

**ANEXO N°11: MEMORIA DE
CÁLCULO**

**ANEXO N°11.1: METRADO DE
CARGAS**

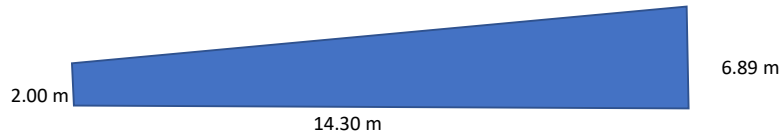
Metrado de cargas de los elementos del Falso Túnel (SAP2000)

Zinicial	2716.08 m	Desnivel	4.77 m
Zfinal	2711.31 m		
Longitud transversal	15.00 m		193.2 KN/m2
Longitud de Falso Túnel	56.70 m		19.70 Tn/m2
Peso total por m2	53.47 Tn/m2	524.34 KN/m2	

CARGAS MUERTAS

CARGA MUERTA DE LA CAPA AMORTIGUADORA (DC)

S/c 11.44 Tn/m2

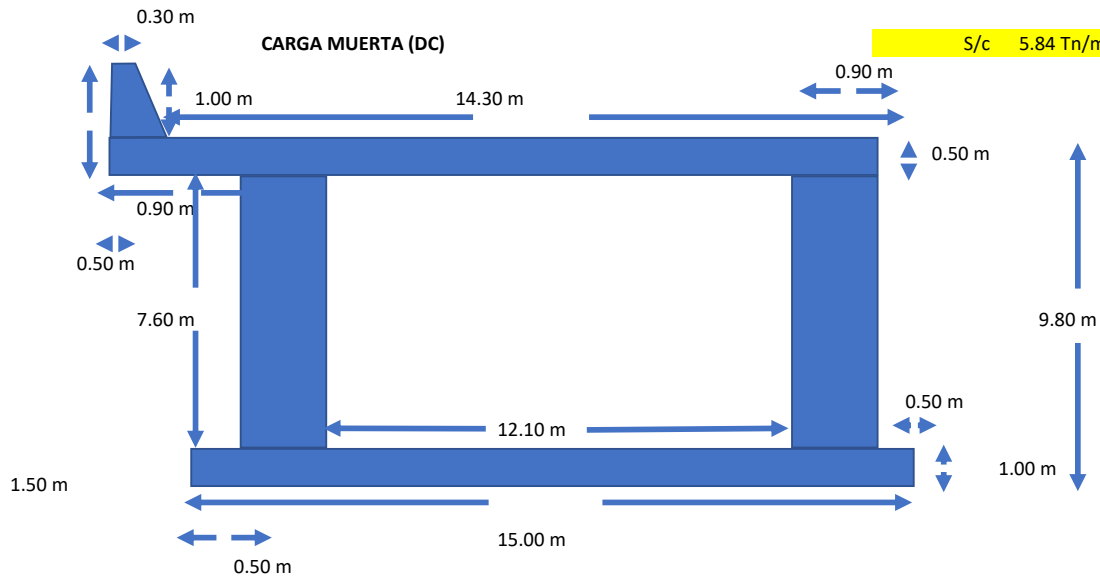


Pendiente de capa amortiguadora 20 %

Espesor promedio	4.45 m
Area	63.57 m2
Volumen	3604.41 m3
Peso específico	2.70 Tn/m3
Peso	9731.91 Tn

CARGA MUERTA (DC)

S/c 5.84 Tn/m2

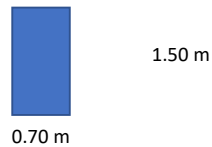


Area transversal	36.48 m2
Volumen	2068.42 m3
Peso específico	2.40 Tn/m3
Peso	4964.20 Tn

Concreto

CARGA MUERTA DE LA VIGA TRANSVERSAL

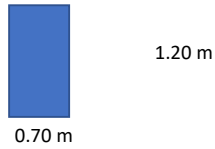
S/c 0.46 Tn/m2



Longitud	12.80 m
Area transversal	1.05 m2
Volumen	13.44 m3
Peso específico	2.40 Tn/m3
Numero de ejes	12
Peso	387.07 Tn

CARGA MUERTA DE LA VIGA LONGITUDINAL

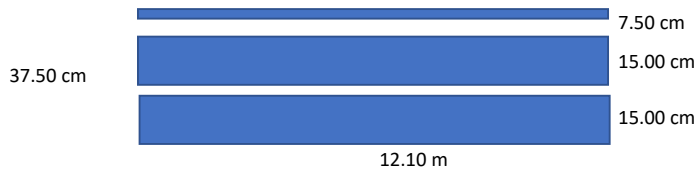
S/c 0.13 Tn/m2



Area transversal	0.84 m2
Volumen	47.63 m3
Peso especifico	2.40 Tn/m3
Peso	114.31 Tn

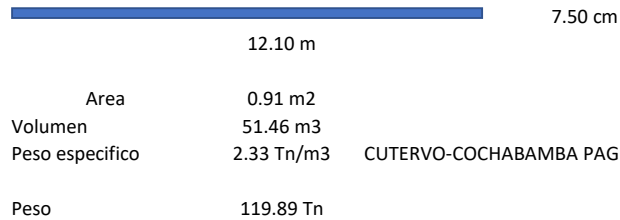
CARGA MUERTA DE LA CARPETA AZFALTICA

S/c 0.79 Tn/m2



CARGA DE ASFALTO

S/c 0.14 Tn/m2



Area	0.91 m2
Volumen	51.46 m3
Peso especifico	2.33 Tn/m3
Peso	119.89 Tn

CUTERVO-COCHABAMBA PAG 90

CARGA DE BASE GRANULAR

S/c 0.33 Tn/m2

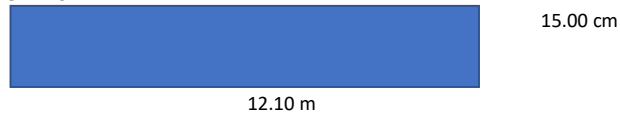


Area	1.82 m2
Volumen	102.91 m3
Peso especifico	2.70 Tn/m3
Peso	277.86 Tn

RIO CALLAYUC (KM 85+200)

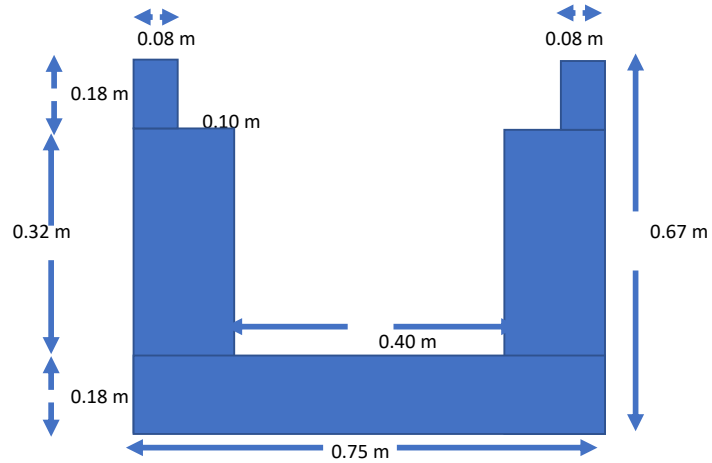
CARGA DE SUBBASE GRANULAR

S/c 0.33 Tn/m2

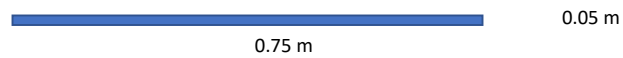


Area	1.82 m2
Volumen	102.91 m3
Peso especifico	2.70 Tn/m3
Peso	277.86 Tn

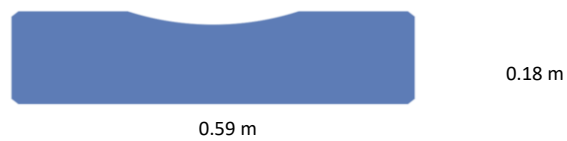
RIO CALLAYUC (KM 85+200)

CARGA MUERTA DE CUNETETAS/c 0.04 Tn/m²

Area	0.27 m ²
Volumen	15.28 m ³
Peso específico	2.40 Tn/m ³
Peso	36.67 Tn

CARGA MUERTA DE SOLADOS/c 0.01 Tn/m²

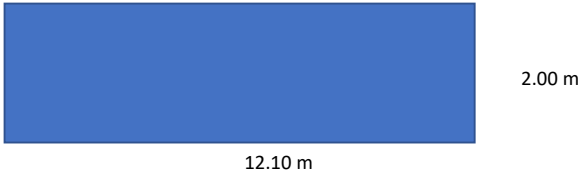
Area	0.04 m ²
Volumen	2.13 m ³
Peso específico	2.10 Tn/m ³
Peso	4.47 Tn

CARGA MUERTA DE TAPA DE CUNETETAS/c 0.03 Tn/m²

Area	0.10 m ²
Volumen	5.85 m ³
Peso específico	2.40 Tn/m ³
Peso	14.05 Tn
Peso ambos lados	28.10 Tn

CARGA MUERTA DE RELLENO COMPACTADO

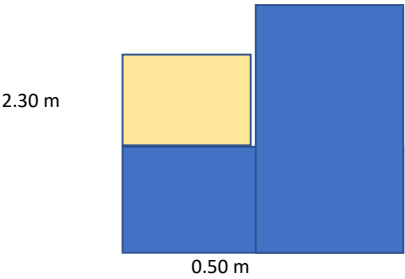
S/c 3.60 Tn/m2



Area	24.20 m2
Volumen	1372.14 m3
Peso especifico	1.80 Tn/m3
Peso	2469.85 Tn

CARGA RELLENO TALON PARTE IZQUIERDA

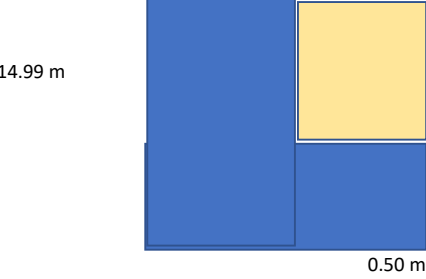
S/c 4.14 Tn/m2



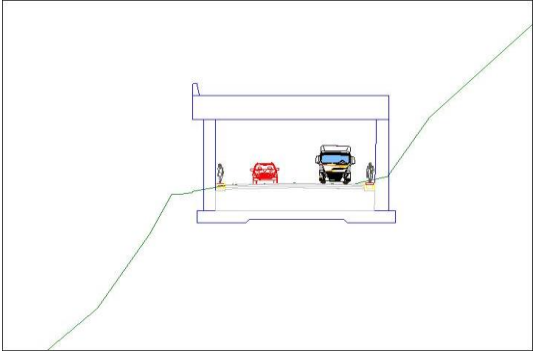
Area	1.15 m2
Volumen	65.21 m3
Peso especifico	1.80 Tn/m3
Peso	117.37 Tn

CARGA RELLENO TALON PARTE DERECHA

S/c 26.98 Tn/m2



Area	7.50 m2
Volumen	424.99 m3
Peso especifico	1.80 Tn/m3
Peso	764.99 Tn



CARGA DEL VEHÍCULO
0.11 Tn/m2

SEGÚN EL REGLAMENTO NACIONAL DE VEHÍCULOS, EN EL ANEXO IV.

Vehículos más pesados

 Peso máximo 48 toneladas
 Longitud mínima 20.5 m

Configuración vehicular

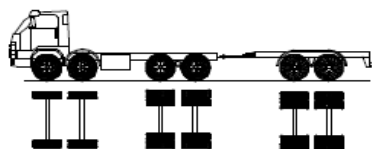
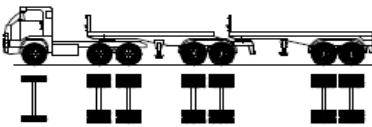
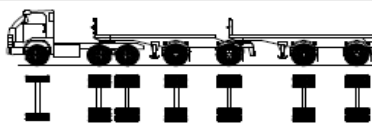
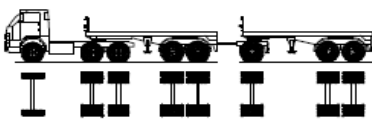
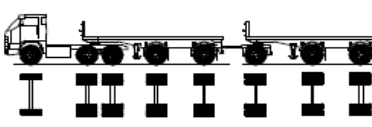
 T3S3
 T3Se3
 C3R3
 C3R4
 C4R2
 C4R3
 8x4R2
 8x4R3
 8x4R4
 C4RB2
 8x4 RB2
 T3S2 S2
 T3S2 S1S2
 T3Se2 S1Se2

 El peso más crítico , es cuando dos vehiculos, se encuentren
 parte superior de la cimentación, uno en cada carril.

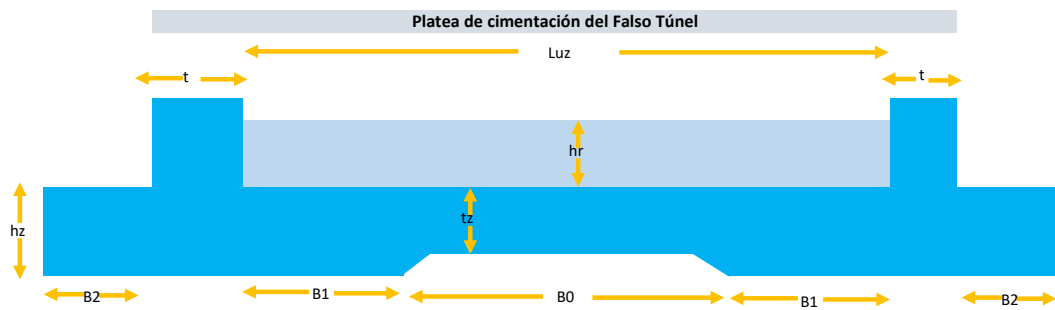
Peso máximo sobre la estructura 96.00 Tn

Área planta 850.50 m2

Peso por metro cuadrado 0.11 Tn/m2

Configuración vehicular	Descripción gráfica de los vehículos	Long. Máx. (m)	Eje Delant	Peso máximo (t)				Peso bruto máx. (t)
				Conjunto de ejes posteriores				
				1º	2º	3º	4º	
8x4 RB2		20,50	7+7 ⁽⁵⁾	18	18	---	---	48 ⁽²⁾
T3S2 S2		23,00	7	18	18	18	---	48 ⁽²⁾
T3Se2 Se2		23,00	7	18	11 + 11 ⁽³⁾	11 + 11 ⁽³⁾	---	48 ⁽²⁾
T3S2 S1S2		23,00	7	18	18	11	18	48 ⁽²⁾
T3Se2 S1Se2		23,00	7	18	11 + 11 ⁽³⁾	11	11 + 11 ⁽³⁾	48 ⁽²⁾

FUENTE: REGLAMENTO NACIONAL DE VEHÍCULOS, EN EL ANEXO IV.



