2) Asumir el Valor de la Profundidad del EN

$C = 5.7\ cm$

3) Calculo de la De Formacion de Acero

$$\varepsilon'_s = \frac{\varepsilon_{cu}(c - d')}{c} = \frac{0.003(5.7 - 4.64)}{5.7} = 5.58 \times 10^{-4}$$

4) Calculo de Esfuerzo en el Acero.

$$f'_s = E_s \times \varepsilon_s = 2 \times 10^6 \times 5.58 \times 10^{-4} = 1116\ kg/cm^2$$

3.1) Calculo de la Deformacion de Acero

$$\varepsilon_s = \frac{\varepsilon_c (d - c)}{c} = \frac{0.003(45.05 - 5.7)}{5.7} = 0.021$$

4.1) Calculo de Esfuerzo en Acero

$$f_s = E_s \times \varepsilon_s = 2 \times 10^6 \times 0.021 = 42000\ kg/cm^2$$

$f_s > f_y \rightarrow 4200\ kg/cm^2$

5) Calculo de C_c

$$\Sigma\ C_c + A'_s \times f'_s = A_s \times f_s$$

$(a = \beta_1 \times c)$

$$- C_c = 0.85 \times f'c \times a \times b = 0.85 \times 210 \times 0.85 \times 5.7 \times 20$$

$$C_c = 17296.65\ kg$$

$$- A'_s \times f'_s = 2.53 \times 1116 = 2823.48\ kg$$

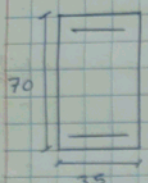
$$\Sigma = 17296.65\ kg + 2823.48\ kg = 20120.13\ kg$$

$$- A_s \times f_s = 5.70 \times 4200 = 23940\ kg$$

$$\Rightarrow 20120.13\ kg \neq 23940\ kg$$

No hay Equilibrio

Ejemplo 04 : Diseñar la Siguiente Viga.



$S'c = 210\ kg/cm^2$
$Sy = 4200\ kg/cm^2$

$Mu = 80\ tn/m$
$r = 4\ cm$

1) Calculo de d y d' Si $\phi = 3/4$

$$d = h - \left(r + \frac{\phi}{2}\right) = 70 - \left(4 + \frac{1.905}{2}\right) = 65.05\ cm$$

$$d' = \left(r + \frac{\phi}{2}\right) = \left(4 + \frac{1.905}{2}\right) = 4.95\ cm$$

2) Calculamos a:

$$a = d - \sqrt{d^2 - \frac{2|Mu|}{\phi \times 0.85 \times S'c \times b}} = 65.05 - \sqrt{65.05^2 - \frac{2 \times 80 \times 10^6}{0.9 \times 0.85 \times 210 \times 35}}$$

$$a = 27.32\ cm$$

3) Calculo de As.

$$As = \frac{0.85 \times S'c \times a \times b}{Sy} = \frac{0.85 \times 210 \times 27.82 \times 35}{4200}$$

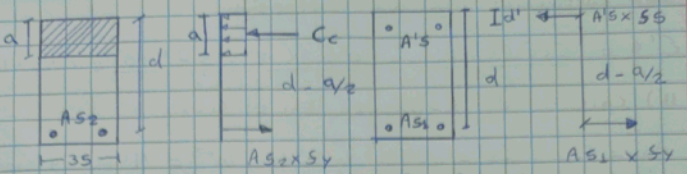
$$As = 41.38\ cm^2$$

4) Calculo de As Max

$$As\ Max = 0.75 \times 1.19 \times 10^{-4} \times S'c \times 0.1 \times b \times d$$

$$As\ Max = 0.75 \times 1.19 \times 10^{-4} \times 210 \times 0.85 \times 35 \times 65.05$$

$$As\ Max = 36.27\ cm^2$$



Seccion 2 (Real)

Seccion 1 (Ficticia)

→ $As_2 = 36.27\ cm^2$

5) Calculamos a:

$$a = \frac{As_2 \times Sy}{0.85 \times f'c \times b} = \frac{36.27 \times 4200}{0.85 \times 210 \times 35} = 24.38\ cm$$

6) Calculamos el ϕMn_2

$$\phi Mn_2 = \phi\,(As_2 \times Sy\,(d - \frac{a}{2}))$$

$$\phi Mn_2 = 0.90\,(36.27 \times 4200\,(65.05 - \frac{24.38}{2})) = 7247137.72$$

$$\phi Mn_2 = 7247137.72\ kg/cm = 72.47\ tn/m$$

7) Calculamos el ϕMn_1

$$\phi Mn_1 = Mu - \phi Mn_2 = 80 - 72.47 = 7.53\ tn/m$$

8) Calculamos As_1

$$As_1 = \frac{Mn_1}{\phi \times Sy\,(d - d')} = \frac{7.53 \times 10^5}{0.90 \times 4200\,(65.05 - 4.95)}$$

$$As_1 = 3.32\ cm^2$$

9) Calculamos la c:

$$C = \frac{a}{0.85} = \frac{24.38}{0.85} = 28.68\ cm$$

10) Calculamos $\varepsilon's$ en compresion

$$\varepsilon's = \frac{\varepsilon cu\,(c - d')}{c} = \frac{0.003(28.68 - 4.95)}{28.68} = 2.48 \times 10^{-3}$$

