4th civil k-f-s (1B)

تصميم منشآت خرسانية مسلحة

REINFORCED CONCRETE DESIGN (3)

د/ أحمـــد عبد الله حمودة

وَإنَّ ضَاقَتْ فِي عَينَيك الدُنيا فـ لكَ في الإِستِغفَارِ فَرَجا كَبيراً..

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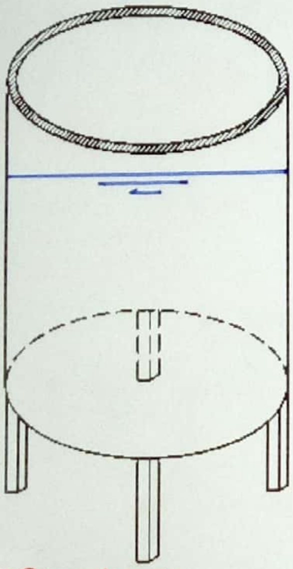
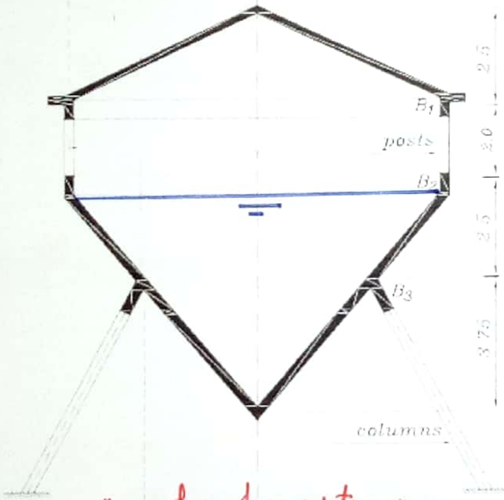
- الخزانات :- عبارة عن مجموعة من الحوائط والأرضيات الخرسانية المسلحة تحتوي بداخلها علي تجمعين من المياة

Classification of tanks :-

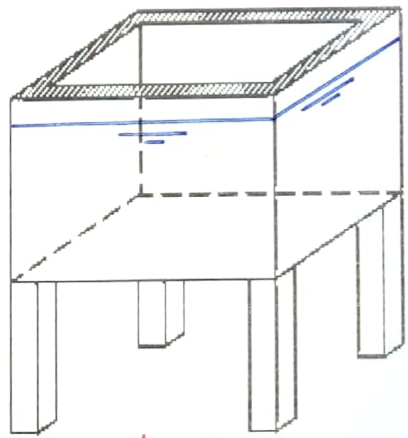
① According to The shape of tanks.



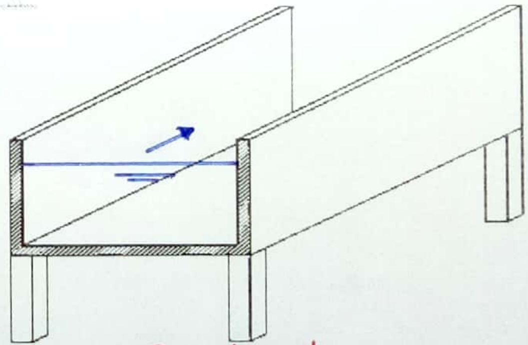
"Circular"



"surface of revolutions"

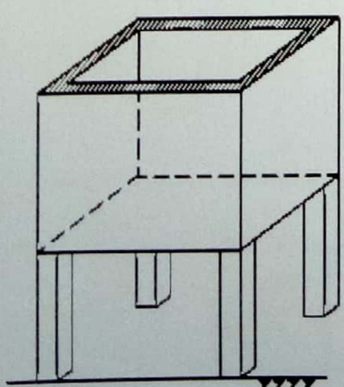


"Rectangular"

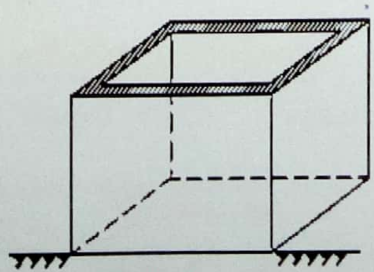


open channel.

② According to the Position of tanks :-

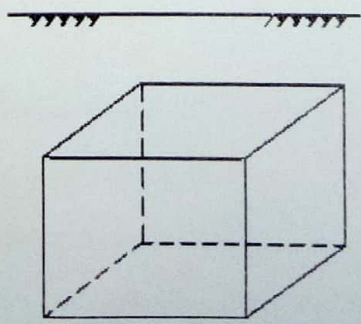


"Elevated"



"Rested"

→ Weak soil
→ rested on Rock soil.



