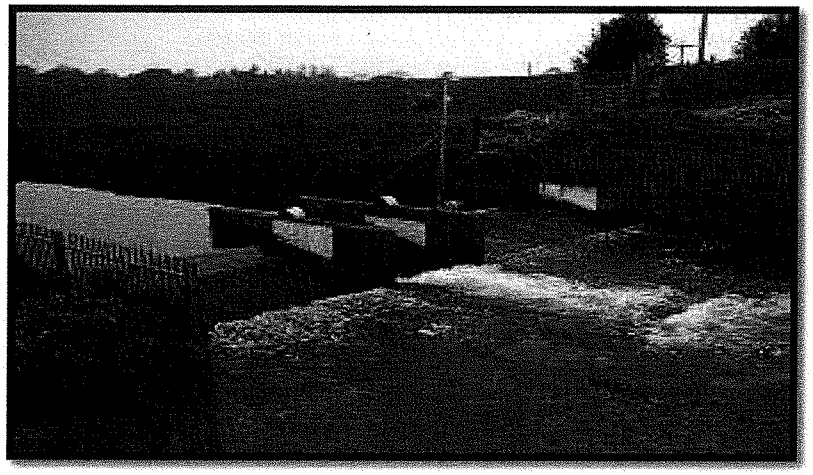
DESIGN OF IRRIGATION STRUCTURE (2)

رابعه مدني



Regulators
(hydraulic design)