11) Calculo de Esfuerzo en el Acero

$$fs = Es \times \varepsilon s = 2\times10^{6} \times 2.48 \times 10^{-3} = 4960\ Kg/cm^2$$

como $fs > fy \rightarrow 4200\ Kg/cm^2$

12) Calculo A'S

$$A'S = \frac{As_1 \times fy}{fs} = \frac{3.31 \times 4200}{4200} = 3.31\ cm^2$$

13) Resumen

$As_1 = 3.31\ cm^2$	$As_2 = 36.27\ cm^2$
$\phi Mn_1 = 7.53\ tn/m$	$\phi Mn_2 = 72.47\ tn/m$

$\Rightarrow$ En traccion

$$As\,t = As_1 + As_2 = 3.31 + 36.27 = 39.58\ cm^2 \quad \text{ok}$$

En compresión

$$A'S = 3.31\ cm^2$$

14) Calculamos As Max

$$Asmax = 0.75 \times Asbr + A'S \times \frac{f'S}{fy}$$

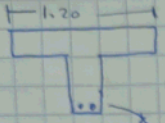
$$\Rightarrow Asbr = 1.19 \times 10^{-4} \times f'c \times \beta_1 \times \underbrace{b \times d}_{050}$$

$$Asbr = 1.19 \times 10^{-4} \times 210 \times 0.85 = 0.02124$$

$$As\,Max = 0.75 \times 0.02124 \times 35 \times 65.05 + 3.31 \times \frac{4200}{4200}$$

$$As\,Max = 39.58\ cm^2 \quad \text{ok}$$

Ejemplo 01 Calcular la resistencia a flexion de la viga tipo T



hs = 20 cm

f'c = 210 kg/cm²

fy = 4200 kg/cm²

d = 65 m

As = 3 #11 = 15.30 cm²

1) Suponemos a < hs y que fs = fy

$T = As\,fy = 15.30 \times 4200 = 64260\ kg$

2) Calculamos a:

$$a = \frac{As \times fy}{0.85 \times f'c \times be} = \frac{64260\ cm^2}{0.85 \times 210 \times 120} = 3\ cm < hs$$

3) Calculo de c

$$c = \frac{a}{\beta_1} = \frac{3}{0.85} = 3.53\ cm$$

4) Calculo de la Deformacion de Acero

$$\varepsilon_s = \frac{\varepsilon_{cu}(d - c)}{c} = \frac{0.003(65 - 3.53)}{3.53} = 0.052 > 0.021$$

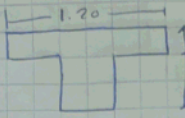
→ sluyer.

5) Calculo de Mn

$$Mn = As \times fs \left(d - \frac{a}{2}\right)$$

$$Mn = 64260 \left(65 - \frac{3}{2}\right) = 4080510\ kg = 40.81\ Tn/m$$

Ejemplo 02 : Calcular el Area de Acero necesaria para que a = hs



$f'c = 210 kg/cm^2$
$fy = 4200 kg/cm^2$
$d = 65 cm$
$a = 20$

$Cc = 0.85 \times f'c \times a \times be$

$Cc = 0.85 \times 210 \times 20 \times 120 = 428400 kg$

1) Consideramos que As fluye.

$+ = As \times fs$
$F = Cc$

$428400 = As \times 4200$
$As = 102 cm^2$ → 20 Ø 1"

2) Calculo de a

$$a = \frac{As \times fs}{0.85 \times f'c \times be} = \frac{428400}{0.85 \times 210 \times 120} = 20 cm$$

3) Calculo de c

$$c = \frac{a}{\beta_1} = \frac{20}{0.85} = 23.53 cm$$

4) Calculo de la Deformacion de Acero

$$\varepsilon s = \frac{\varepsilon cu (d - c)}{c} = \frac{0.003 (65 - 20)}{20} =$$

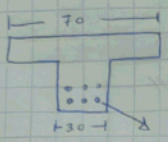
$\varepsilon s = 6.75 \times 10^{-3}$ $0.00675 > fy$ → fluye!

5) Calculo de Mn

$Mn = As \times fs (d - \frac{a}{2}) = 428400 (65 - \frac{20}{2})$

$Mn = 23562000 kg/cm = 235.62 tn/m$

Ejemplo 3: Calcular el Momento resistente a la flexión de la siguiente Viga T



f'c = 210 kg/cm2
fy = 4200 kg/cm2
r = 5cm

$d = h - (r + \phi + \frac{\phi}{2}) = 70 - (5 + 2.5 + \frac{2.5}{2}) = 61\ cm$

1) Supongamos a < hs y que fs = fy

$T = As \times fy = 40.80 \times 4200 = 171360\ kg$

2) Calculo de a:

$$a = \frac{As \times fs}{0.85 \times f'c \times be} = \frac{171360}{0.85 \times 210 \times 70} = 13.71\ cm$$