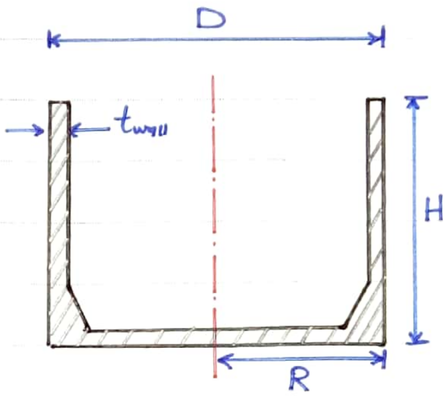
"under ground"

Circular Tanks

Tank Rested on Rock Soil

■ Step of Design :-

1- Empirical dimensions :-



∴ The Volume $(V) = H * \frac{\pi D^2}{4}$

... Assume :- $H \not> 4m$

- $t_{wall} = 0.4\, \gamma_w * H * R \not< 200mm$

2- Straining actions on wall :-

- $\frac{H^2}{D*t} = ...$

a- To Calculate ring force affecting on HZ direction :-

••من كود شاكر البحيري صفحة (١٦٧) table (I)

$\frac{H^2}{D*t}$	Coefficients at Point									
	0.0H	0.1 H	0.2H	0.3H	0.4 H	0.5H	0.6H	0.7H	0.8H	0.9H
T →	+ ...	+ ...	+ ...	+ ...	+ ...	+ ...	+ ...	+ ...	+ ...	+ ...

∴ $T = Coeff * \gamma_w * H * R = ...\ KN$

← الخلاصة :- روح للجدول وشوف أكبر معامل مناظر لقيمة $\frac{H^2}{D*t}$ وهات ال (T_{max}).

b- To Calculate B.M affecting on VL direction :-

••من كود شاكر البحيري صفحة (١٧٠) Table (VII)

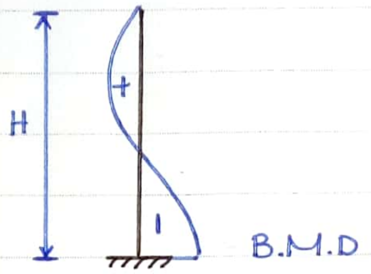
$\frac{H^2}{D*t}$	Coefficients at Point									
	0.1 H	0.2H	0.3H	0.4H	0.5 H	0.6 H	0.7H	0.8H	0.9H	1 H
M →	+ ...	+ ...	+ ...	+ ...	+ ...	− ...	− ...	− ...	− ...	− ...

• $M_{max} = Coeff * \gamma_w * H^3$

← الخلاصة :- روح للجدول وشوف أقصى معامل (+) ، (-) وهات قيمتهم واعرف العزم الموجب موجود على أرتفاع كام ؟!

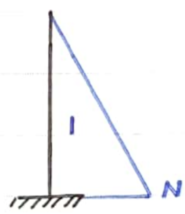
$\therefore$ +Ve Max = +... kN.m at ... m hieght Air section

, -Ve max = -... kN.m water section



C- To Calculate Normal force affecting on VL. Direction :-

$N = \gamma_c * t_w * H = ...$ kN



... Maximum straining actions :-

- For horizontal direction : $\therefore T_{max} = ...$ kN at ... m
- For vertical direction : ★ $\therefore$ +Ve M_{max} = ... kN.m at H = ... m

  , N at H = ... m = $\gamma_c * t_w * H$ = ✓ kN

  $\therefore$ M = ... kN.m , N = ... kN (Air section).

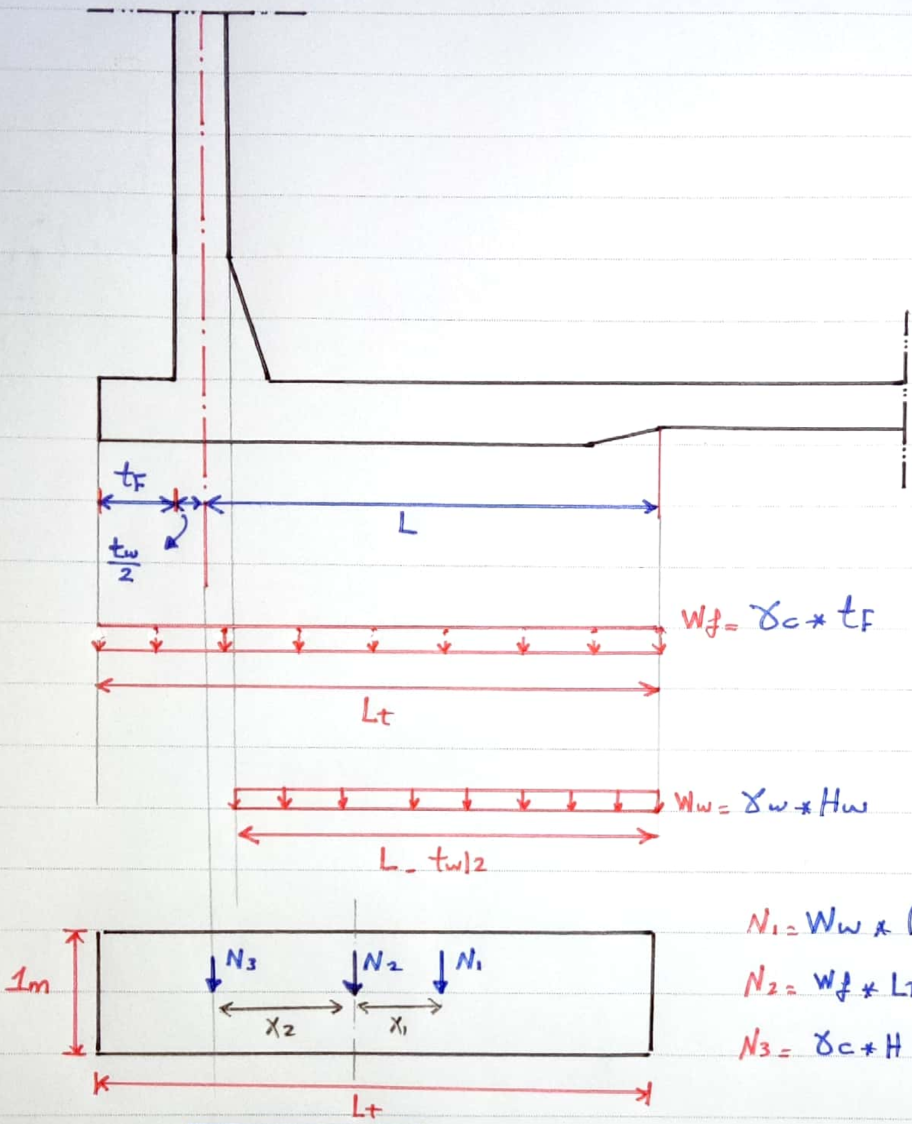
  ★ $\therefore$ -Ve M_{max} = ... kN.m at total height , N = ... kN (Water section).