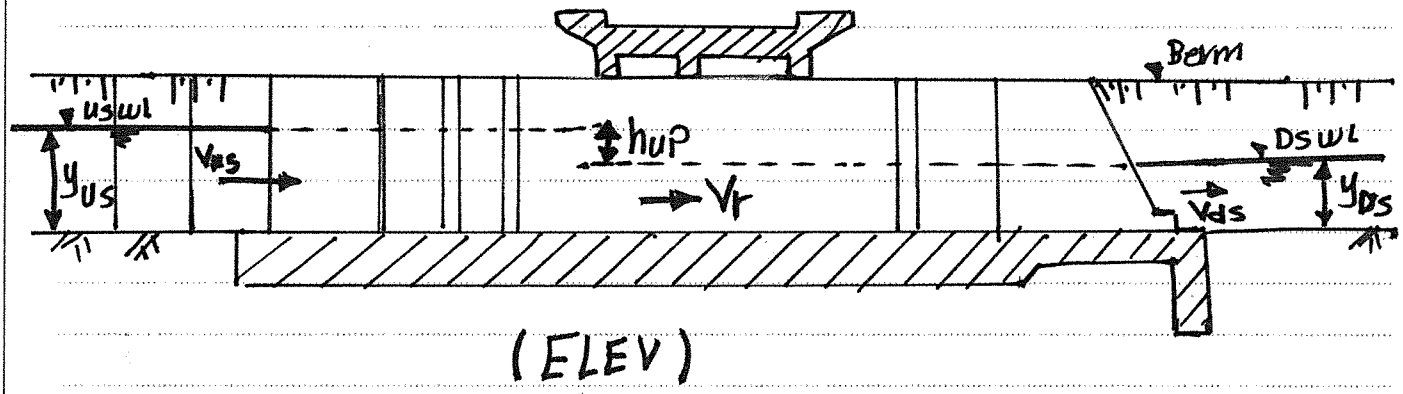
2

Hydraulic Design

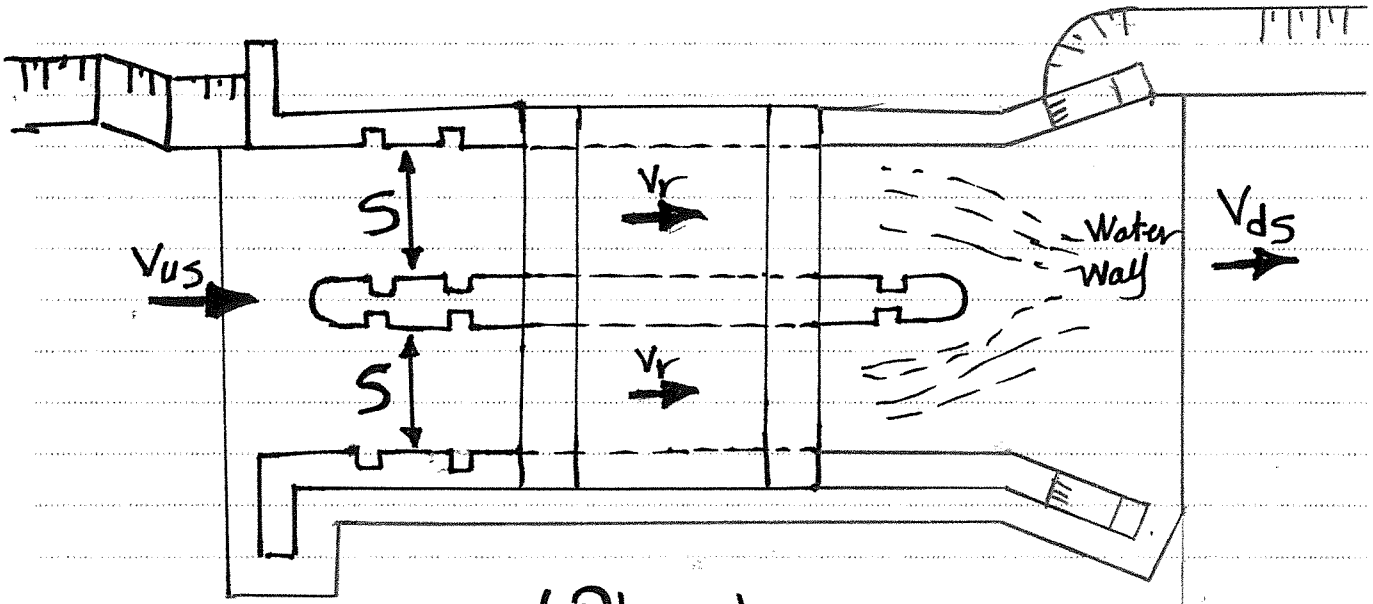
التصميم الهيدروليكى

← الغرض من التصميم الهيدروليكى هو :-

ايجاد عدد الفتحات **(N)** وعرض كل فتحة **(S)**



(ELEV)



(Plan)

∴ y_{DS} → DS water DePth

∴ y_{US} → US water DePth

∴ V_{DS} → DS water velocity

∴ V_{US} → US water velocity

∴ V_r → Regulator water velocity

$$\therefore y_{US} = y_{DS} + h_{up}$$ → 0.1 m

التصميم الهيدروليكى

* ايجاد عدد الفتحات (N) وعرض الفتحة (S)

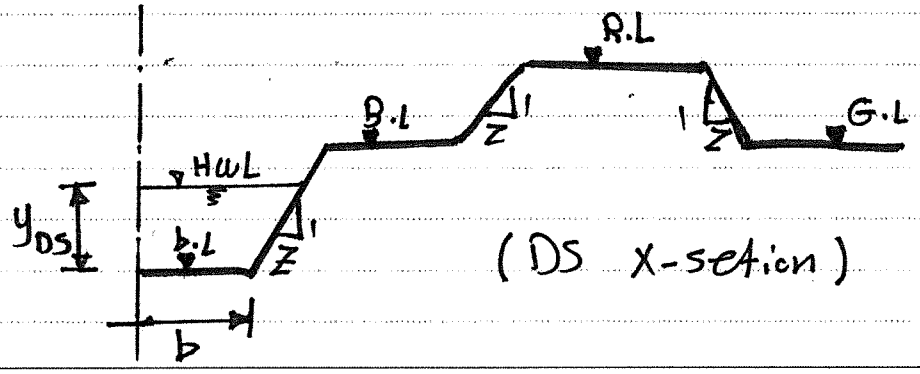
* وعمل (Check) على (heating up) .