Datos

hr= 4.45 m	Altura de relleno
H= 9.80 m	Altura total desde el fondo de la cimentación hasta techo
Luz= 12.90 m	Luz de entre columna y muro.
hr= 2.35 m	Altura de relleno de solera
L= 56.70 m	Longitud del muro de cimentación
γ_c = 2.40 m	Peso específico del concreto
γ_s = 1.80 m	Peso específico del relleno
ϕ = 30.00 °	Angulo de inclinación del relleno

Predimensionamiento

B = 3.70 m
 B total = 15.00 m
 Bo = 7.65 m
 t = 0.90 m
 B1 = 2.30 m
 B2 = 0.50 m

Hz= 1.00 m
 tz= 0.70 m
 h1= 7.60 m

METRADOS DE CARGAS TOMADAS EN EL DISEÑO (SAP2000)

CARGA MUERTA (DC) DEAD

Peso propio de la platea de cimentación, calculado por el programa SAP2000

CARGA RELLENO TALON PARTE IZQUIERDA 4.14 Tn/m2

CARGA RELLENO TALON PARTE DERECHA 26.98 Tn/m2

CAPA AMORTIGUADORA (DC) 11.44 Tn/m2

RELLENO PAVIMENTO (EV) 3.60 Tn/m2

CARPETA ASFALTICA 0.79 Tn/m2

CUNETAS 0.08 Tn/m2

CARGA VIVA TECHO 0.50 Tn/m2

CARGA VIVA E IMPACTO (LL+IM) 1.20 Tn/m2

CARGA VIVA PEATONAL (PL) 0.25 Tn/m2

FUERZA DE IMPACTO DE LA ROCA 15.45 Tn/m2

CARGA VEHICULAR 0.11 Tn/m2

**ANEXO N°11.2: FUERZA DE
IMPACTO DE LA ROCA**

$$F_k = 2,8 \cdot e^{-0.5} \cdot r^{0.7} \cdot M_{E,K}^{0.4} \cdot \tan \phi_k \cdot \left(\frac{m_k V_k^2}{2} \right)^{0.6}$$

F_k [KN] Fuerza de impacto.

e [m] espesor de la capa de material amortiguador

r [m] radio de la esfera ideal equivalente.

$M_{E,K}$ [KN/m²] módulo de elasticidad de de la capa de amortiguamiento.

ϕ_k [°] ángulo de fricción interno del material de la capa .

m_k [t] masa del bloque.

V_k [m/s] velocidad de impacto.

$$t = \left(\frac{m_k V_k^2}{2} \right)$$

t [m] Penetración.

$$e \geq 0,5 \text{ m}$$

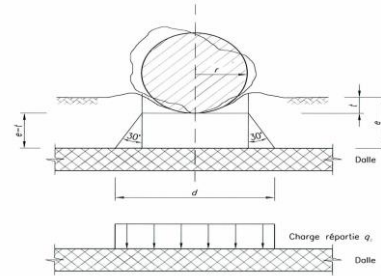
$$e \geq t + 3 \cdot \phi_{max}$$

$$e \geq 2 \cdot t$$

$$A_d = C \cdot F_k$$

Coefficiente de construcción C

Modo de falla	C
Dúctil (falla a flexión de vigas o losas, falla de elementos reforzados a cortante o punzonamiento)	0.4
Frágil (falla de elementos no reforzados a cortante o punzonamiento)	1.2



C: Coeficiente de seguridad sobre el valor de la fuerza de impacto, requerido por la normativa Suiza para cubrir las incertidumbre que pueden existir en el resto de parámetros que influyen en la fuerza de impacto (espesor de tierras, módulo elástico de las tierras, etc) y se toma igual a 1,20 para el caso de falla frágil para hacerlo comparable con la fuerza $F_{lmáx}$ usada en esta investigación para modelar el mecanismo de punzonamiento.

$$F_k = 2,8 \cdot e^{-0.5} \cdot r^{0.7} \cdot M_{E,K}^{0.4} \cdot \tan \phi_k \cdot \left(\frac{m_k V_k^2}{2} \right)^{0.6}$$

e	4.45 m	Espesor de capa de amortiguamiento
r	1.50 m	Radio de la esfera
M _{e,k}	30000.00 KN/m2	Valor crítico de módulo de elasticidad
Ø	36	Angulo de fricción del material
m _k	15.87 Tn	Masa de la roca
v _k	28.01 m/s	Velocidad de impacto de la roca
Ø max	0.10 m	Ø max es el diámetro máximo del material granular
Ø	30	Normativa Suiza, (ASTRA 12 006, Oficina Federal de Vías - OFROU)

Altura crítica probable de desprendimiento40.00 m

Gravedad9.81 m/s2

$V = \sqrt{2 \cdot g \cdot h}$

Velocidad 28.01 m/s

Cálculo de fuerza de impacto:

Prueba c

4.45 m

m (mínimo)

-0.5

0.7

0.4

0.6

F_k=2.8

[4.45 m]

[1.50 m]

[30000.00 KN/m2]

[0.73]

$\left(\frac{15.87 \text{ Tn} \times 28.01}{2} \right)^{0.6}$

F_k=14967.78 KN

F_k=1526.29 Tn

Cálculo de la penetracion máxima

$$t = \left(\frac{m_k V_k^2}{F_k} \right)^2$$

$$t = \left(\frac{15.87 \text{ Tn} \times 28.01 \text{ m/s}}{14968} \right)^2$$

t=0.83 m

t=0.90 m

tomado

Verificaciones de espesor	4.45 m ≥ 0.5m	OK
	4.45 m ≥ t+3*Ø max	OK
	4.45 m ≥ 2*t	OK

Diámetro de la fuerza equivalente

$$d = 2 * (r + (e - t) * \tan(\phi))$$

d

2

[1.50 m

+

[4.45 m

0.90 m]

×

0.58]

d

7.09 m

Esfuerzo equivalente

$$q_d = \frac{F_k * C}{\left(\frac{\pi * d^2}{4} \right)}$$

qd=

$\frac{14967.78 \text{ KN}}{\left(\frac{3.14 \times 7.09^2}{4} \right)}$

qd=

378.70 KN/m2

=

38.62 Tn/m2

qd=

0.38 Mpa

qd=

15.45 Tn/m2

Con el factor C (0.4)

En conclusión, de acuerdo a la normativa Suiza; el Falso Túnel requiere una capa de material granular de espesor 4.45 m

La estructura se puede diseñar incluyendo la carga del impacto como un esfuerzo estático equivalente igual a	0.38 Mpa	38.62 Tn/m2	15.45 Tn/m2 Con factor C=0.4	46.34 Tn/m2 Con factor C=1.2
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Ubicado sobre una área circular de diametro. 7.09 m

**ANEXO N°11.3: DISEÑO DE VIGAS
DE CONCRETO ARMADO**

DISEÑO DE VIGA INTERIOR (FLEXIÓN)

$f'c = 280 \text{ kgf/cm}^2$
 $fy = 4200 \text{ kgf/cm}^2$
 $L = 12.00 \text{ m}$
 $b = 0.70 \text{ m}$
 $h = 1.50 \text{ m}$
 $\text{losa} = 0.40 \text{ m}$

Resumen de Momentos

$M (-)$	126.25 tn.m	74.77 tn.m	144.86 tn.m
$M (+)$	109.57 tn.m	591.94 tn.m	131.86 tn.m

Diseño del Refuerzo

Estado Límite: Resistencia Última

Apoyo Izquierdo EJE 1-1

MOMENTO SUPERIOR

$$\begin{aligned} \mu_u &= 126.25 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 142.46 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{\mu_u}{\phi * fy * (d - a/2)} \\ a &= 6.04 \text{ cm} \\ As &= 23.95 \text{ cm}^2 \\ C &= 7.10 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 3.51 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 1'' &= 5.10 \text{ cm}^2 \\ nb &= 5 \end{aligned}$$

Usar **6 Ø 1"**

$$b_{min} = 45.56 \text{ cm}$$

Claro

MOMENTO SUPERIOR

$$\begin{aligned} \mu_u &= 74.77 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 142.46 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{\mu_u}{\phi * fy * (d - a/2)} \\ a &= 3.54 \text{ cm} \\ As &= 14.06 \text{ cm}^2 \\ C &= 4.17 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 5.62 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 1'' &= 5.10 \text{ cm}^2 \\ nb &= 3 \end{aligned}$$

Usar **6 Ø 1"**

$$b_{min} = 45.56 \text{ cm}$$

Apoyo Derecho EJE 2-2

MOMENTO SUPERIOR

$$\begin{aligned} \mu_u &= 144.86 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 142.46 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{\mu_u}{\phi * fy * (d - a/2)} \\ a &= 6.95 \text{ cm} \\ As &= 27.57 \text{ cm}^2 \\ C &= 8.18 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 3.11 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 1'' &= 5.10 \text{ cm}^2 \\ nb &= 6 \end{aligned}$$

Usar **6 Ø 1"**

$$b_{min} = 45.56 \text{ cm}$$

Momento último resistente

$$A_s = 30.60 \text{ cm}^2$$

$$a = 7.71 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y (d - \frac{a}{2})$$

$$M_{ur} = 160.32 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\text{mín}} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\text{mín}} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * (\frac{6300}{6300 + f_y})$$

$$\rho_b = 0.0289$$

$$\rho_{\text{máx}} = 0.75 * \rho_b$$

$$\rho_{\text{máx}} = 0.0217$$

$$\rho = \frac{A_s}{b.d}$$

$$\rho = 0.0031 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 167.91 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 160.32 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array} \quad \text{ok}$$

Momento último resistente

$$A_s = 30.60 \text{ cm}^2$$

$$a = 7.71 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y (d - \frac{a}{2})$$

$$M_{ur} = 160.32 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\text{mín}} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\text{mín}} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * (\frac{6300}{6300 + f_y})$$

$$\rho_b = 0.0289$$

$$\rho_{\text{máx}} = 0.75 * \rho_b$$

$$\rho_{\text{máx}} = 0.0217$$

$$\rho = \frac{A_s}{b.d}$$

$$\rho = 0.0031 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 99.44 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 160.32 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array} \quad \text{ok}$$

Momento último resistente

$$A_s = 30.60 \text{ cm}^2$$

$$a = 7.71 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y (d - \frac{a}{2})$$

$$M_{ur} = 160.32 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\text{mín}} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\text{mín}} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * (\frac{6300}{6300 + f_y})$$

$$\rho_b = 0.0289$$

$$\rho_{\text{máx}} = 0.75 * \rho_b$$

$$\rho_{\text{máx}} = 0.0217$$

$$\rho = \frac{A_s}{b.d}$$

$$\rho = 0.0031 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 192.66 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 160.32 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array} \quad \text{ok}$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 109.57 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 137.38 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 5.43 \text{ cm} \\ As &= 21.52 \text{ cm}^2 \\ C &= 6.38 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 3.73 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 5.10 \text{ cm}^2$$

$$nb = 5$$

Usar 6 Ø 1"

$$bmin = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 30.60 \text{ cm}^2 \\ a &= 7.71 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 154.44 \text{ tnf.m} > Mu \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 591.94 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 137.38 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 32.61 \text{ cm} \\ As &= 129.34 \text{ cm}^2 \\ C &= 38.36 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 1.04 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 5.10 \text{ cm}^2$$

$$nb = 26$$

Usar 27 Ø 1"

$$bmin = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 137.70 \text{ cm}^2 \\ a &= 34.71 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 624.73 \text{ tnf.m} > Mu \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 131.86 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 137.38 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 6.56 \text{ cm} \\ As &= 26.01 \text{ cm}^2 \\ C &= 7.72 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 3.17 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 5.10 \text{ cm}^2$$

$$nb = 6$$

Usar 6 Ø 1"

$$bmin = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 30.60 \text{ cm}^2 \\ a &= 7.71 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 154.44 \text{ tnf.m} > Mu \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0032$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 145.73 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 154.44 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array}$$

Refuerzo por Temperatura

$$As, t = \frac{0.18 \times b \times h}{2(b + h)}$$

$$b = 70.00 \text{ cm}$$

$$h = 150.00 \text{ cm}$$

$$\text{losa} = 40.00$$

$$As, t = 4.30 \text{ cm}^2/\text{m}$$

$$y = 85.95 \text{ cm}$$

$$As, t = 3.69 \text{ cm}^2$$

$$\text{barra de } 1/2" = 1.27 \text{ cm}^2$$

$$N_b = 3$$

$$2.33 \text{ cm}^2/\text{m} \leq As, temp \leq 12.75 \text{ cm}^2/\text{m}$$

Usar 3 Ø 1/2" @ en cada cara

Refuerzo por Paramento

$$As, k = 0.10 \times (d - 76)$$

$$As, k = 6.65 \text{ cm}^2/\text{m}$$

$$y = 85.95 \text{ cm}$$

$$As, k = 5.71 \text{ cm}^2$$

$$\text{barra de } 5/8" = 1.27 \text{ cm}^2$$

$$N_b = 5$$

Usar 5 Ø 1/2" @ en cada cara

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0143$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 787.28 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 624.73 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array}$$

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0032$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 175.37 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 154.44 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array}$$

ok

DISEÑO DE VIGA EXTERIOR (FLEXIÓN)

$f'c = 280 \text{ kgf/cm}^2$
 $fy = 4200 \text{ kgf/cm}^2$
 $L = 12.00 \text{ m}$
 $b = 0.70 \text{ m}$
 $h = 1.50 \text{ m}$
 $losa = 0.40 \text{ m}$

Resumen de Momentos

$M (-)$	99.95 tn.m	59.00 tn.m	91.13 tn.m
$M (+)$	144.50 tn.m	468.03 tn.m	123.84 tn.m

Diseño del Refuerzo

Estado Límite: Resistencia Última

Apoyo Izquierdo EJE 1-1

MOMENTO SUPERIOR

$$\begin{aligned} Mu &= 99.95 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 142.46 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)} \\ a &= 4.76 \text{ cm} \\ As &= 18.88 \text{ cm}^2 \\ C &= 5.60 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 4.32 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 1'' &= 5.10 \text{ cm}^2 \\ nb &= 4 \end{aligned}$$

Usar 6 Ø 1"

$$bmin = 45.56 \text{ cm}$$

Claro

MOMENTO SUPERIOR

$$\begin{aligned} Mu &= 59.00 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 142.46 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)} \\ a &= 2.79 \text{ cm} \\ As &= 11.06 \text{ cm}^2 \\ C &= 3.28 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 7.01 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 1'' &= 5.10 \text{ cm}^2 \\ nb &= 3 \end{aligned}$$

Usar 6 Ø 1"

$$bmin = 45.56 \text{ cm}$$

Apoyo Derecho EJE 2-2

MOMENTO SUPERIOR

$$\begin{aligned} Mu &= 91.13 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 142.46 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)} \\ a &= 4.33 \text{ cm} \\ As &= 17.18 \text{ cm}^2 \\ C &= 5.10 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 4.69 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 1'' &= 5.10 \text{ cm}^2 \\ nb &= 4 \end{aligned}$$

Usar 6 Ø 1"

$$bmin = 45.56 \text{ cm}$$

Momento último resistente

$$A_s = 30.60 \text{ cm}^2$$

$$a = 7.71 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 160.32 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * \left(\frac{6300}{6300 + f_y} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

$$\rho = \frac{A_s}{b.d}$$

$$\rho = 0.0031 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 132.93 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 160.32 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array} \quad \text{ok}$$