- Air section :- عبارة عن القطاعات التي تكون جهة الشد ناحية الـ ... وبيتم تصميمها على أنها قطاعات مشرخة (cracked section) . يعني صمم بالطرق العادية من غير الـ (β_{cr})
- Water section :- عبارة عن القطاعات التي تكون جوا الشد ناحية المياة وبيتم تصميمها على أنها قطاعات غير مشرخة (uncracked section) يعني صمم زي المحاضرة السابقة (β_{cr}).

3- Design of critical section :-

.. نفس خطوات التصميم في المحاضرة السابقة ... هنشوفها في المثال .

4. Check stresses of foot on soil:-



$N_1 = W_w * (L - t_w/2)$

$N_2 = W_f * L_T$

$N_3 = \gamma_c * H * t_w$

$\therefore L = 2\sqrt{\frac{M_w (N.mm)}{(W_F + W_w)(kN/m)}} = \ldots . mm \qquad , L_t = (L + t_w/2 + t_F)$

$\therefore N = N_1 + N_2 + N_3$

$, M_t = M_w - N_1 (X_1) + N_3 * (X_2) \qquad , X_1 = L_T/2 - 0.5(L - t_w/2)$

$X_2 = (L_T/2 - t_f - t_w/2)$

$$\therefore f_{\frac{1}{2}} = \frac{-N}{L_T * 1m} \pm \frac{6 M_t}{L_t^2 * 1m}$$

4.2. SOLVED EXAMPLES OF CIRCULAR TANKS:-

(4.2.1-Circular tank rested on good soil (rock soil)

Execute a full design of a circular tank rested on good soil, if you know that the supposed volume is 1000 m^3. Knowing that: (f_{cu} =$25\ N/mm^2$ & f_y =350 N/mm^2). Then check the stresses over soil (soil strength is – 300 kN/m^2)

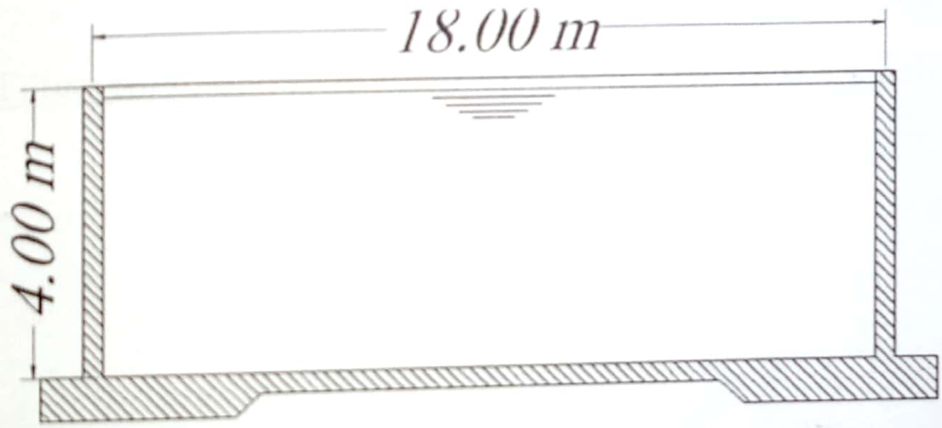
Solution:-

1- Empirical dimensions:

