $A = 3.00\; m.$

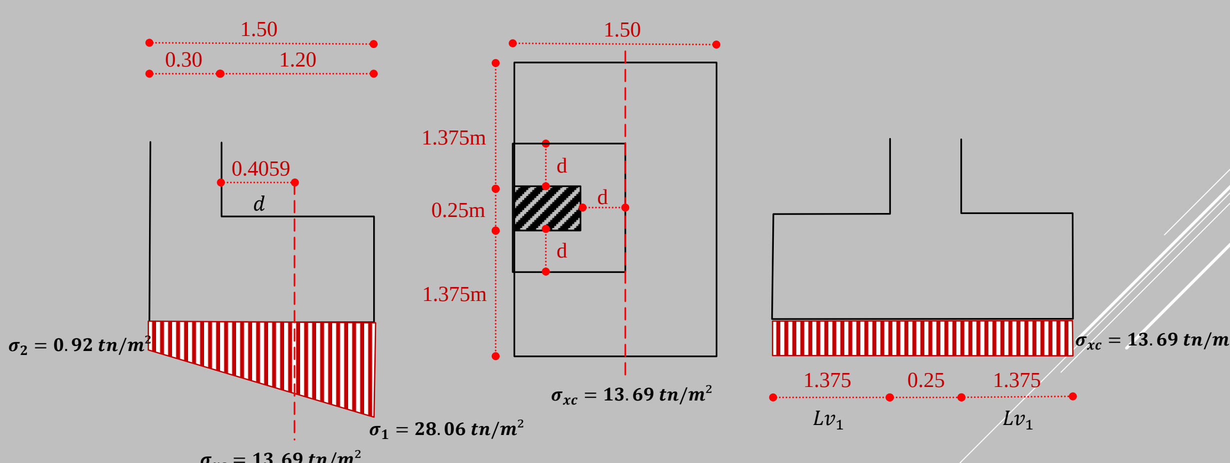
$$S = \frac{A - 2r - \phi b}{n - 1} = \frac{300 - 2x7.5 - 1.59}{12 - 1} = 25.40 \approx 25.00 cm$$

$$\therefore \boldsymbol{Usar = 12\;\; \phi\, 5/8"\;\; @\;\; 0.25m}$$

CAPÍTULO III: ANALISIS Y DISEÑO DE ZAPATA EXCENTRICA

4.2. ACERO TRANSVERSAL

4.2.1 MOMENTO ULTIMO



$$Mu = Wnu \ x \ B \ x \ \frac{Lv^2}{2}$$

$$Mu = 13.69 \ x \ 1.50 \ x \ \frac{1.375^2}{2} = 19.41 \ tn - m$$

4.2.2 MOMENTO NOMINAL (Mn)

$$Mn = \frac{Mu}{\phi} \qquad \phi = 0.90 \quad (flexión)$$

$$Mn = \frac{19.41}{0.90} = 21.57 \ tn - m$$

4.2.3. AREA DE ACERO

$$A_S = \left(0.85 - \sqrt{0.7225 - \frac{1.7 \ x \ Mn \ x \ 10^5}{f'c \ x \ B \ x \ d^2}}\right) x \ \frac{f'c}{fy} \ x \ B \ x \ d$$

$$A_S = \left(0.85 - \sqrt{0.7225 - \frac{1.7 \ x \ 21.57 \ x \ 10^5}{210 \ x \ 150 \ x \ 40.59^2}}\right) x \ \frac{210}{4200} \ x \ 150 \ x \ 40.59 = 12.98 \ cm^2$$

4.2.4. VERIFICACION DE CUANTIA

Debe cumplir: $\boldsymbol{\rho > \rho_{min}} \quad \boldsymbol{si \ \rho < \rho_{min} \ \ entonces \ tomar \ \rho_{min}} = \mathbf{0.0018}$

$$\rho = \frac{A_s}{B \ x \ d} = \frac{12.98}{(150 \ x \ 40.59)} = \mathbf{0.0021}$$

$$\therefore \boldsymbol{\rho = 0.0021 > \rho_{min} = 0.0018 \ldots\ldots\ldots OK}$$

4.2.5. DISTRIBUCION DE ACERO (n)

Numero de varillas longitudinales en $B = 1.50 \ m$

Si elegimos $\phi = 5/8"$

$$\left.\begin{matrix} db = 1.59cm \\ Ab = 1.98 \ cm^2 \end{matrix}\right\} n = \frac{As}{Ab} = \frac{12.98}{1.98} = 6.55 \approx 7 \ varillas$$

4.2.6. ESPACIAMIENTO DE LAS BARRAS (s)

Distribucion en $A = 1.50 \ m$

$$S = \frac{B - 2r - \phi b}{n - 1} = \frac{1.50 - 2x7.5 - 1.98}{7 - 1} = 22.17 \approx 22 \ cm$$

$$\therefore \boldsymbol{Usar = 7 \ \ \phi \, 5/8" \ @ \ 0.22 \ m}$$

QUAERENS VERITATEM

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