Momento último resistente

$$A_s = 30.60 \text{ cm}^2$$

$$a = 7.71 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 160.32 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * \left(\frac{6300}{6300 + f_y} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

$$\rho = \frac{A_s}{b.d}$$

$$\rho = 0.0031 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 78.47 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 160.32 \text{ tnf.m} & > & 78.47 \text{ tnf.m} \end{array} \quad \text{ok}$$

Momento último resistente

$$A_s = 30.60 \text{ cm}^2$$

$$a = 7.71 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 160.32 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * \left(\frac{6300}{6300 + f_y} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

$$\rho = \frac{A_s}{b.d}$$

$$\rho = 0.0031 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 121.20 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 160.32 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array} \quad \text{ok}$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 144.50 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 139.92 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 7.07 \text{ cm} \\ As &= 28.03 \text{ cm}^2 \\ C &= 8.31 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 3.02 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 5.10 \text{ cm}^2$$

$$nb = 6$$

Usar 6 Ø 1"

$$b_{min} = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 30.60 \text{ cm}^2 \\ a &= 7.71 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 157.38 \text{ tnf.m} > Mu \quad ok$$

Cuantía

$$\rho_{min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{max} = 0.75 * \rho_b$$

$$\rho_{max} = 0.0217$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 468.03 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 139.92 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 24.44 \text{ cm} \\ As &= 96.96 \text{ cm}^2 \\ C &= 28.76 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 1.23 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 5.10 \text{ cm}^2$$

$$nb = 20$$

Usar 20 Ø 1"

$$b_{min} = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 102.00 \text{ cm}^2 \\ a &= 25.71 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 489.90 \text{ tnf.m} > Mu \quad ok$$

Cuantía

$$\rho_{min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{max} = 0.75 * \rho_b$$

$$\rho_{max} = 0.0217$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 123.84 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 150.00 \text{ cm} \\ d &= 139.92 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 6.03 \text{ cm} \\ As &= 23.93 \text{ cm}^2 \\ C &= 7.10 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 3.46 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 5.10 \text{ cm}^2$$

$$nb = 5$$

Usar 6 Ø 1"

$$b_{min} = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 30.60 \text{ cm}^2 \\ a &= 7.71 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 157.38 \text{ tnf.m} > Mu \quad ok$$

Cuantía

$$\rho_{min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{max} = 0.75 * \rho_b$$

$$\rho_{max} = 0.0217$$

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0031$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'_c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 192.19 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 157.38 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array}$$

Refuerzo por Temperatura

$$As, t = \frac{0.18 \times b \times h}{2(b + h)}$$

$$b = 70.00 \text{ cm}$$

$$h = 150.00 \text{ cm}$$

$$losa = 40.00$$

$$As, t = 4.30 \text{ cm}^2/\text{m} \quad 2.33 \text{ cm}^2/\text{m} \leq As, temp \leq 12.75 \text{ cm}^2/\text{m}$$

$$y = 85.95 \text{ cm}$$

$$As, t = 3.69 \text{ cm}^2$$

$$\text{barra de } 1/2" = 1.27 \text{ cm}^2$$

$$N_b = 3$$

Usar 3 Ø 1/2" @ en cada cara

Refuerzo por Paramento

$$As, k = 0.10 \times (d - 76)$$

$$As, k = 6.65 \text{ cm}^2/\text{m}$$

$$y = 85.95 \text{ cm}$$

$$As, k = 5.71 \text{ cm}^2$$

$$\text{barra de } 5/8" = 1.27 \text{ cm}^2$$

$$N_b = 5$$

Usar 5 Ø 1/2" @ en cada cara

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0104$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'_c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 622.48 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 489.90 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array}$$

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0031$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'_c}$$

$$s = 262500 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 97.12 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 164.71 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 157.38 \text{ tnf.m} & > & 97.12 \text{ tnf.m} \end{array}$$

ok

DISEÑO DE VIGA DE BORDE (FLEXIÓN)

$f'c = 280 \text{ kgf/cm}^2$
 $fy = 4200 \text{ kgf/cm}^2$
 $L = 12.00 \text{ m}$
 $b = 0.70 \text{ m}$
 $h = 1.20 \text{ m}$
 $losa = 0.40 \text{ m}$

Resumen de Momentos

$M (-)$	43.83 tn.m	9.03 tn.m	4.95 tn.m
$M (+)$	11.72 tn.m	63.87 tn.m	13.06 tn.m

Diseño del Refuerzo

Estado Límite: Resistencia Última

Apoyo Izquierdo EJE 1-1

MOMENTO SUPERIOR

$Mu = 43.83 \text{ tnf.m}$
 $b = 70.00 \text{ cm}$
 $h = 120.00 \text{ cm}$
 $d = 112.78 \text{ cm}$
 $\phi = 0.90$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$a = 2.62 \text{ cm}$
 $As = 10.40 \text{ cm}^2$
 $C = 3.09 \text{ cm}$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$\phi = 5.98 > 0.90 \quad \phi = 0.90$

barra de 3/4" = 2.85 cm²

nb = 4

Usar 8 Ø 3/4"

bmin = 45.56 cm

Claro

MOMENTO SUPERIOR

$Mu = 9.03 \text{ tnf.m}$
 $b = 70.00 \text{ cm}$
 $h = 120.00 \text{ cm}$
 $d = 112.78 \text{ cm}$
 $\phi = 0.90$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$a = 0.54 \text{ cm}$
 $As = 2.12 \text{ cm}^2$
 $C = 0.63 \text{ cm}$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$\phi = 27.36 > 0.90 \quad \phi = 0.90$

barra de 3/4" = 2.85 cm²

nb = 1

Usar 8 Ø 3/4"

bmin = 45.56 cm

Apoyo Derecho EJE 2-2

MOMENTO SUPERIOR

$Mu = 4.95 \text{ tnf.m}$
 $b = 70.00 \text{ cm}$
 $h = 120.00 \text{ cm}$
 $d = 112.78 \text{ cm}$
 $\phi = 0.90$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$a = 0.29 \text{ cm}$
 $As = 1.16 \text{ cm}^2$
 $C = 0.34 \text{ cm}$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$\phi = 49.56 > 0.90 \quad \phi = 0.90$

barra de 3/4" = 2.85 cm²

nb = 1

Usar 8 Ø 3/4"

bmin = 45.56 cm

Momento último resistente

$$A_s = 22.80 \text{ cm}^2$$

$$a = 5.75 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 94.72 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * \left(\frac{6300}{6300 + f_y} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

$$\rho = \frac{A_s}{b * d}$$

$$\rho = 0.0029 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 168000 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 62.16 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 58.29 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 94.72 \text{ tnf.m} & > & 58.29 \text{ tnf.m} \end{array} \quad \text{ok}$$

Momento último resistente

$$A_s = 22.80 \text{ cm}^2$$

$$a = 5.75 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 94.72 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * \left(\frac{6300}{6300 + f_y} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

$$\rho = \frac{A_s}{b * d}$$

$$\rho = 0.0029 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 168000 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 62.16 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 12.01 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 94.72 \text{ tnf.m} & > & 12.01 \text{ tnf.m} \end{array} \quad \text{ok}$$

Momento último resistente

$$A_s = 22.80 \text{ cm}^2$$

$$a = 5.75 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 94.72 \text{ tnf.m} > M_u \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{f_y}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{f_y} * \left(\frac{6300}{6300 + f_y} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

$$\rho = \frac{A_s}{b * d}$$

$$\rho = 0.0029 \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 168000 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 62.16 \text{ tnf.m}$$

$$1.33 M_u$$

$$1.33 M_u = 6.58 \text{ tnf.m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 94.72 \text{ tnf.m} & > & 6.58 \text{ tnf.m} \end{array} \quad \text{ok}$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 11.72 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 120.00 \text{ cm} \\ d &= 112.78 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 0.70 \text{ cm} \\ As &= 2.76 \text{ cm}^2 \\ C &= 0.82 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 21.18 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 2.85 \text{ cm}^2$$

$$nb = 1$$

Usar 8 Ø 3/4"

$$b_{min} = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 22.80 \text{ cm}^2 \\ a &= 5.75 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 94.72 \text{ tnf.m} > Mu \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 63.87 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 120.00 \text{ cm} \\ d &= 112.78 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 3.84 \text{ cm} \\ As &= 15.24 \text{ cm}^2 \\ C &= 4.52 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 4.24 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 2.85 \text{ cm}^2$$

$$nb = 6$$

Usar 8 Ø 3/4"

$$b_{min} = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 22.80 \text{ cm}^2 \\ a &= 5.75 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 94.72 \text{ tnf.m} > Mu \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

MOMENTO INFERIOR

$$\begin{aligned} \text{Mu} &= 13.06 \text{ tnf.m} \\ b &= 70.00 \text{ cm} \\ h &= 120.00 \text{ cm} \\ d &= 112.78 \text{ cm} \\ \phi &= 0.90 \end{aligned}$$

$$a = \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{Mu}{\phi * fy * (d - a/2)}$$

$$\begin{aligned} a &= 0.78 \text{ cm} \\ As &= 3.07 \text{ cm}^2 \\ C &= 0.91 \text{ cm} \end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 19.05 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1'' = 2.85 \text{ cm}^2$$

$$nb = 2$$

Usar 8 Ø 3/4"

$$b_{min} = 45.56 \text{ cm}$$

Momento último resistente

$$\begin{aligned} As &= 22.80 \text{ cm}^2 \\ a &= 5.75 \text{ cm} \end{aligned}$$

$$Mur = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$Mur = 94.72 \text{ tnf.m} > Mu \quad \text{ok}$$

Cuantía

$$\rho_{\min} = 0.70 * \frac{\sqrt{f'c}}{fy}$$

$$\rho_{\min} = 0.0028$$

$$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \left(\frac{6300}{6300 + fy} \right)$$

$$\rho_b = 0.0289$$

$$\rho_{\max} = 0.75 * \rho_b$$

$$\rho_{\max} = 0.0217$$

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0029$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'_c}$$

$$s = 168000 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 62.16 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 15.59 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 94.72 \text{ tnf.m} & > & 15.59 \text{ tnf.m} \end{array}$$

Refuerzo por Temperatura

$$As, t = \frac{0.18 \times b \times h}{2(b + h)}$$

$$b = 70.00 \text{ cm}$$

$$h = 120.00 \text{ cm}$$

$$\text{losa} = 40.00$$

$$As, t = 3.98 \text{ cm}^2/\text{m}$$

$$y = 55.95 \text{ cm}$$

$$As, t = 2.23 \text{ cm}^2$$

$$\text{barra de } 1/2" = 1.27 \text{ cm}^2$$

$$N_b = 2$$

$$2.33 \text{ cm}^2/\text{m} \leq As, temp \leq 12.75 \text{ cm}^2/\text{m}$$

Usar 2 Ø 1/2" @ en cada cara

Refuerzo por Paramento

$$As, k = 0.10 \times (d - 76)$$

$$As, k = 3.68 \text{ cm}^2/\text{m}$$

$$y = 55.95 \text{ cm}$$

$$As, k = 2.06 \text{ cm}^2$$

$$\text{barra de } 1/2" = 1.27 \text{ cm}^2$$

$$N_b = 2$$

Usar 2 Ø 1/2" @ en cada cara

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0029$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'_c}$$

$$s = 168000 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 62.16 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 84.95 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 94.72 \text{ tnf.m} & > & 62.16 \text{ tnf.m} \end{array}$$

$$\rho = \frac{As}{b \cdot d}$$

$\rho = 0.0029$ **ok**

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'_c}$$

$$s = 168000 \text{ cm}^3 \quad S = \frac{bh^2}{6}$$

$$M_{cr} = 62.16 \text{ tnf.m}$$

$$1.33 M_U$$

$$1.33 M_u = 17.37 \text{ tnf.m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 94.72 \text{ tnf.m} & > & 17.37 \text{ tnf.m} \end{array}$$

ok

DISEÑO DE VIGA INTERIOR (CORTANTE)

$f'c =$	280 kgf/cm ²	
$f_y =$	4200 kgf/cm ²	
$\gamma_c =$	2.50 tn/m ³	
$L_n =$	12.00 m	
$b =$	0.70 m	
$h =$	1.50 m	
losa =	0.40 m	
AT =	2.80 m	Ancho tributario
DC =	11.44 tn/m ²	Capa de amortiguamiento
CV =	0.50 tn/m ²	Carga viva de techo
IR =	15.45 tn/m ²	Fuerza de impacto de la roca

30.60 cm ²	30.60 cm ²
137.70 cm ²	137.70 cm ²

1.- Momento en la Viga**Apoyo Izquierdo EJE 1-1****Momento Superior**

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2}\right)$$

$As = 30.60 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 150.00 \text{ cm}$
 $d = 142.46 \text{ cm}$
 $a = 7.71 \text{ cm}$
 $Mn = 178.13 \text{ tnf.m}$

Momento Inferior

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2}\right)$$

$As = 137.70 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 150.00 \text{ cm}$
 $d = 137.38 \text{ cm}$
 $a = 34.71 \text{ cm}$
 $Mn = 694.14 \text{ tnf.m}$

Apoyo Derecho EJE 2-2**Momento Superior**

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2}\right)$$

$As = 30.60 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 150.00 \text{ cm}$
 $d = 142.46 \text{ cm}$
 $a = 7.71 \text{ cm}$
 $Mn = 178.13 \text{ tnf.m}$

Momento Inferior

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2}\right)$$

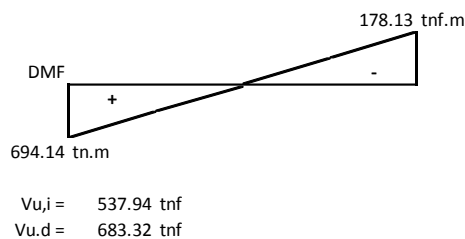
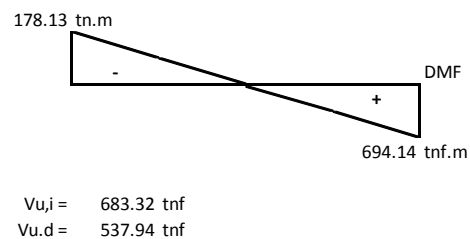
$As = 137.70 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 150.00 \text{ cm}$
 $d = 137.38 \text{ cm}$
 $a = 34.71 \text{ cm}$
 $Mn = 694.14 \text{ tnf.m}$