The volume = $\pi*D^2/4 = 1000$ m^3

Assume tank height (H) = 4.00 m

Then, D = 18.00 m

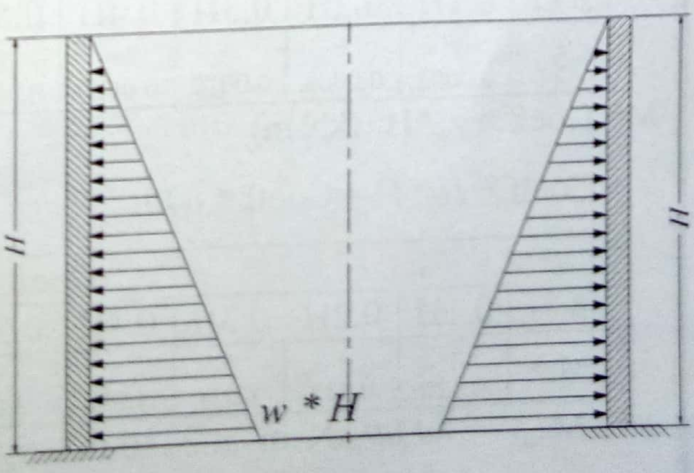


$t_{wall} = 0.4\ \gamma_w*H*R = 0.4*10*4*9 = 144\ mm$ ------------ <u>should be >200</u>

Take $t_{wall} = 200\ mm$

2- Straining action on wall:

Both bending moment (B.M) and weight of wall (N) are the main forces affecting on vertical direction (same direction of wall). Contrarily, only the ring force (T) is the force acting on horizontal direction resulted by water pressure.



Based on value of $(\frac{H^2}{D*t})$ choose the coefficient that will be multiplied by γ_w*H*R

$$\left(\frac{H^2}{D*t}\right) = \frac{4^2}{18*0.2} = 4.45$$

a) To calculate ring force (T) affecting on **horizontal direction** of the wall(Table I):-

$\frac{H^2}{D*t}$	Coefficient at levels									
	0.0H	0.1H	0.2H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H
5	+ 0.025	+ 0.137	+ 0.245	+ 0.346	+ 0.428	+ 0.477	+ 0.469	+ 0.398	+ 0.259	+ 0.092

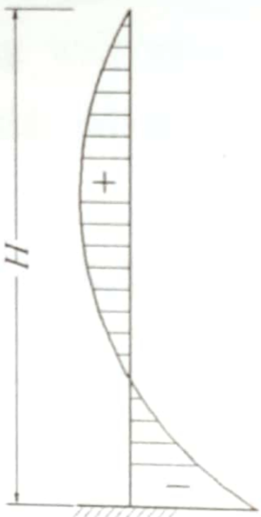
T = Coeff * γ_w*H*R=(kN)

= Coeff * *10*4*9* = Coeff * *350*

$\frac{H^2}{D*t}$	Coefficient at levels									
	0.0H	0.1H	0.2H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H
T→	+9	+49.3	+88	+125	+154	+172	+169	+144	+94	+33

T_{max} = *+172 kN* at *2 .00 m* height

b) To calculate B.M affecting on **vertical- direction** of the wall(Table VII):-



B.M.D

$\frac{H^2}{D*t}$	Coefficient at levels									
	0.1H	0.2H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H	1.0H
5	+ 0.0002	+ 0.0008	+ 0.0016	+ 0.0029	+ 0.0046	+ 0.0059	+ 0.0059	+ 0.0028	- 0.0058	- 0.0222

M= Coeff * γ_w*H^3 (kN.m)

= Coeff * *10*4^3* = Coeff * *640*

$\frac{H^2}{D*t}$	Coefficient at levels									
	0.1H	0.2H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H	1.0H
M→	+ 0.128	+ 0.512	+ 1.024	+ 1.856	+ 3.00	+ 4.00	+ 4.00	+ 2.00	- 4	- 14

+ve M_{max} = *+4.00* kN .m at 2 .40 m height (Air-section)

-ve M_{max} = *-14* kN.m at total height (Water-section)

c) To calculate Normal Force affecting on **vertical- direction** of the wall:-

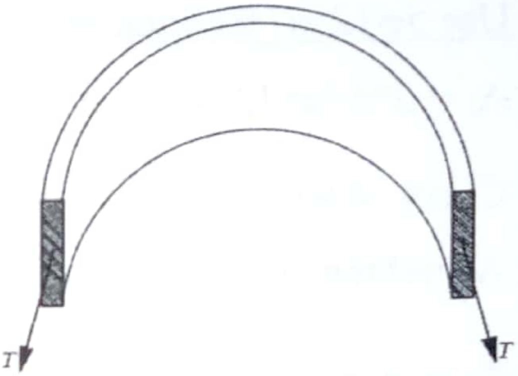
Such force is caused by the self-weight of R.C wall

$N = \gamma_c * t_w * H$ (kN)