Given

1- Q_{Max} اقصى تصرف تصميمى

2- Canal Cross section **DS** the regulator

قطاع الترعة فى الـ DS



(DS X-section)

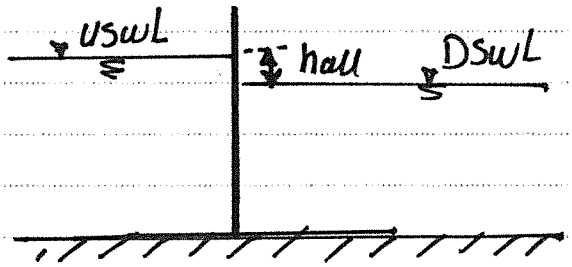
3- Maximum allowable heading up (h_{all})

يوجد ثلاث حالات (h_{all})

A- h_{all} = ~~vv~~ given

B- from Longitudinal section (Synoptic Diagram)
من القطاع الطولى للترعة

$h_{all} = USWL - DSWL$



C- if not given take h_{all} = 10 cm = 0.1 m

Requires

1- Find No. of vents and Span of each vent (S)

2- check the allowable heading up (h_{up})

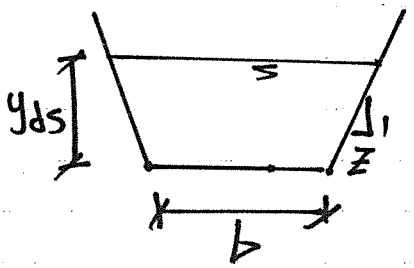
STEPS

طريقة المحاضرة

خطوات التصميم

1- $A_{ds} = (b + y_{ds} Z)\, y_{ds}$ = ?? m^2

2- $V_{ds} = \frac{Q_{Max}}{A_{ds}}$



3- حساب V_r

$$2\,V_{ds} \leq V_r \leq 3\,V_{ds}$$

ولابد ان تكون السرعة V_r ← شرط مهم (Velocity Condition)

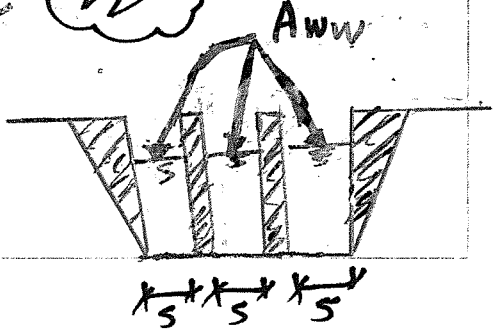
$$1.0 \leq V_r \leq 2.0$$

4- $$A_{ww} = \frac{Q_{Max}}{V_r} = \frac{Q_{Max}}{2\,V_{ds} : 3\,V_{ds}}$$

(??) $\geq A_{ww} \geq$ (??)

5- $$B_{e_1} = \frac{A_{ww}}{y_{ds}} = ?? = N * S$$

$\therefore$ (??) $\geq B_{e_1} \geq$ (??)



where

Be → effective width

* Contraction Condition

لابد ان تكون A_{ww} اكبر من $(0.5\,A_{ds})$

$$\alpha = \frac{A_{ds} - A_{ww}}{A_{ds}} \leqslant 0.5$$

OR

$$\frac{A_{ww}}{A_{ds}} \geqslant 0.5$$

$$\therefore \frac{B_e * y_{ds}}{A_{ds}} \geqslant 0.5$$

$$\therefore B_{e_1} \geqslant 0.5 \frac{A_{ds}}{y_{ds}}$$

* لابد من اختيار B_e تحقق $(B_{e_2}\ (B_{e_1})$

ونجد ايجاد (B_e) يتم ايجاد عدد الفتحات N وعرض الفتحة S

$$\therefore \boxed{B_e = N * S}$$

* يتم فرض قيم لـ (S) من $(\frac{1}{m} \rightarrow \frac{8}{m})$ عدا $\frac{7}{m}$ ثم حساب N