2.- Fuerzas Cortantes

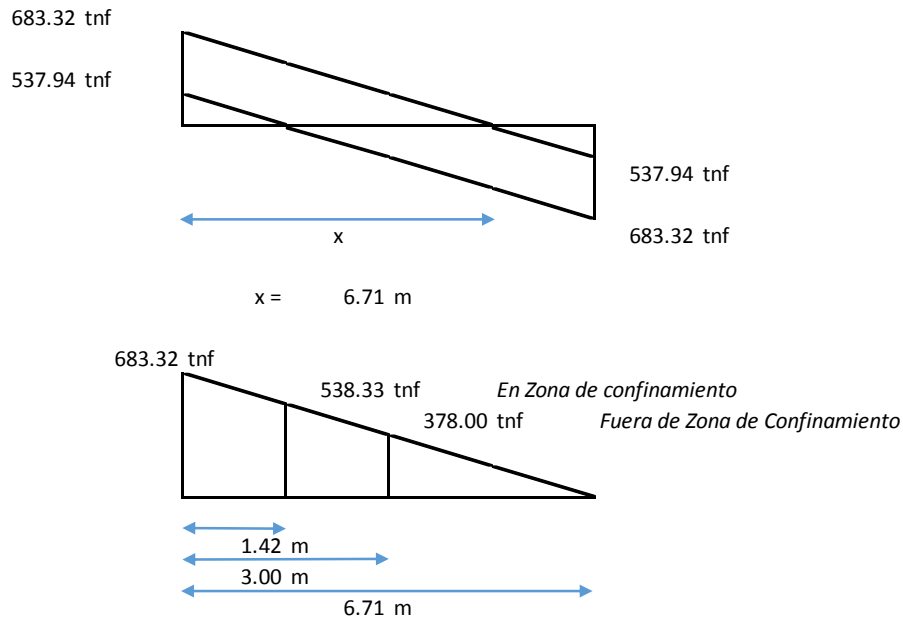
PP viga =	2.63 tnf/m	Peso propio de viga
PP losa =	2.10 tnf/m	Peso propio de losa
DC =	32.03 tnf/m	Capa de amortiguamiento
WD =	36.76 tnf/m	
CV =	1.40 tnf/m	Carga viva de techo
IR =	43.26 tnf/m	Fuerza de impacto de la roca
WL =	44.66 tnf/m	

$$Wu = 1.25(WD + WL)$$

Wu =	101.77 tnf/m
Ln =	12.00 m

Caso 01**Caso 02**

3.- Diagrama de fuerza cortante



En Zona de Confinamiento

$$\begin{aligned} V_u &= 538.33 \text{ tnf} \\ \phi &= 0.85 \\ V_n &= 633.33 \text{ tnf} \\ f'_c &= 280 \text{ kgf/cm}^2 \\ f_y &= 4200 \text{ kgf/cm}^2 \\ b &= 70.00 \text{ cm} \\ d &= 142.46 \text{ cm} \end{aligned}$$

$$V_c = 0.53 \sqrt{f'_c} * b * d$$

$$V_c = 88.44 \text{ tnf}$$

$$V_s = V_n - V_c$$

$$V_s = 544.89 \text{ tnf}$$

$$s = \frac{A_v * f_y * d}{V_s}$$

$$A_s = 1.27 \text{ cm}^2$$

$$s = 10.00 \text{ cm}$$

Capítulo 21

$$s \leq d/4 = 35.62 \text{ cm}$$

$$s \leq 10d_b = 20.32 \text{ cm}$$

$$s \leq 24d_e = 22.80 \text{ cm}$$

$$s \leq 30.00 \text{ cm}$$

$$s = 10.00 \text{ cm}$$

Estribo 4 ramas 1/2"

$$\begin{aligned} 1 @ & 5.00 \text{ cm} \\ 15 @ & 10.00 \text{ cm} \\ \text{rto. @} & 15.00 \text{ cm} \end{aligned}$$

Fuerza de Zona de Confinamiento

$$\begin{aligned} V_u &= 378.00 \text{ tnf} \\ \phi &= 0.85 \\ V_n &= 444.71 \text{ tnf} \\ f'_c &= 280 \text{ kgf/cm}^2 \\ f_y &= 4200 \text{ kgf/cm}^2 \\ b &= 70.00 \text{ cm} \\ d &= 142.46 \text{ cm} \end{aligned}$$

$$V_c = 0.53 \sqrt{f'_c} * b * d$$

$$V_c = 88.44 \text{ tnf}$$

$$V_s = V_n - V_c$$

$$V_s = 356.27 \text{ tnf}$$

$$s = \frac{A_v * f_y * d}{V_s}$$

$$A_s = 1.27 \text{ cm}^2$$

$$s = 15.00 \text{ cm}$$

Capítulo 21

$$s \leq d/2 = 71.23 \text{ cm}$$

$$s = 15.00 \text{ cm}$$

DISEÑO DE VIGA EXTERIOR (CORTANTE)

$f'c =$	280 kgf/cm ²	
$f_y =$	4200 kgf/cm ²	
$\gamma_c =$	2.50 tn/m ³	
$L_n =$	12.00 m	
$b =$	0.70 m	
$h =$	1.50 m	
losa =	0.40 m	
AT =	1.75 m	Ancho tributario
DC =	11.44 tn/m ²	Capa de amortiguamiento
CV =	0.50 tn/m ²	Carga viva de techo
IR =	15.45 tn/m ²	Fuerza de impacto de la roca

30.60 cm ²	30.60 cm ²
102.00 cm ²	102.00 cm ²

1.- Momento en la Viga**Apoyo Izquierdo EJE 1-1****Momento Superior**

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2}\right)$$

$As = 30.60 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 150.00 \text{ cm}$
 $d = 142.46 \text{ cm}$
 $a = 7.71 \text{ cm}$
 $Mn = 178.13 \text{ tnf.m}$

Momento Inferior

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2}\right)$$

$As = 102.00 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 150.00 \text{ cm}$
 $d = 137.38 \text{ cm}$
 $a = 25.71 \text{ cm}$
 $Mn = 533.46 \text{ tnf.m}$

Apoyo Derecho EJE 2-2**Momento Superior**

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2}\right)$$

$As = 30.60 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 150.00 \text{ cm}$
 $d = 142.46 \text{ cm}$
 $a = 7.71 \text{ cm}$
 $Mn = 178.13 \text{ tnf.m}$

Momento Inferior

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2}\right)$$

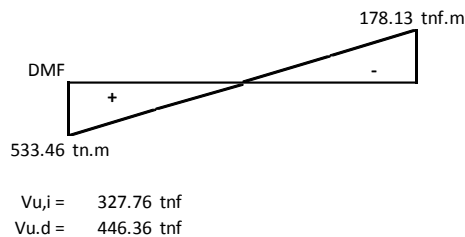
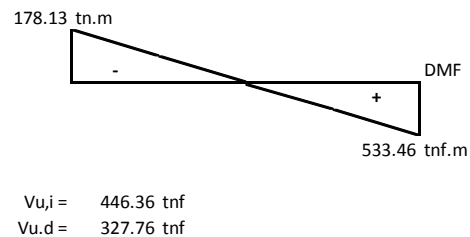
$As = 102.00 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 150.00 \text{ cm}$
 $d = 137.38 \text{ cm}$
 $a = 25.71 \text{ cm}$
 $Mn = 533.46 \text{ tnf.m}$

2.- Fuerzas Cortantes

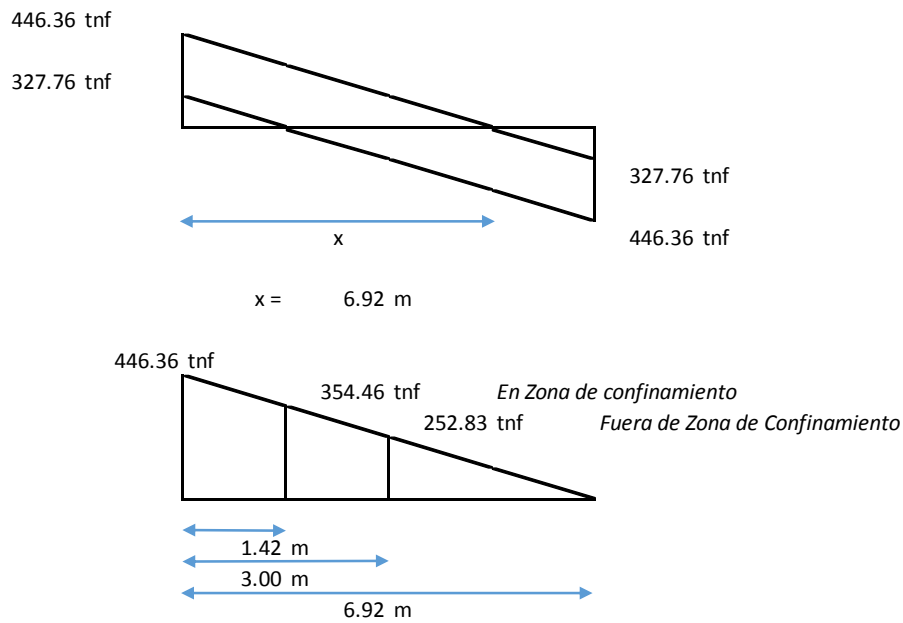
PP viga =	2.63 tnf/m	Peso propio de viga
PP losa =	1.05 tnf/m	Peso propio de losa
DC =	20.02 tnf/m	Capa de amortiguamiento
WD =	23.70 tnf/m	
CV =	0.88 tnf/m	Carga viva de techo
IR =	27.04 tnf/m	Fuerza de impacto de la roca
WL =	27.91 tnf/m	

$$Wu = 1.25(WD + WL)$$

$Wu =$	64.51 tnf/m
$L_n =$	12.00 m

Caso 01**Caso 02**

3.- Diagrama de fuerza cortante



En Zona de Confinamiento

$$\begin{aligned} V_u &= 354.46 \text{ tnf} \\ \phi &= 0.85 \\ V_n &= 417.01 \text{ tnf} \\ f'_c &= 280 \text{ kgf/cm}^2 \\ f_y &= 4200 \text{ kgf/cm}^2 \\ b &= 70.00 \text{ cm} \\ d &= 142.46 \text{ cm} \end{aligned}$$

$$V_c = 0.53 \sqrt{f'_c} * b * d$$

$$V_c = 88.44 \text{ tnf}$$

$$V_s = V_n - V_c$$

$$V_s = 328.57 \text{ tnf}$$

$$s = \frac{A_v * f_y * d}{V_s}$$

$$A_s = 1.27 \text{ cm}^2$$

$$s = 12.50 \text{ cm}$$

Capítulo 21

$$s \leq d/4 = 35.62 \text{ cm}$$

$$s \leq 10d_b = 20.32 \text{ cm}$$

$$s \leq 24d_e = 22.80 \text{ cm}$$

$$s \leq 30.00 \text{ cm}$$

$$s = 12.50 \text{ cm}$$

Estribo 3 ramas 1/2"

$$\begin{aligned} 1 @ & 5.00 \text{ cm} \\ 15 @ & 12.50 \text{ cm} \\ \text{rto. @} & 20.00 \text{ cm} \end{aligned}$$

Fuerza de Zona de Confinamiento

$$\begin{aligned} V_u &= 252.83 \text{ tnf} \\ \phi &= 0.85 \\ V_n &= 297.44 \text{ tnf} \\ f'_c &= 280 \text{ kgf/cm}^2 \\ f_y &= 4200 \text{ kgf/cm}^2 \\ b &= 70.00 \text{ cm} \\ d &= 142.46 \text{ cm} \end{aligned}$$

$$V_c = 0.53 \sqrt{f'_c} * b * d$$

$$V_c = 88.44 \text{ tnf}$$

$$V_s = V_n - V_c$$

$$V_s = 209.00 \text{ tnf}$$

$$s = \frac{A_v * f_y * d}{V_s}$$

$$A_s = 1.27 \text{ cm}^2$$

$$s = 20.00 \text{ cm}$$

Capítulo 21

$$s \leq d/2 = 71.23 \text{ cm}$$

$$s = 20.00 \text{ cm}$$

DISEÑO DE VIGA DE BORDE (CORTANTE)

$f'c =$	280 kgf/cm ²	
$f_y =$	4200 kgf/cm ²	
$\gamma_c =$	2.50 tn/m ³	
$L_n =$	2.10 m	
$b =$	0.70 m	
$h =$	1.20 m	
losa =	0.40 m	
AT =	7.50 m	Ancho tributario
DC =	11.44 tn/m ²	Capa de amortiguamiento
CV =	0.50 tn/m ²	Carga viva de techo
IR =	15.45 tn/m ²	Fuerza de impacto de la roca

22.80 cm ²	22.80 cm ²
22.80 cm ²	22.80 cm ²

1.- Momento en la Viga**Apoyo Izquierdo EJE 1-1****Momento Superior**

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2} \right)$$

$As = 22.80 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 120.00 \text{ cm}$
 $d = 112.46 \text{ cm}$
 $a = 5.75 \text{ cm}$
 $Mn = 104.94 \text{ tnf.m}$

Momento Inferior

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2} \right)$$

$As = 22.80 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 120.00 \text{ cm}$
 $d = 107.38 \text{ cm}$
 $a = 5.75 \text{ cm}$
 $Mn = 100.07 \text{ tnf.m}$

Apoyo Derecho EJE 2-2**Momento Superior**

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2} \right)$$

$As = 22.80 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 120.00 \text{ cm}$
 $d = 112.46 \text{ cm}$
 $a = 5.75 \text{ cm}$
 $Mn = 104.94 \text{ tnf.m}$

Momento Inferior

$$a = \frac{As * f_y}{0.85 * f'c * b} \quad Mn = As * f_y \left(d - \frac{a}{2} \right)$$

$As = 22.80 \text{ cm}^2$
 $b = 70.00 \text{ cm}$
 $h = 120.00 \text{ cm}$
 $d = 107.38 \text{ cm}$
 $a = 5.75 \text{ cm}$
 $Mn = 100.07 \text{ tnf.m}$

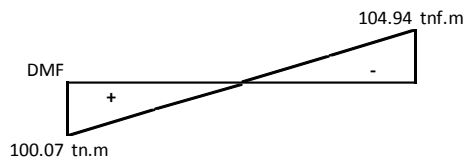
2.- Fuerzas Cortantes

PP viga =	2.10 tnf/m	Peso propio de viga
PP losa =	6.80 tnf/m	Peso propio de losa
DC =	85.80 tnf/m	Capa de amortiguamiento
WD =	94.70 tnf/m	
CV =	3.75 tnf/m	Carga viva de techo
IR =	115.88 tnf/m	Fuerza de impacto de la roca
WL =	119.63 tnf/m	

$$Wu = 1.25(WD + WL)$$

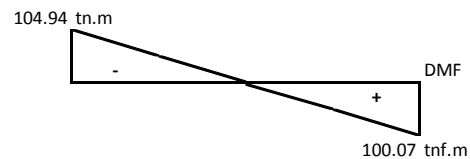
$$Wu = 267.91 \text{ tnf/m}$$

$$Ln = 2.10 \text{ m}$$

Caso 01

$$Vu,i = 183.68 \text{ tnf}$$

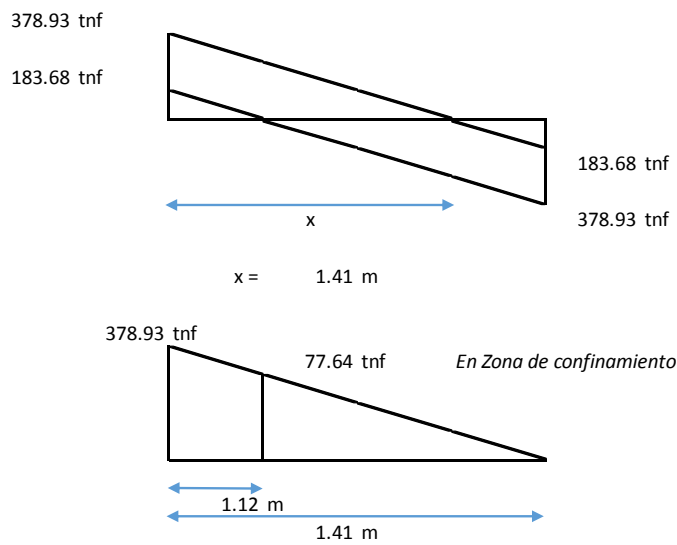
$$Vu,d = 378.93 \text{ tnf}$$

Caso 02

$$Vu,i = 378.93 \text{ tnf}$$

$$Vu,d = 183.68 \text{ tnf}$$

3.- Diagrama de fuerza cortante



En Zona de Confinamiento

$$\begin{aligned} V_u &= 77.64 \text{ tnf} \\ \phi &= 0.85 \\ V_n &= 91.34 \text{ tnf} \\ f'_c &= 280 \text{ kgf/cm}^2 \\ f_y &= 4200 \text{ kgf/cm}^2 \\ b &= 70.00 \text{ cm} \\ d &= 112.46 \text{ cm} \end{aligned}$$

$$V_c = 0.53 \sqrt{f'_c} * b * d$$

$$V_c = 69.82 \text{ tnf}$$

$$V_s = V_n - V_c$$

$$V_s = 21.53 \text{ tnf}$$

$$s = \frac{A_v * f_y * d}{V_s}$$

$$A_s = 0.71 \text{ cm}^2$$

$$s = 30.00 \text{ cm}$$

Capítulo 21

$$\begin{aligned} s \leq d/4 &= 28.12 \text{ cm} \\ s \leq 10d_b &= 20.32 \text{ cm} \\ s \leq 24d_e &= 22.80 \text{ cm} \\ s &\leq 30.00 \text{ cm} \\ s &= 20.00 \text{ cm} \end{aligned}$$