3) Calculo de Cs y Cw

* $Cs = 0.85 \times f'c\ (be - bw) \times hs = 0.85 \times 210\ (70 - 30) \times 10$
$Cs = 71400\ kg$

* $Cw = 0.85 \times f'c \times bw \times a$ ⇒

$Cw = T - Cs = 171360 - 71400 = 99960\ kg$

4) Calculo de a:

$$a = \frac{Cw}{0.85 \times f'c \times bw} = \frac{99960}{0.85 \times 210 \times 30} = 18.67\ cm$$

5) Verificando si As fluye

* $C = \frac{a}{\beta_1} = \frac{18.67}{0.85} = 21.96\ cm$

* $\varepsilon s = \frac{\varepsilon cu\ (d - c)}{c} = \frac{0.003(61 - 21.96)}{21.96} = 5.33 \times 10^{-3}$

⇒ $0.00533 > \varepsilon y$ → fluye!

6) Calculo de A_{sf}

$$A_{sf} = \frac{0.85 \times f'c}{fy} (be - bw) \times hf$$

$$A_{sf} = \frac{0.85 \times 210}{4200} (70 - 30) \times 10 = 17 \text{ cm}^2$$

7) Calculo M_{nf}

$$M_{nf} = A_{sf} \times fy \times \left(d - \frac{hf}{2}\right) = 17 \times 4200 \times \left(61 - \frac{10}{2}\right) =$$

$$M_{nf} = 3998400 \text{ kg/cm} = 39.98 \text{ tn/m}$$

8) Calculo de A_{sw}

$$A_{sw} = As - A_{sf}$$
$$A_{sw} = 40.80 - 17 = 23.80 \text{ cm}^2$$

9) Calculo de M_{nw}

$$M_{nw} = A_{sw} \times fy \left(d - \frac{a}{2}\right)$$

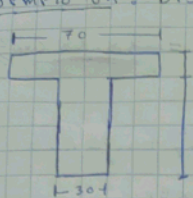
$$M_{nw} = 23.8 \times 4200 \left(61 - \frac{18.67}{2}\right) = 5164433.40 \text{ kg/cm}$$

$$M_{nw} = 51.64 \text{ tn/m}$$

10) Calculo M_n

$$M_n = M_{nf} + M_{nw} = 39.98 + 51.64 = 91.62 \text{ tn/m}$$

Ejemplo 04: Diseñar la siguiente viga T



$f'c = 210\ kg/cm^2$
$fy = 4200\ kg/cm^2$
$Mu = 82.5\ tn/m$
$d = 61\ cm$
* 2 capas de Acero

1) Supongamos $a < hs$ y que $fs = fy \rightarrow a > hs$

$$a = d - \sqrt{d^2 - \frac{2|Mu|}{\phi \times 0.85 \times f'c \times be}} = 61 - \sqrt{61^2 - \frac{2(82.5)\times 10^5}{0.9 \times 0.85 \times 210 \times 70}}$$

$a = 13.53\ cm$ //

* $Mu \leq \phi Mn$ ojo

2) Para Equilibrar Cc s (alas):

* $$Asf = \frac{0.85\ f'c}{fy}(be - bw) \times hs = \frac{0.85 \times 210}{4200} \times (70 - 30) \times 10$$

$Asf = 17\ cm^2$ //

∴

* $$Mnf = Asf \times fy \times \left(d - \frac{hs}{2}\right) = 17 \times 4200 \times \left(61 - \frac{10}{2}\right)$$

$Mnf = 3998400\ kg/cm = 39.98\ tn/m$ //

3) Calculo de Mnw

$Mnw = Mu - Mnf = 82.50 - 39.98 = 42.52\ tn/m$ //

4) Para Equilibrar Cc w (Alma)

$$a = d - \sqrt{d^2 - \frac{2|Mnw|}{\phi \times 0.85 \times f'c \times bw}} = 61 - \sqrt{61^2 - \frac{2 \times 42.52 \times 10^5}{0.90 \times 0.85 \times 210 \times 30}}$$

$a = 16.77\ cm$ //

5) Calculo de Asw

$$Asw = \frac{0.85 \times f'c \times bw \times a}{fy} = \frac{0.85 \times 210 \times 30 \times 16.77}{4200}$$

$Asw = 21.38\ cm^2$ //

6) Calculo Ast

$$Ast = Ass + Asw = 17 + 21.38 = 38.38\ cm^2$$

7) Verificando que As sluye

$$\Rightarrow As\ max = 0.75 \times As_b^t = 0.75\, As_b^R + 0.75\, Ass$$

$$\times\ As_b^R = 1.19 \times 10^{-4} \times S'c \times bw \times d \times D_1$$

$$As_b^R = 1.19 \times 10^{-4} \times 210 \times 30 \times 61 \times 0.85$$

$$As_b^R = 38.87\ cm^2$$

$$\Rightarrow As\ max = 0.75(38.87) + 0.75(17)$$

$$As\ max = 41.90\ cm^2$$

$$Ast = Ass + Asw = 38.38\ cm^2 < As\ Max \rightarrow OK$$

$$Ast = 8\ \phi\ 1 = 40.80\ cm^2$$