$= 25*0.2*4 = 20$ *kN (compressive force on the wall base)*

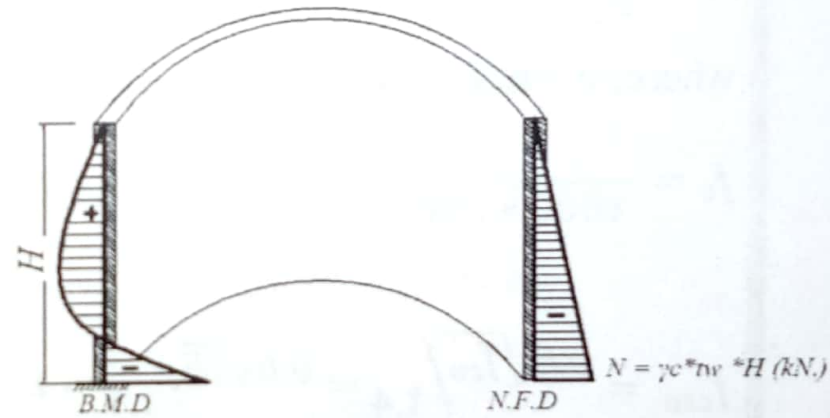
Maximum S.A

For horizontal directions



$T_{max} = +172$ *kN* at 2 .00 m height

For vertical directions



- +ve $M_{max} = +4.00$ *kN .m* at 2 .40 m height

  N at 2.40 m = *25*0.2 *2.4 = -12 kN*

  (Air section with M = *4.00* kN.m & N = *-12* kN)

- -ve $M_{max} = -14$ *kN.m* at total height (Water-section)

  At total H: N = -20 kN

  (water-section M = *14.00* kN.m & N = *-20*

3- Design of critical sections:-

a) For section subjected to maximum tensile ring force $T_{max} = +172$ *kN*.

$t_{mm} \cong 0.6 * T_{kN}$ -- where $t \geq 200$ mm

$t = 0.6*172 = 103$ mm *so, t=200 is O.K*

Evaluating A_s (using ultimate loads):

$T_u = T*1.4 = 172*1.4 = 241$ kN

$$A_s = \frac{T_u * 10^3}{\beta_{cr} * f_y/\gamma_s}$$

$$A_s = \frac{241 * 10^3}{0.93 * \frac{350}{1.15}} = 851\ mm^2$$

For each side use $A_s/2 = 425\ mm^2$

Use 5ϕ12/m\` for each side as a minimum steel for **RING DIRECTION**

$A_s = 2*5*\pi*12^2/4 = 1130\ mm^2$

Check of tensile stresses caused cracks (using working loads):

Actual tensile stress of R.C section subjected to pure tensile force=

$$f_t = \frac{T}{A_c + n * A_s}$$

where; $n = E_s/E_c = 10$

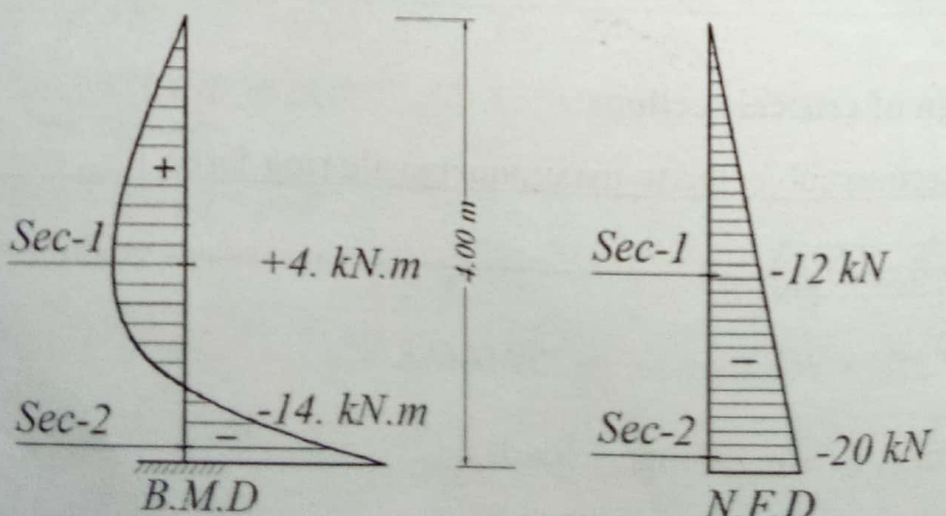
$$f_t = \frac{172 * 1000}{1000 * 200 + 10 * 1130} = 0.81\ N/mm^2$$

$$f_{cto} = 0.6\sqrt{f_{cu}}/1.4 = 0.6\sqrt{25}/1.4 = 2.14\ N/mm^2$$

$f_t < f_{cto}$, section is perfectly safe.

b) For section subjected to B.M & -N at vertical direction

Sec1; M= *4.00 kN & N = -12 (Air section - A_c = 1000*200 mm²)*



$M_u = M*1.4 = 4*1.4 = 5.6\ kN.m$

$N_u = N*1.4 = 12*1.4 = 17$ kN.m

$e = M/T = 5.6/17 = 0.33m$

$e/t = 0.33/0.20 = 0.33 > 0.5$ -------(Axis is outside section, use. M_{ues}.)