Estribo 1 ramas 1/2"

$$\begin{aligned} &1 @ \quad 5.00 \text{ cm} \\ \text{rto. } &@ \quad 20.00 \text{ cm} \end{aligned}$$

**ANEXO N°11.4: DISEÑO DE
COLUMNAS DE CONCRETO ARMADO**

DISEÑO DE COLUMNA

$$\begin{aligned}f'_c &= 280 \text{ kg/cm}^2 \\f_y &= 4200 \text{ kg/cm}^2\end{aligned}$$

Características de la Sección de Columna

$$\begin{aligned}b &= 90.00 \text{ cm} \\h &= 70.00 \text{ cm} \\r &= 5.00 \text{ cm}\end{aligned}$$

Solicitaciones Últimas (Mayoradas) sobre la Columna

$$\begin{aligned}P_u &= 311.95 \text{ tnf} \\M_x &= 79.52 \text{ tnf.m} \\M_y &= 126.39 \text{ tnf.m}\end{aligned}$$

Cálculo de la Excentricidad Equivalente

$$\left(\frac{e}{h}\right) = \sqrt{\left(\frac{e}{h}\right)_x^2 + \left(\frac{e}{h}\right)_y^2}$$

Excentricidad adimensional en x

$$\begin{aligned}\left(\frac{e}{h}\right)_x &= \frac{M_{uy}}{P_u \cdot b} \\(e/h)_x &= 0.45\end{aligned}$$

Excentricidad adimensional en y

$$\begin{aligned}\left(\frac{e}{h}\right)_y &= \frac{M_{ux}}{P_u \cdot h} \\(e/h)_y &= 0.36\end{aligned}$$

$$(e/h) = 0.58$$

Factor de recubrimiento γ

$$\begin{aligned}\gamma &= \frac{h - 2r}{h} \\\gamma &= 0.86\end{aligned}$$

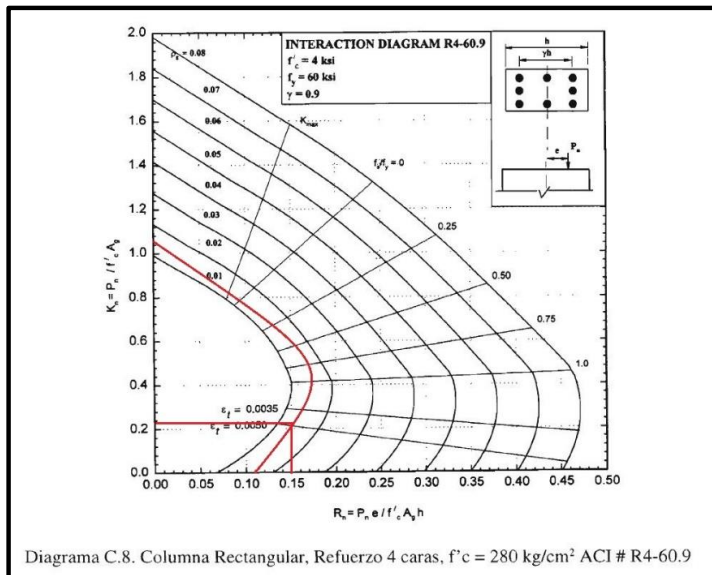
Fuerza axial de Compresión Adimensional

$$\begin{aligned}K_n &= \frac{P_n}{f'_c \cdot b \cdot h} \\K_n &= 0.25\end{aligned}$$

$$(e/h) = 0.58$$

$$\begin{aligned}R_n &= \frac{P_n \cdot e}{f'_c \cdot A_g \cdot h} \\R_n &= 0.15\end{aligned}$$

Cuantía de acero de refuerzo



$$\rho = 1.40 \%$$

Área de acero del refuerzo

$$A_s = \rho \cdot b \cdot h$$

$$A_s = 88.2 \text{ cm}^2$$

$$\text{barras de } 1'' = 5.07 \text{ cm}^2$$

$$nb = 18$$

$$A_s \text{ real} = 91.26 \text{ cm}^2 \quad \text{ok}$$

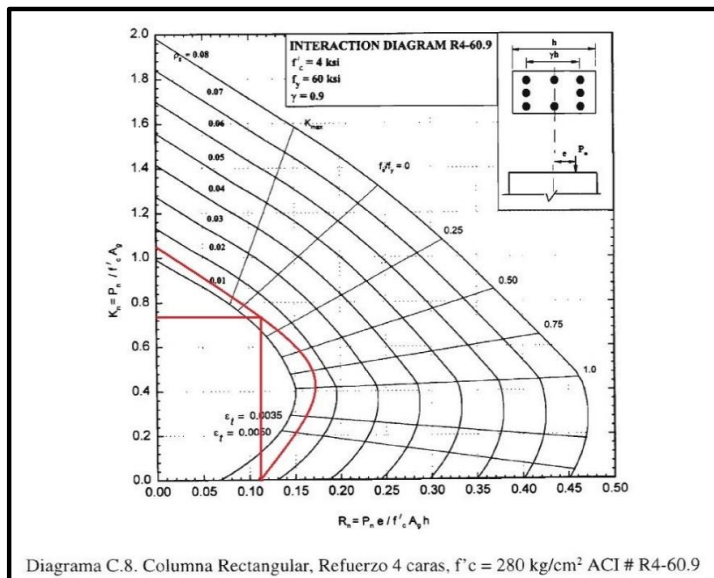
Excentricidad adimensional en x

$$(e/h)_x = 0.45$$

$$R_n = \frac{P_n \cdot e}{f'_c \cdot A_g \cdot h}$$

$$R_{nx} = 0.11$$

$$k_{nx} = 0.74$$



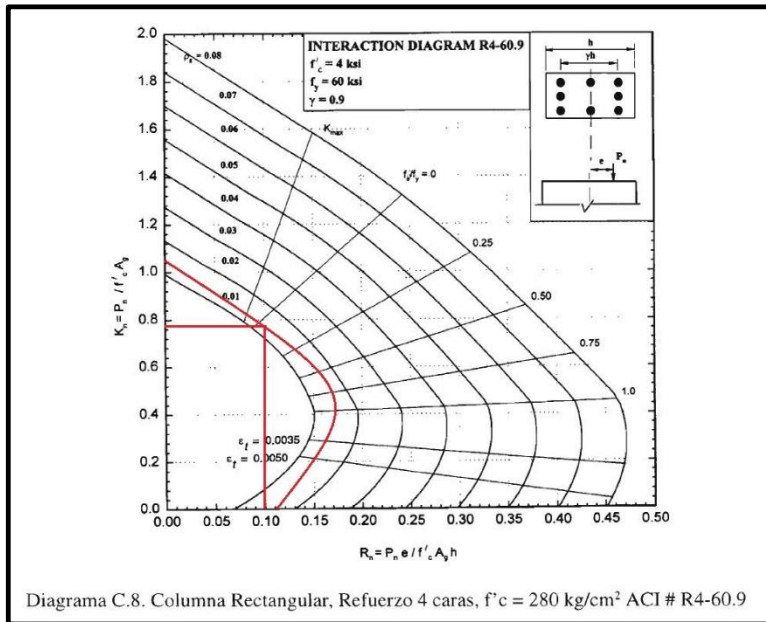
Excentricidad adimensional en y

$$(e/h)_y = 0.36$$

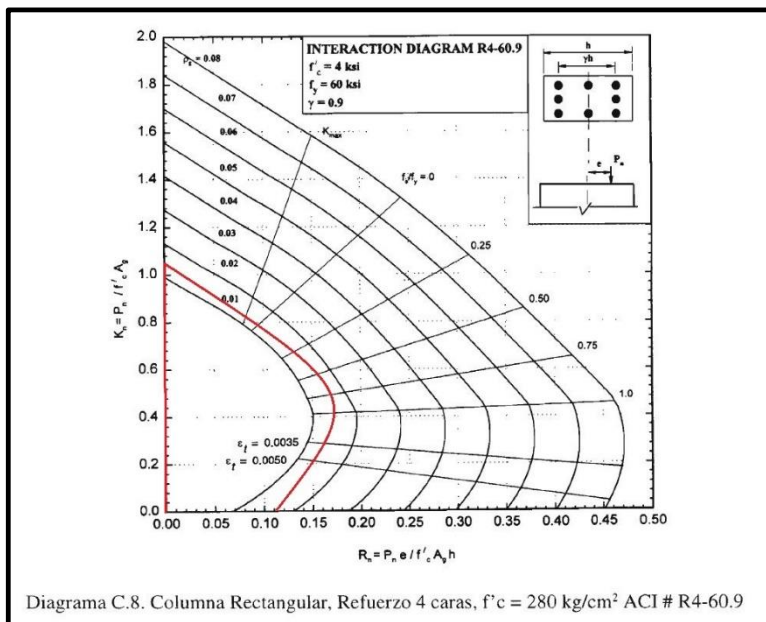
$$R_n = \frac{P_n \cdot e}{f'_c \cdot A_g \cdot h}$$

$$R_{ny} = 0.09$$

$$K_{ny} = 0.78$$



$$k_o = 1.05$$



$$F.B = \frac{k_u}{k_x} + \frac{k_u}{k_y} - \frac{k_u}{k_0}$$

$$F.B = 0.4247 \quad \text{ok}$$

DISEÑO DE COLUMNA

$f'c = 280 \text{ kg/cm}^2$

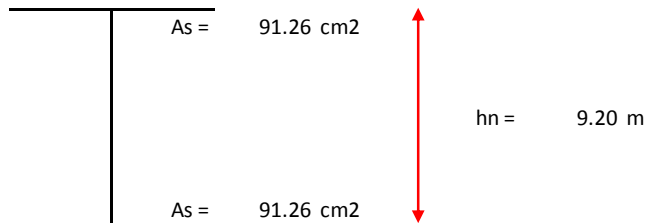
$f_y = 4200 \text{ kg/cm}^2$

Características de la Sección de Columna

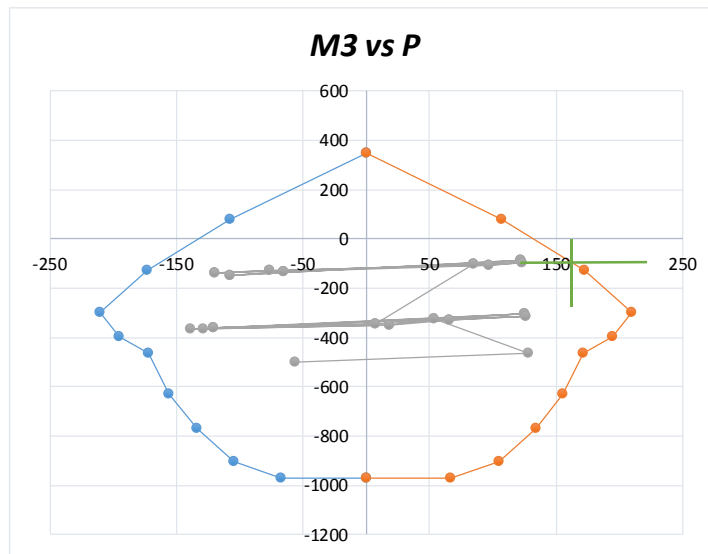
$b = 90.00 \text{ cm}$

$h = 70.00 \text{ cm}$

$r = 5.00 \text{ cm}$

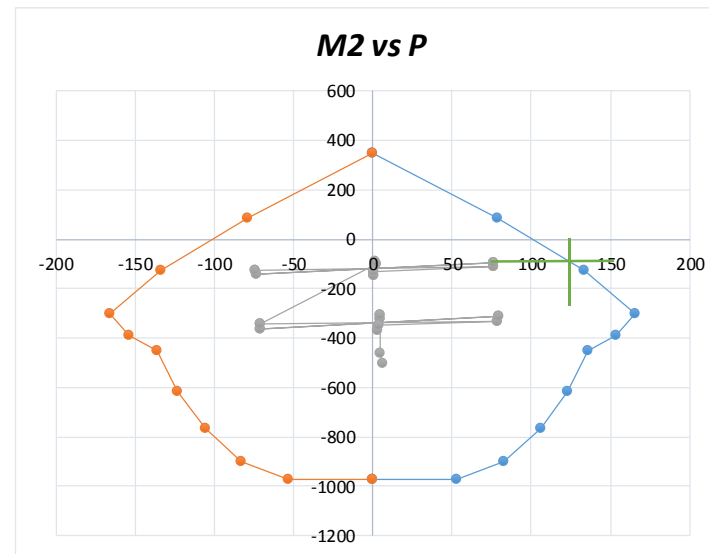


Momento Nominal Superior M 3-3



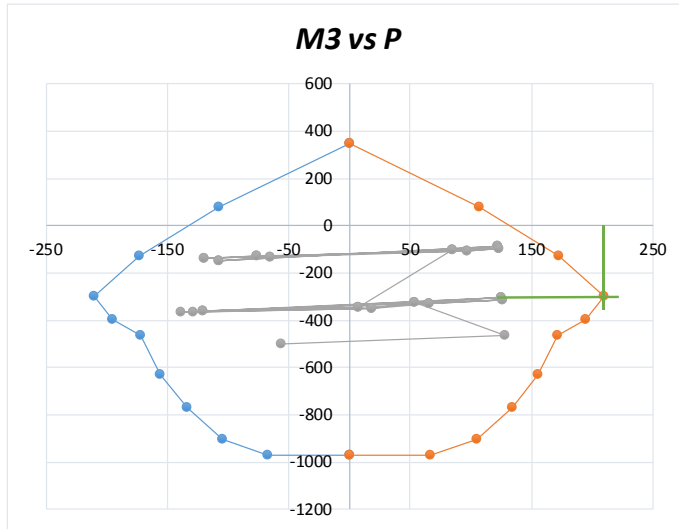
Mns = 165.00 tnf.m

Momento Nominal Superior M 2-2



Mns = 125.00 tnf.m

Momento Nominal Inferior M 3-3



Mni = 215.00 tnf.m

$$Vu = \frac{(Mni + Mns)}{hn}$$

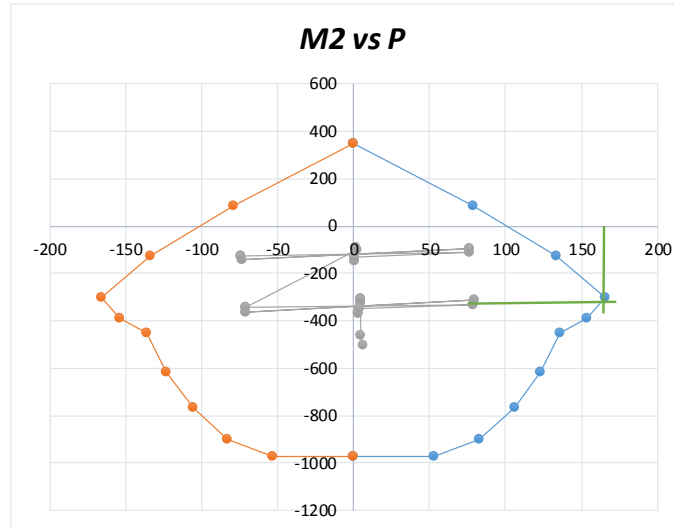
Vu = 41.30 tnf

En Zona de Confinamiento

L ≤ hn/6 = 153.33 cm
L ≤ b/2 o t/2 = 45.00 cm
L ≤ 45.00 cm
Lc = 153.33 cm

Vu = 37.60 tnf
b = 90.00 cm
d = 82.46 cm
Ø = 0.85
Vn = 44.24 tnf
f'c = 280 kgf/cm²
fy = 4200 kgf/cm²

Momento Nominal Inferior M 2-2



Mni = 165.00 tnf.m

$$Vu = \frac{(Mni + Mns)}{hn}$$

Vu = 31.52 tnf

En Zona de Confinamiento

L ≤ hn/6 = 153.33 cm
L ≤ b/2 o t/2 = 45.00 cm
L ≤ 45.00 cm
Lc = 153.33 cm

Vu = 29.38 tnf
t = 70.00 cm
d = 62.46 cm
Ø = 0.85
Vn = 34.57 tnf
f'c = 280 kgf/cm²
fy = 4200 kgf/cm²

$$Vc = 0.53\sqrt{f'c} * b * d$$

$$Vc = 65.82 \text{ tnf}$$

$$\left(\frac{A_v}{s}\right)_{min} = 0.27\sqrt{f'c} \frac{b}{f_y}$$

$$(Av/s)_{min} = 0.10 \text{ cm}^2/\text{cm}$$

$$s_{req} = \frac{A_v}{\left(\frac{A_v}{s}\right)_{min}}$$

$$\text{barra de } 1/2" = 1.27 \text{ cm}^2$$

$$n \text{ ramas} = 1$$

$$Av = 1.27 \text{ cm}^4$$

$$S_{req} = 10.00 \text{ cm}$$

Capítulo 21

$$s \leq d/4 = 20.62 \text{ cm}$$

$$s \leq 10db = 20.32 \text{ cm}$$

$$s \leq 24de = 22.80 \text{ cm}$$

$$s \leq 30.00 \text{ cm}$$

$$s = 20.00 \text{ cm}$$

Fuera de Zona de Confinamiento

Capítulo 21

$$s \leq d/2 = 41.23 \text{ cm}$$

$$s = 40.00 \text{ cm}$$

Usar estribos de 1/2"

$$1 @ 5.00 \text{ cm}$$

$$\text{rto. } @ 10.00 \text{ cm}$$

$$Vc = 0.53\sqrt{f'c} * b * d$$

$$Vc = 38.78 \text{ tnf}$$

$$\left(\frac{A_v}{s}\right)_{min} = 0.27\sqrt{f'c} \frac{b_v}{f_y}$$

$$(Av/s)_{min} = 0.08 \text{ cm}^2/\text{cm}$$

$$s_{req} = \frac{A_v}{\left(\frac{A_v}{s}\right)_{min}}$$

$$\text{barra de } 1/2" = 1.27 \text{ cm}^2$$

$$n \text{ ramas} = 1$$

$$Av = 1.27 \text{ cm}^4$$

$$S_{req} = 15.00 \text{ cm}$$

Capítulo 21

$$s \leq d/4 = 15.62 \text{ cm}$$

$$s \leq 10db = 20.32 \text{ cm}$$

$$s \leq 24de = 22.80 \text{ cm}$$

$$s \leq 30.00 \text{ cm}$$

$$s = 15.00 \text{ cm}$$

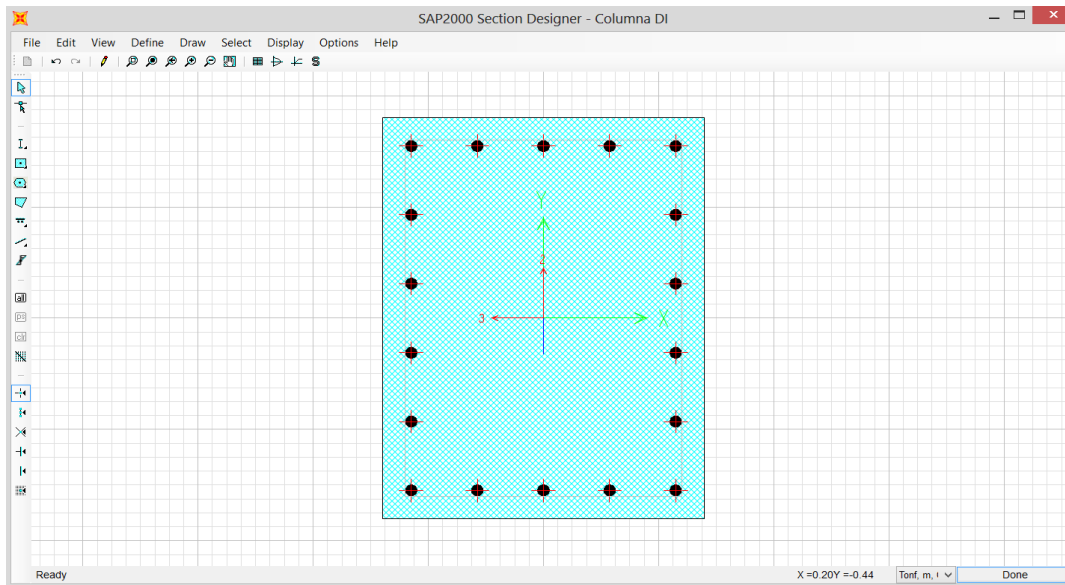
Fuera de Zona de Confinamiento

Capítulo 21

$$s \leq d/2 = 31.23 \text{ cm}$$

$$s = 30.00 \text{ cm}$$

DIAGRAMA DE INTERACCIÓN DE COLUMNA



Interaction Surface (ACI 318-14)

Edit

	P	M2	M3
1	-972.9459	0	0
2	-972.9459	0	67.2787
3	-902.2976	0	104.8677
4	-771.8005	0	133.891
5	-629.0327	0	155.5019
6	-465.9041	0	171.5896
7	-396.9355	0	195.2029
8	-296.3735	0	209.8742
9	-125.8198	0	173.0177
10	78.6314	0	107.0552
11	348.3045	0	0
12			
13			
14			
15			
16			
17			
18			

Curve 1
Angle 0

Design Options

☒ Design-Code Curve
☐ Fiber-Model Curve

☒ phi
☐ no phi
☐ no phi with fy increase

☒ Show Design-Code Results
☐ Show Fiber-Model Results

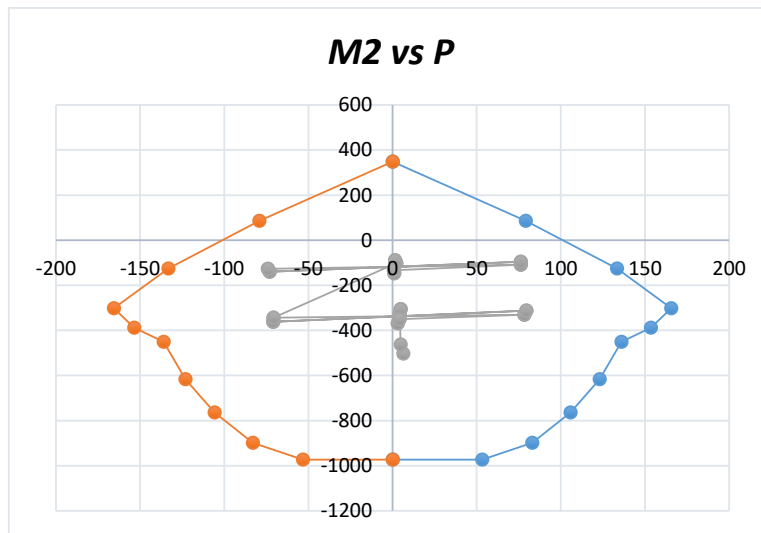
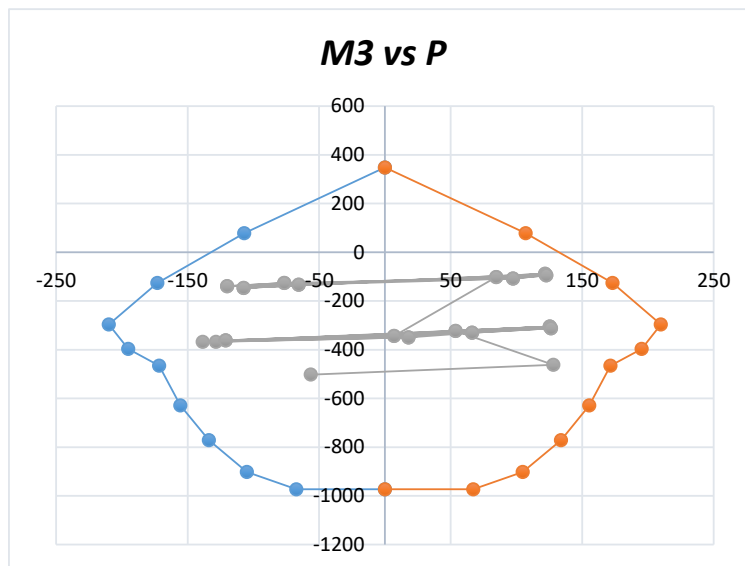
3D View

315 Plan
35 Elevation

3d MM PM3 PM2

Done

Curve 1 0 degrees				Curve 7 90 degrees			
	Pu	M3	M3		Pu	M2	M2
1	-972.946	0	0	1	-972.946	0	0
2	-972.946	-67.2787	67.2787	2	-972.946	53.3329	-53.3329
3	-902.298	-104.868	104.868	3	-898.067	83.0763	-83.0763
4	-771.801	-133.891	133.891	4	-763.643	105.819	-105.819
5	-629.033	-155.502	155.502	5	-616.192	123.02	-123.02
6	-465.904	-171.59	171.59	6	-450.755	136.071	-136.071
7	-396.936	-195.203	195.203	7	-388.239	153.564	-153.564
8	-296.374	-209.874	209.874	8	-301.456	165.629	-165.629
9	-125.82	-173.018	173.018	9	-125.974	133.312	-133.312
10	78.6314	-107.055	107.055	10	86.2077	79.1045	-79.1045
11	348.305	0	0	11	348.305	0	0



Frame	P	M2	M3
Text	Tonf	Tonf-m	Tonf-m
43	-502.462	6.41553	-56.3366
43	-461.772	4.86881	128.0479
43	-323.551	4.33433	53.76526
43	-305.386	4.75762	125.3607
43	-368.351	3.07646	-138.44
43	-350.186	4.07594	18.05479
43	-323.551	4.33433	53.76526
43	-305.386	4.75762	125.3607
43	-368.351	3.07646	-128.44
43	-350.186	4.07594	18.05479
43	-330.115	78.32616	66.32098
43	-311.95	79.52543	126.3856
43	-361.786	-70.9154	-120.996
43	-343.622	-70.6919	7.02983
43	-330.115	78.32616	66.32098
43	-311.95	79.52543	126.3856
43	-361.786	-70.9154	-120.996
43	-343.622	-70.6919	7.02983
43	-101.49	2.22357	84.76936
43	-88.4108	1.39789	121.7869
43	-146.29	0.9657	-107.436
43	-133.211	0.71621	-65.519
43	-101.49	2.22357	84.76936
43	-88.4108	1.39789	121.7869
43	-146.29	0.9657	-107.436
43	-133.211	0.71621	-65.519
43	-108.054	76.2154	97.32507
43	-94.9752	76.1657	122.8118
43	-139.725	-73.0261	-119.992
43	-126.647	-74.0516	-76.544
43	-108.054	76.2154	97.32507
43	-94.9752	76.1657	122.8118
43	-139.725	-73.0261	-119.992
43	-126.647	-74.0516	-76.544
44	-707.546	-2.16306	-71.5832
44	-666.856	4.86249	128.7057
44	-464.579	-1.60349	47.36765
44	-446.414	4.38366	124.1841
44	-523.986	-2.4545	-124.017
44	-505.821	3.68965	30.00017
44	-464.579	-1.60349	47.36765
44	-446.414	4.38366	124.1841
44	-523.986	-2.4545	-124.017
44	-505.821	3.68965	30.00017
44	-473.064	78.02252	31.8868
44	-454.899	84.04391	126.9146
44	-515.501	-82.0805	-128.536
44	-497.336	-75.9706	47.26963
44	-473.064	78.02252	31.8868

44	-454.899	84.04391	126.9146
44	-515.501	-82.0805	-128.536
44	-497.336	-75.9706	47.26963
44	-141.215	-0.18434	85.85264
44	-128.136	1.50655	129.82
44	-200.622	-1.03535	-115.532
44	-187.543	0.81254	-64.3639
44	-141.215	-0.18434	85.85264
44	-128.136	1.50655	129.82
44	-200.622	-1.03535	-115.532
44	-187.543	0.81254	-64.3639
44	-149.7	79.44167	70.37179
44	-136.621	81.1668	122.5505
44	-192.137	-80.6614	-100.051
44	-179.058	-78.8477	-47.0945
44	-149.7	79.44167	70.37179
44	-136.621	81.1668	122.5505
44	-192.137	-80.6614	-100.051
44	-179.058	-78.8477	-47.0945
45	-733.265	-1.58888	-74.7124
45	-692.576	1.74818	125.601
45	-483.718	-0.87564	46.10438
45	-465.553	1.70146	120.4329
45	-544.852	-1.50913	-127.235
45	-526.687	1.00331	34.11021
45	-483.718	-0.87564	46.10438
45	-465.553	1.70146	120.4329
45	-544.852	-1.50913	-127.235
45	-526.687	1.00331	34.11021
45	-490.395	80.95165	5.12769
45	-472.23	83.98495	106.6758
45	-538.175	-83.3364	-116.258
45	-520.01	-81.2802	77.86726
45	-490.395	80.95165	5.12769
45	-472.23	83.98495	106.6758
45	-538.175	-83.3364	-116.258
45	-520.01	-81.2802	77.86726
45	-145.129	0.10641	86.12103
45	-132.05	0.60092	122.3909
45	-206.264	-0.52708	-117.218
45	-193.185	-0.09723	-63.9318
45	-145.129	0.10641	86.12103
45	-132.05	0.60092	122.3909
45	-206.264	-0.52708	-117.218
45	-193.185	-0.09723	-63.9318
45	-151.806	81.9337	45.14434
45	-138.727	82.88441	108.6338
45	-199.587	-82.3544	-76.2418
45	-186.508	-82.3807	-20.1748
45	-151.806	81.9337	45.14434
45	-138.727	82.88441	108.6338