$e_s = e + t/2 - c = 0.33 + 0.2/2 - 0.05 = 0.38\ m$

$M_{ues} = N_u * e_s = 17*0.38 = 6.6$kN.m

$$200 = c_1\sqrt{\frac{6.6*10^6}{25*1000}} \qquad C1 = 12.3 \quad J = 0.826$$

$$A_s = \frac{M_{ues}*10^6}{\beta_{cr}*f_y*J*d} - \frac{N_u*10^3}{\beta_{cr}*f_y/\gamma_s}$$

$$A_s = \frac{6.6*10^6}{0.93*350*0.826*200} - \frac{17*10^3}{0.93*350/1.15} = 66\ mm^2$$

Use 5 ϕ 12/m` for outside of wall and **VERTICAL DIRECTION**

Sec2; M = *14.00 kN & N = -20* (Water section - $A_c = 1000*t_w\ mm^2$)

$t_{mm} \cong \sqrt{M/_{0.3b}} - 20\ mm$ ---------------------------- where $t \geq 200$ mm

$t_{mm} \cong \sqrt{14*10^6/_{0.3*1000}} - 20\ mm == 196$ mm

It should be noted that the thickness of wall at region connected with floor should be equaled to floor thickness

(At sec-2 $t_w = t_f = t_w + 100\ mm$)

So, $t_f = 300\ mm$, ($A_c = 1000*300\ mm^2$)

Check of tensile stresses caused cracks (using working loads):
Actual tensile stress of R.C section subjected to bending moment& axial tensile force= f_{ct}

$$f_{ct} = f_{ct(N)} + f_{ct(M)} = -\frac{N}{A_C} + \frac{6M}{b*t^2}$$

$$f_{ct} = -\frac{20*10^3}{1000*300} + \frac{6*14*10^6}{1000*300^2}$$

$$f_{ct} = -0.067 + 0.94 = 0.866\ N/mm^2$$

$$f_{ct\,(M)}\,for\ pure\ bending \cong 2\ N/mm^2$$

$f_{ct} < f_{ct(M)}$, section is safe.

Evaluating A_s (using ultimate loads):

$M_u = M*1.4 = 14*1.4 = 20$ kN.m

$N_u = N*1.4 = 20*1.4 = 28$ kN.m

$e = M/T = 20/28 = 0.7$ m

$e/t = 0.7/0.3 = 3.56 > 0.5$ -------------------(Axis is outside section, use. M_{ues})

$e_s = e + t/2 - c = 0.7 + 0.3/2 - 0.05 = 0.8$ m

$M_{ues} = N_u * e_s = 28*0.8 = 22.4$ kN.m

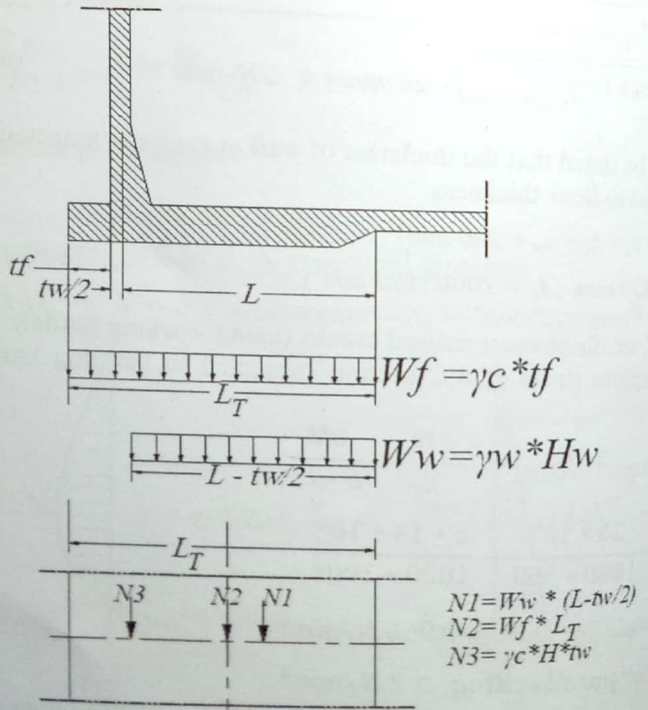
$$250 = c_1\sqrt{\frac{22.4*10^6}{25*1000}} \qquad C1 = 8.4 \quad J = 0.826$$

$$A_s = \frac{M_{ues}*10^6}{\beta_{cr}*f_y*J*d} - \frac{N_u*10^3}{\beta_{cr}*f_y/\gamma_s}$$

$$A_s = \frac{22.4*10^6}{0.93*350*0.826*250} - \frac{28*10^3}{0.93*350/1.15} = 227\ mm^2$$

Use 5 ϕ 12/m` for both sides.