45	-199.587	-82.3544	-76.2418
45	-186.508	-82.3807	-20.1748
46	-731.65	0.17721	-75.0859
46	-690.96	-0.26239	127.1642
46	-484	0.59667	46.08921
46	-465.835	0.06068	121.9492
46	-543.775	-0.05718	-127.741
46	-525.61	-0.70098	35.0021
46	-484	0.59667	46.08921
46	-465.835	0.06068	121.9492
46	-543.775	-0.05718	-127.741
46	-525.61	-0.70098	35.0021
46	-497.225	83.01844	-19.4698
46	-479.06	83.18421	132.224
46	-530.55	-82.4789	-92.1817
46	-512.385	-83.8245	104.7273
46	-497.225	83.01844	-19.4698
46	-479.06	83.18421	122.224
46	-530.55	-82.4789	-92.1817
46	-512.385	-83.8245	104.7273
46	-146.114	0.72397	86.30676
46	-133.036	-0.01544	123.0381
46	-205.889	0.07013	-117.523
46	-192.811	-0.7771	-63.909
46	-146.114	0.72397	86.30676
46	-133.036	-0.01544	123.0381
46	-205.889	0.07013	-117.523
46	-192.811	-0.7771	-63.909
46	-159.34	83.14574	20.74772
46	-146.261	83.10809	83.31296
46	-192.664	-82.3516	-51.9642
46	-179.585	-83.9006	5.81623
46	-159.34	83.14574	20.74772
46	-146.261	83.10809	83.31296
46	-192.664	-82.3516	-51.9642
46	-179.585	-83.9006	5.81623
47	-729.581	0.87172	-75.1227
47	-688.892	-0.91923	127.4697
47	-483.023	1.15564	46.13018
47	-464.858	-0.4245	122.2762
47	-541.872	0.45525	-127.821
47	-523.707	-1.26009	35.17176
47	-483.023	1.15564	46.13018
47	-464.858	-0.4245	122.2762
47	-541.872	0.45525	-127.821
47	-523.707	-1.26009	35.17176
47	-506.717	83.65116	-43.7315
47	-488.552	82.80307	126.6612
47	-518.178	-82.0403	-67.9596
47	-500.013	-84.4877	120.7868
47	-506.717	83.65116	-43.7315

**ANEXO N°11.5: DISEÑO DE LOSA
UNIDIRECCIONAL DE CONCRETO ARMADO**

DISEÑO DE LOSA UNIDIRECCIONAL

$$\begin{aligned}f'c &= 280 \text{ kgf/cm}^2 \\f_y &= 4200 \text{ kgf/cm}^2 \\b &= 1.00 \text{ m} \\h &= 0.40 \text{ m} \\S &= 2.80 \text{ m} \\L &= 25.00 \text{ m}\end{aligned}$$

DISEÑO DEL REFUERZO POR FLEXIÓN

Estado Límite: Resistencia Última

Refuerzo Positivo:

$$\begin{aligned}M_u &= 27.34 \text{ tnf.m/m} \\b &= 100.00 \text{ cm} \\h &= 40.00 \text{ cm} \\d &= 34.37 \text{ cm} \\\phi &= 0.90\end{aligned}$$

$$a = \frac{A_s * f_y}{0.85 * f'c * b} \quad A_s = \frac{M_u}{\phi * f_y * (d - a/2)}$$

$$\begin{aligned}a &= 3.94 \text{ cm} \\A_s &= 22.33 \text{ cm}^2 \\C &= 4.64 \text{ cm}\end{aligned}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 1.61 > 0.90 \quad \phi = 0.90$$

$$\begin{aligned}\text{barra de } 3/4" &= 2.85 \text{ cm}^2 \\s &= 12.76 \text{ cm}\end{aligned}$$

Usar 1 ϕ 3/4" @ 0.125 m

Momento último resistente

$$\begin{aligned}s &= 12.50 \text{ cm} \\A_s &= 22.80 \text{ cm}^2 \\a &= 4.02 \text{ cm}\end{aligned}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 27.88 \text{ tnf.m/m} > M_u \quad \text{ok}$$

Refuerzo mínimo

a. $M_{cr} = 1.10 f_r S$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'c}$$

$$s = 26666.67 \text{ cm}^3 \quad s = \frac{bh^2}{6}$$

$$M_{cr} = 9.87 \text{ tnf.m/m}$$

b. 1.33 M_U

$$1.33 M_u = 36.3622 \text{ tnf.m/m}$$

$$\begin{array}{ccc} \text{Mur} & & \text{menor } M_{cr}, 1.33 M_u \\ 27.88 \text{ tnf.m/m} & > & 9.87 \text{ tnf.m/m} \end{array} \quad \text{ok}$$

Refuerzo por distribución

$$\frac{220}{\sqrt{s}} \leq 67\%$$

$$s = 2.80 \text{ m}$$

$$s = 9.18 \text{ pie}$$

$$\% = 72.60$$

$$\% = 67.00$$

$$A_s = 14.96 \text{ cm}^2/\text{m}$$

$$\text{barra de } 5/8" = 1.98 \text{ cm}^2$$

$$s = 13.24 \text{ cm}$$

Usar 1 $\emptyset 5/8"$ @ 0.125 m

Refuerzo por Temperatura

$$A_{s,t} = \frac{0.18b \cdot h}{2(b+h)}$$

$$b = 2500.00 \text{ cm}$$

$$h = 40.00 \text{ cm}$$

$$A_{s,t} = 3.54 \text{ cm}^2/\text{m} \quad 2.33 \text{ cm}^2/\text{m} \leq A_{s,temp} \leq 12.75 \text{ cm}^2/\text{m}$$

$$A_{s,t} = 3.54 \text{ cm}^2/\text{m}$$

$$\text{barra de } 3/8" = 0.71$$

$$s = 20.04 \text{ cm}$$

$$s \leq 3h \quad 120.00 \text{ cm} \quad \text{ok}$$

$$s \leq 45cm \quad 45.00 \text{ cm} \quad \text{ok}$$

Usar 1 $\emptyset 3/8"$ 0.20 m

Control de Agrietamiento

Estado Límite de Servicio

Refuerzo Positivo

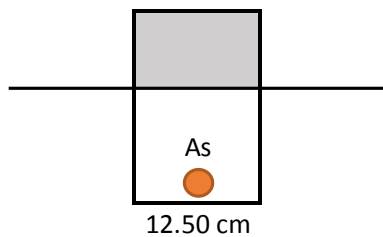
$$M_s = 14.44 \text{ tnf.m/m}$$

$$f_s = \frac{M_s}{A_s \cdot j d} \leq 0.60 f_y$$

$$s = 0.125 \text{ m}$$

$$M_s = 1.81 \text{ tnf.m}$$

$$A_s = 2.85 \text{ cm}^2$$



$$b \times kd \times \frac{kd}{2} = n A_s \times (d - kd)$$

$$b = 12.50 \text{ cm}$$

$$n = 8.37$$

$$n \cdot A_s = 23.84 \text{ cm}^2$$

$$d = 36.83 \text{ cm}$$

$$kd = 10.10 \text{ cm}$$

$$jd = d - \frac{kd}{3}$$

$$jd = 33.46 \text{ cm}$$

$$f_s = 1892.86 \text{ kgf/cm}^2 \leq 2520.00 \text{ kgf/cm}^2 \quad \text{ok}$$

Espaciamiento máximo del refuerzo

$$S_{max} = \frac{125000 \gamma_e}{\beta_s \cdot f_{se}} - 2 \cdot dc$$

$$\beta_s = 1 + \frac{dc}{0.7 \cdot (h - dc)}$$

$$h = 40.00 \text{ cm}$$

$$dc = 3.18 \text{ cm}$$

$$\beta_s = 1.12$$

$$\gamma_e = 0.75$$

condición severa

$$S_{max} = 37.75 \text{ cm}$$

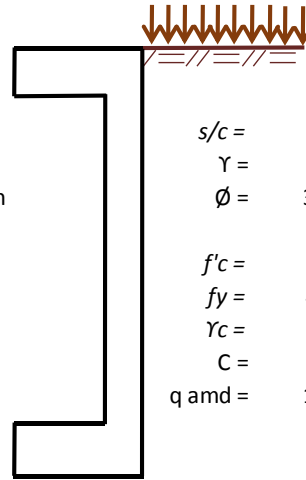
$$S = 12.50 \text{ cm} \quad \text{ok}$$

**ANEXO N°11.6: DISEÑO DE MURO
DE CONCRETO ARMADO**

MURO CON UN ESTRATO

$H = 10.60 \text{ m}$
 $t_p = 0.90 \text{ m}$
 $h_c = 1.00 \text{ m}$

Altura cimentación
 Espesor de muro
 Altura de cimentación



$s/c = 1.00 \text{ tn/m}^2$
 $\gamma = 1.80 \text{ tn/m}^3$
 $\phi = 30.00^\circ$

Sobrecarga
 Peso específico del relleno
 Ángulo de fricción interna del relleno

$f'c = 280 \text{ kg/cm}^2$
 $f_y = 4200 \text{ kg/cm}^2$
 $\gamma_c = 2.50 \text{ tn/m}^3$
 $C = 0.00$
 $q_{\text{adm}} = 12.40 \text{ kg/cm}^2$

Resistencia especificada a la compresión del concreto
 Esfuerzo de cedencia del acero de refuerzo
 Peso específico del concreto
 Cohesión del suelo de soporte
 Capacidad admisible del suelo

CALCULO DE EMPUJES

1.- Empuje Activo

$$K_a = \tan^2 \left(45^\circ - \frac{\phi}{2} \right)$$

$k_a = 0.33$

2.- Sobrecarga

$$P_1 = k_a * s/c$$

$P_1 = 0.33 \text{ tn/m}^2$

$$E_1 = k_a * s/c * h$$

$E_1 = 3.53 \text{ tn/m}$

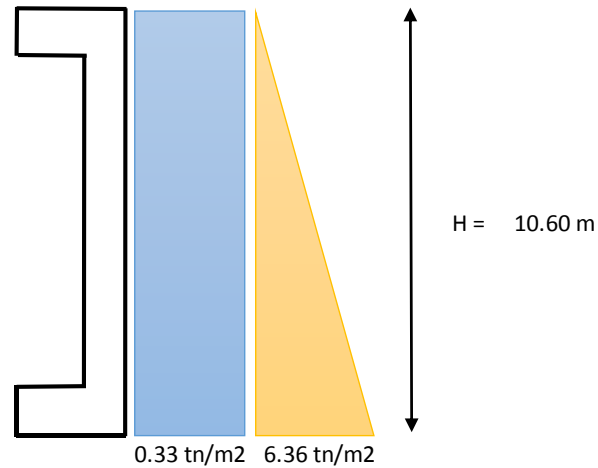
3.- Empuje de relleno

$$P_2 = k_a * \gamma * h$$

$P_2 = 6.36 \text{ tn/m}^2$

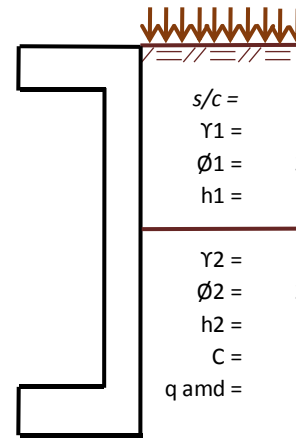
$$E_2 = \frac{1}{2} * k_a * \gamma * h^2$$

$E_2 = 33.71 \text{ tn/m}$



MURO CON DOS ESTRATOS

$H =$	10.60 m	Altura cimentación
$t_p =$	0.90 m	Espesor de muro
$h_c =$	1.00 m	Altura de cimentación
$f'_c =$	280 kg/cm ²	Resistencia especificada a la compresión del concreto
$f_y =$	4200 kg/cm ²	Esfuerzo de cedencia del acero de refuerzo
$\gamma_c =$	2.50 tn/m ³	Peso específico del concreto



$s/c =$	1.00 tn/m ²	Sobrecarga
$\gamma_1 =$	1.80 tn/m ³	Peso específico del relleno
$\phi_1 =$	30.00 °	Ángulo de fricción interna del relleno
$h_1 =$	6.60 m	Altura del relleno
$\gamma_2 =$	2.70 tn/m ³	Peso específico del suelo
$\phi_2 =$	28.00 °	Ángulo de fricción interna del suelo
$h_2 =$	4.00 m	Altura del estrato
$C =$	0.00	Cohesión del suelo de soporte
$q_{amd} =$	12.40 kg/cm ²	Capacidad admisible del suelo

CALCULO DE EMPUJES

1.- Empuje Activo

$$K_a = \tan^2 \left(45^\circ - \frac{\phi}{2} \right)$$

$ka_1 =$	0.33
$ka_2 =$	0.36

2.- Sobrecarga

$$P_1 = k_a * s/c$$

$$P_1 = 0.33 \text{ tn/m}^2$$

3.- Empuje de relleno

$$h_{s/c} = \frac{s/c}{\gamma_1}$$

$$h_{s/c} = 0.56 \text{ m}$$

$$P_2 = k_{a1} * \gamma_1 * (h_1 + h_{s/c})$$

$$P_2 = 4.29 \text{ tn/m}^2$$

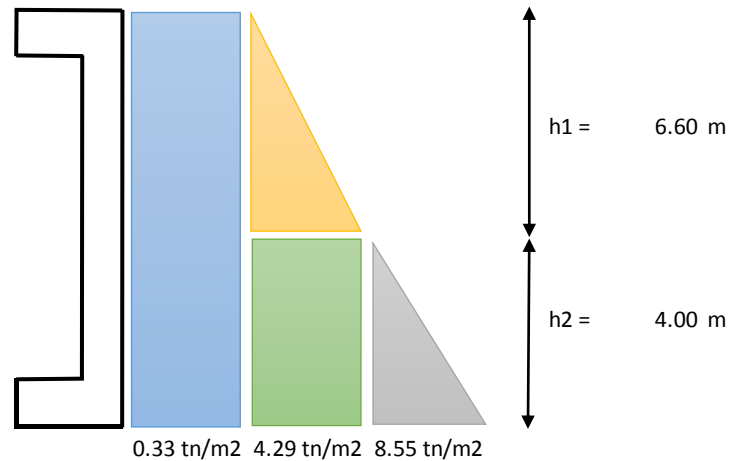
4.- Empuje del suelo

$$h_e = \frac{\gamma_1 * h_1 + s/c}{\gamma_2}$$

$$h_e = 4.77 \text{ m}$$

$$P_3 = k_{a2} * \gamma_2 * (h_2 + h_e)$$

$$P_3 = 8.55 \text{ tn/m}^2$$



DISEÑO DE MURO

Nudo Superior

$$\begin{aligned} \mu &= 87.48 \text{ tnf.m/m} \\ b &= 100.00 \text{ cm} \\ h &= 90.00 \text{ cm} \\ d &= 84.05 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{\mu}{\phi * fy * (d - a/2)} \\ a &= 5.01 \text{ cm} \\ As &= 28.38 \text{ cm}^2 \\ C &= 5.89 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 2.64 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 3/4" &= 2.85 \text{ cm}^2 \\ s &= 10.04 \text{ cm} \end{aligned}$$