4- Check stresses of foot on soil:-



$W_f = \gamma_c * t_f = 25*0.3 = 7.50\ kN/m^2$

$W_{water} = \gamma_w * H_w = 10*4.0 = 40\ kN/m^2$

$$L(mm) = 2*\sqrt{\frac{M_w\ (N.mm)}{(w_f + w_w)(kN/m)}} = 2*\sqrt{\frac{14*10^6}{7.5+40}} = 1085$$

L = 1100 mm

$L_T = (L + t_w/2 + t_f) = 1.1 + 0.2/2 + 0.3 = 1.50$ m

$N_T = N_1 + N_2 + N_3$

$N_1 = 10*4*(1.1 - 0.2/2) = 40$ kN/m`

$N_2 = 25*0.3*(1.1 + 0.2/2 + 0.3) = 11.25$ kN/m`

$N_3 = 25*0.2*4 = 20$ kN/m`

$N_T = 40 + 11.25 + 20 = 71.25$ kN/m`

$$M_t = M_w - N_1\left[\frac{L_T}{2} - 0.5*\left(L - \frac{t_w}{2}\right)\right] + N_3\left(\frac{L_T}{2} - t_f - t_w/2\right)$$

Where negative value means with clock wise

$$M_t = 14 - 40\left[\frac{1.5}{2} - 0.5*\left(1.1 - \frac{0.2}{2}\right)\right] + 20\left(\frac{1.5}{2} - 0.3 - \frac{0.2}{2}\right) = 11\ kN.m$$

$M_t = 11$ kN.m anticlockwise

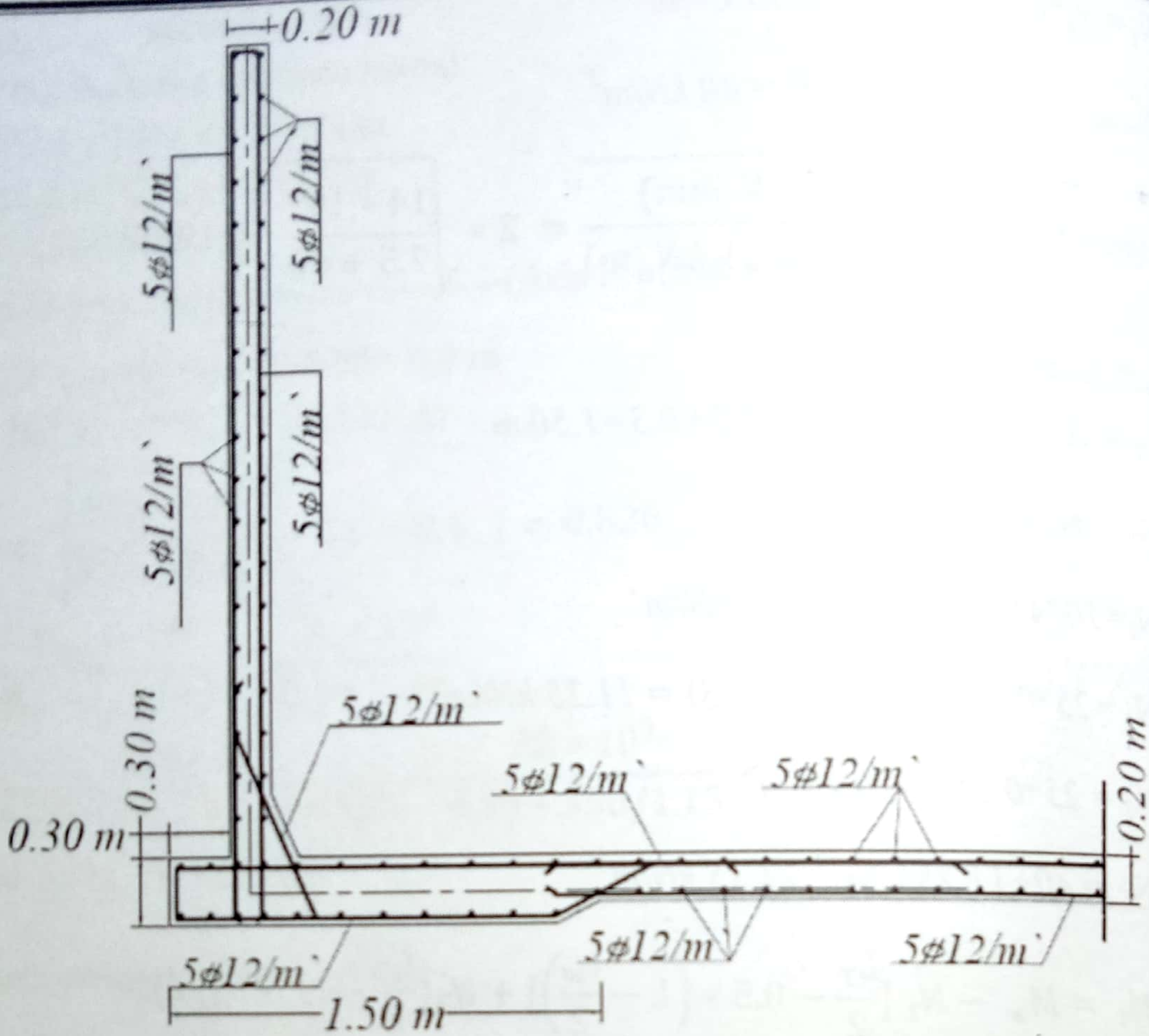
$$f_{min,max} = -\frac{N_T}{A} \pm \frac{M_t}{Z} \qquad b = L_t \ \ \& \ \ t = 1.00m \qquad Z = \frac{L_t^2 * 1}{6}$$

$$f_{min,max} = -\frac{N_T}{1.0*L_t} \pm \frac{6\ M_t}{L_t^2}$$

$$f_{min,max} = -\frac{71.25}{1*1.5} \pm \frac{11*6}{1.5^2} = -77\ kN/m^2 \ \ \& \ -3.5\ kN/m^2$$

f_{min} → shows that there is no tensile stress on the wall-------O.K,

f_{max} → shows that the maximum stress is lower than the soil strength--O.K


0.20 m
5ϕ12/m`
5ϕ12/m`
5ϕ12/m`
5ϕ12/m`
0.30 m
5ϕ12/m`
0.30 m
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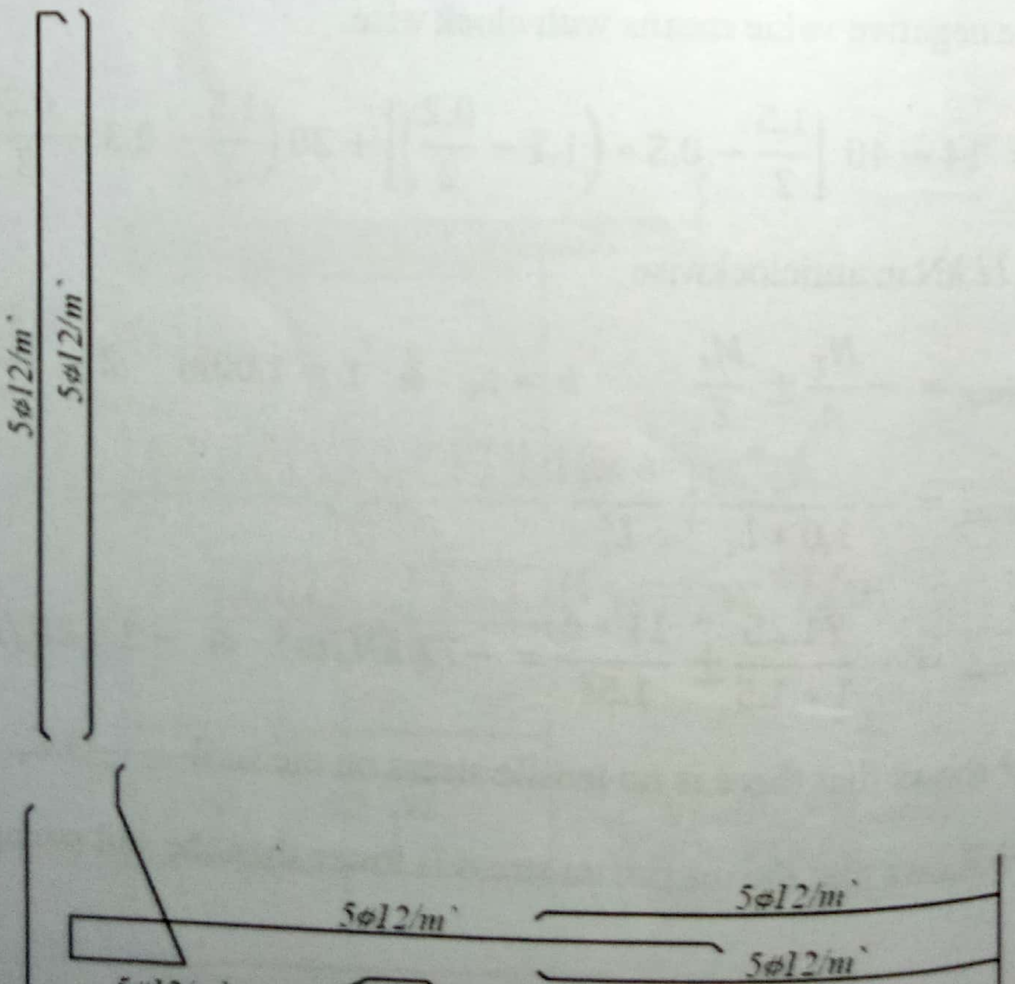
5ϕ12/m`
1.50 m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