Usar 1 $\phi 3/4"$ @ 0.10 m

Momento último resistente

$$\begin{aligned} s &= 10.00 \text{ cm} \\ As &= 28.50 \text{ cm}^2 \\ a &= 5.03 \text{ cm} \end{aligned}$$

$$M_{ur} = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 87.83 \text{ tnf.m/m} > \mu \quad \text{ok}$$

Claro

$$\begin{aligned} \mu &= 78.39 \text{ tnf.m/m} \\ b &= 100.00 \text{ cm} \\ h &= 90.00 \text{ cm} \\ d &= 84.05 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{\mu}{\phi * fy * (d - a/2)} \\ a &= 4.47 \text{ cm} \\ As &= 25.35 \text{ cm}^2 \\ C &= 5.26 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 2.90 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 3/4" &= 2.85 \text{ cm}^2 \\ s &= 11.24 \text{ cm} \end{aligned}$$

Usar 1 $\phi 3/4"$ @ 0.10 m

Momento último resistente

$$\begin{aligned} s &= 10.00 \text{ cm} \\ As &= 28.50 \text{ cm}^2 \\ a &= 5.03 \text{ cm} \end{aligned}$$

$$M_{ur} = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 87.83 \text{ tnf.m/m} > \mu \quad \text{ok}$$

Nudo Inferior

$$\begin{aligned} \mu &= 165.03 \text{ tnf.m/m} \\ b &= 100.00 \text{ cm} \\ h &= 90.00 \text{ cm} \\ d &= 81.82 \text{ cm} \\ \phi &= 0.90 \\ a &= \frac{As * fy}{0.85 * f'c * b} \quad As = \frac{\mu}{\phi * fy * (d - a/2)} \\ a &= 10.03 \text{ cm} \\ As &= 56.84 \text{ cm}^2 \\ C &= 11.80 \text{ cm} \\ \phi &= 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90 \\ \phi &= 1.54 > 0.90 \quad \phi = 0.90 \\ \text{barra de } 3/4" &= 2.85 \text{ cm}^2 \\ s &= 10.03 \text{ cm} \end{aligned}$$

Usar 2 $\phi 3/4"$ @ 0.10 m

Momento último resistente

$$\begin{aligned} s &= 10.00 \text{ cm} \\ As &= 57.00 \text{ cm}^2 \\ a &= 10.06 \text{ cm} \end{aligned}$$

$$M_{ur} = \phi As * fy \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 165.45 \text{ tnf.m/m} > \mu \quad \text{ok}$$

Refuerzo mínimo

a. $M_{cr} = 1.10 f_r S$

fr = 33.63 kgf/cm² $fr = 2.01 \sqrt{f'_c}$

s = 135000 cm³ $s = \frac{bh^2}{6}$

Mcr = 49.95 tnf.m/m

b. $1.33 M_u$

1.33 Mu = 116.35 tnf.m/m

Mur = 87.83 tnf.m/m > menor Mcr, 1.33 Mu
49.95 tnf.m/m

ok

Refuerzo mínimo

a. $M_{cr} = 1.10 f_r S$

fr = 33.63 kgf/cm² $fr = 2.01 \sqrt{f'_c}$

s = 135000 cm³ $s = \frac{bh^2}{6}$

Mcr = 49.95 tnf.m/m

b. $1.33 M_u$

1.33 Mu = 104.26 tnf.m/m

Mur = 87.83 tnf.m/m > menor Mcr, 1.33 Mu
49.95 tnf.m/m

ok

Refuerzo mínimo

a. $M_{cr} = 1.10 f_r S$

fr = 33.63 kgf/cm² $fr = 2.01 \sqrt{f'_c}$

s = 135000 cm³ $s = \frac{bh^2}{6}$

Mcr = 49.95 tnf.m/m

b. $1.33 M_u$

1.33 Mu = 219.49 tnf.m/m

Mur = 165.45 tnf.m/m > menor Mcr, 1.33 Mu
49.95 tnf.m/m

ok

Refuerzo por Temperatura

$As_t = \frac{0.18b \cdot h}{2(b+h)}$

b = 90.00 cm

h = 960.00 cm

As,t = 7.41 cm²/m

As,t = 7.41 cm²/m

barra de 3/8" = 1.27

s = 17.15 cm

$2.33 \text{ cm}^2/\text{m} \leq As_{temp} \leq 12.75 \text{ cm}^2/\text{m}$

$s \leq 3h$ 2880.00 cm ok

$s \leq 45cm$ 45.00 cm ok

Usar 1 Ø 1/2" 15.00 m

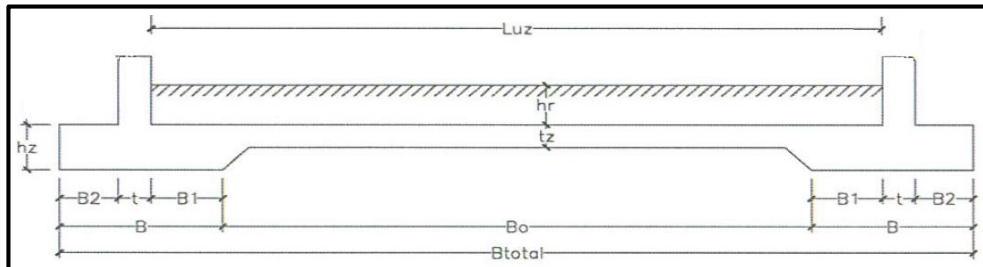
**ANEXO N°11.7: DISEÑO DE CIMENTACIÓN
DE CONCRETO ARMADO**

DISEÑO DE LOSA DE CIMENTACIÓN

1.- DATOS

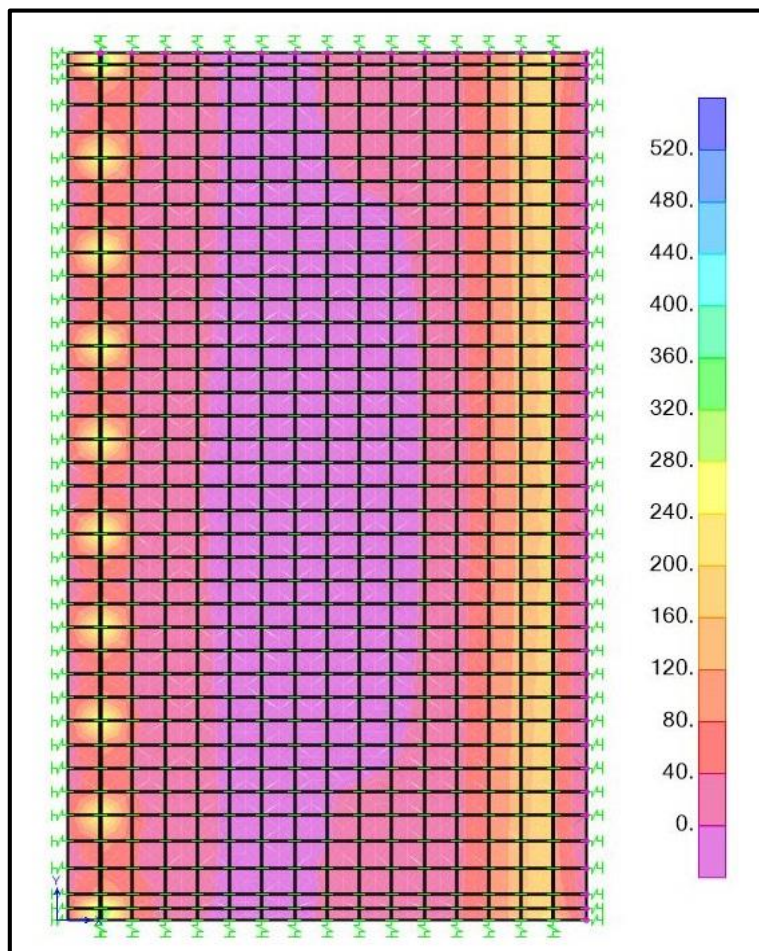
$f'_c =$	280 kg/cm ²	Resistencia especificada a la compresión del concreto
$f_y =$	4200 kg/cm ²	Esfuerzo de cedencia del acero de refuerzo
$\gamma_c =$	2.50 tn/m ³	Peso específico del concreto
$q_{amd} =$	12.40 kg/cm ²	Capacidad admisible del suelo

2.- PREDIMENSIONAMIENTO



B =	3.60 m	hz =	1.00 m
B total =	14.70 m	tz =	0.70 m
Bo =	7.50	h1 =	2.00 m
t =	0.90 m	hr =	2.30 m
B1 =	2.20 m		
B2 =	0.50 m		

3.- MODELAMIENTO LOSA DE CIMENTACIÓN SAP2000



4.- DISEÑO DE LOSA DE CIMENTACIÓN

DISEÑO DEL REFUERZO POR FLEXIÓN - FRANJA DE BORDE

Estado Límite: Resistencia Última

Refuerzo Positivo:

$$M_u = 164.31 \text{ tnf.m/m}$$

$$b = 100.00 \text{ cm}$$

$$h = 100.00 \text{ cm}$$

$$d = 91.23 \text{ cm}$$

$$\phi = 0.90$$

$$a = \frac{A_s * f_y}{0.85 * f'_c * b} \quad A_s = \frac{M_u}{\phi * f_y * (d - a/2)}$$

$$a = 8.84 \text{ cm}$$

$$A_s = 50.07 \text{ cm}^2$$

$$C = 10.40 \text{ cm}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 1.82 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 1" = 5.01 \text{ cm}^2$$

$$s = 10.01 \text{ cm}$$

Usar 1 Ø 1" @ 0.10 m

Momento último resistente

$$s = 10.00 \text{ cm}$$

$$A_s = 50.10 \text{ cm}^2$$

$$a = 8.84 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 164.40 \text{ tnf.m/m} > M_u \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 33.63 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'_c}$$

$$s = 166667 \text{ cm}^3 \quad s = \frac{bh^2}{6}$$

$$M_{cr} = 61.66 \text{ tnf.m/m}$$

$$1.33 M_u$$

$$1.33 M_u = 218.53 \text{ tnf.m/m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 164.40 \text{ tnf.m/m} & > & 61.66 \text{ tnf.m/m} \quad \text{ok} \end{array}$$

DISEÑO DEL REFUERZO POR FLEXIÓN - FRANJA DE INTERMEDIA

Estado Límite: Resistencia Última

Refuerzo Negativo:

$$M_u = 28.98 \text{ tnf.m/m}$$

$$b = 100.00 \text{ cm}$$

$$h = 70.00 \text{ cm}$$

$$d = 61.23 \text{ cm}$$

$$\phi = 0.90$$

$$a = \frac{A_s * f_y}{0.85 * f'_c * b} \quad A_s = \frac{M_u}{\phi * f_y * (d - a/2)}$$

$$a = 2.25 \text{ cm}$$

$$A_s = 12.76 \text{ cm}^2$$

$$C = 2.65 \text{ cm}$$

$$\phi = 0.65 + 0.15 \left(\frac{d}{C} - 1 \right) \leq 0.90$$

$$\phi = 3.97 > 0.90 \quad \phi = 0.90$$

$$\text{barra de } 3/4" = 2.85 \text{ cm}^2$$

$$s = 22.34 \text{ cm}$$

Usar 1 $\phi 3/4"$ @ 0.20 m

Momento último resistente

$$s = 20.00 \text{ cm}$$

$$A_s = 14.25 \text{ cm}^2$$

$$a = 2.51 \text{ cm}$$

$$M_{ur} = \phi A_s * f_y \left(d - \frac{a}{2} \right)$$

$$M_{ur} = 32.30 \text{ tnf.m/m} > M_u \quad \text{ok}$$

Refuerzo mínimo

$$M_{cr} = 1.10 f_r S$$

$$f_r = 4.92 \text{ kgf/cm}^2 \quad f_r = 2.01 \sqrt{f'_c}$$

$$s = 81667 \text{ cm}^3 \quad s = \frac{bh^2}{6}$$

$$M_{cr} = 4.42 \text{ tnf.m/m}$$

$$1.33 M_u$$

$$1.33 M_u = 38.54 \text{ tnf.m/m}$$

$$\begin{array}{ccc} M_{ur} & & \text{menor } M_{cr}, 1.33 M_u \\ 32.30 \text{ tnf.m/m} & > & 4.42 \text{ tnf.m/m} \end{array} \quad \text{ok}$$

Refuerzo por distribución

$$\frac{220}{\sqrt{s}} \leq 67\%$$

s =	2.80 m
s =	9.18 pie
%=	72.60
%=	67.00
As =	8.55 cm ² /m
barra de 5/8" =	1.98 cm ²
s =	23.17 cm

Usar 1 Ø 5/8" @ 0.20 m

Refuerzo por Temperatura

$$A_{s,t} = \frac{0.18b \cdot h}{2(b+h)}$$

b =	1500.00 cm
h =	100.00 cm
As,t =	8.44 cm ² /m
As,t =	8.44 cm ² /m
barra de 1/2" =	1.27
s =	15.05 cm

$$2.33 \text{ cm}^2/\text{m} \leq A_{s,temp} \leq 12.75 \text{ cm}^2/\text{m}$$

$s \leq 3h$	300.00 cm	ok
$s \leq 45cm$	45.00 cm	ok

Usar 1 Ø 1/2" 0.15 m

5.- PUNZONAMIENTO

Vu =	204.52 tnf
h =	100.00 cm
d =	91.23 cm
bo =	202.62 cm
α =	30.00
β =	2.00
Ø =	0.85

$$Vc \leq 0.27 \cdot \left(2 + \frac{4}{\beta}\right) \cdot \sqrt{f'c} \cdot b_o \cdot d$$

$$Vc \leq 0.27 \cdot \left(\frac{\alpha_s \cdot d}{b_o} + 2\right) \cdot \sqrt{f'c} \cdot b_o \cdot d$$

$$Vc \leq 1.06 \cdot \sqrt{f'c} \cdot b_o \cdot d$$

Vc1 =	334.06 tnf	ok
Vc2 =	1128.08 tnf	ok
Vc3 =	327.87 tnf	ok

6.- APLASTAMIENTO

$$Pu \leq \phi \left(0.85 \cdot f'c \cdot A_1 \cdot \sqrt{A_2/A_1} \right)$$

b =	70.00 cm
t =	90.00 cm
A1 =	6300 cm ²
A2 =	100800 cm ²
φ =	0.70
Pu =	1095.56 tnf
Pub =	4198.32 tnf

ok