المناظرة لكل S ونقرب N للاكبر مع تقليل عدد الفتحات قدر الامكان

$N = \square \quad S = \square$

* بعد ايجاد (N ، S) :-

يتم عمل Check على السرعة Vr

$$1.0 \leq Vr \leq 2.0 \quad m/sec$$

$$Vr_{act} = \frac{Q_{Max}}{N * S * y_{ds}} = \sim (1 \rightarrow 2) \, m/sec$$

* Check of heading UP :- (For open gates)

$$h_{up} = \frac{V_{us}^2}{2g\,C^2}\left(\left(\frac{A_{us}}{A_{ww}}\right)^2 - 1\right) * h_{all}$$

Where

C → معامل يعتمد على عرض الفتحة (S)

$C = 0.72 \rightarrow S < 2$

$C = 0.82 \rightarrow 2 \leq S \leq 4$ ← خذ

$C = 0.92 \rightarrow S > 4$

→ $A_{ww} = S * N * y_{ds}$ = ـــ m^2

→ $A_{us} = (b + y_{us} z)\, y_{us}$ = ـــ m^2

$\therefore y_{us} = y_{DS} + 0.1$

→ $V_{us} = \frac{Q_{max}}{A_{us}}$ = ـــ m/s-a

* if $h_{up} \leq h_{all}$ ok

$h_{up} > h_{all}$ Not ok

يتم زيادة عرض الفتحة (S) او زيادة عدد الفتحات (N) وتعيد الحل

* يوجد طريقة اخرى لحساب (heading up) طريقة (empirical)

* Empirical Formula

$$h_{up} = \alpha * \beta \frac{V_{DS}^2}{2g} + h_{all}$$

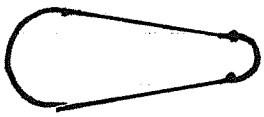
where

$$\alpha = \frac{A_{ds} - A_{ww}}{A_{ds}}$$

$$V_{ds} = (b + y_{ds} z)\, y_{ds}$$

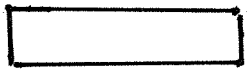
β → معامل يتوقف على شكل الـ Pier

$\beta = 0.46$

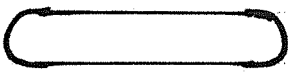


$\beta = 0.8$

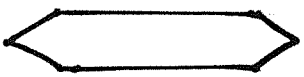
$\beta = 2.1$ ←



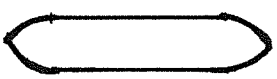
$\beta = 1.3$ ←



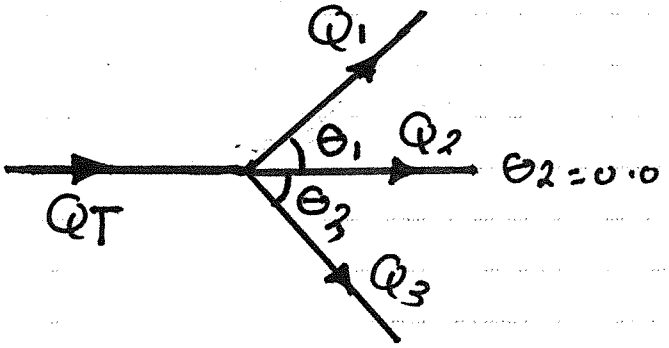
$\beta = 1.1$ ←



$\beta = 1$ ←



Group of Regulators



$$QT = Q_1 + Q_2 + Q_3$$

* في حالة توزيع المياة على اكثر من فرع يتم عمل قنطرة في بداية كل فرع للتحكم في التصرف الداخل لكل فرع
* يتم عمل التصحيح الهيدروليكي لكل فرع لايجاد (S,N) للقنطرة الموجودة عليه بتصرف هذا الفرع وقطاع الترعة لهذا الفرع.
* للتحقق من شرط ادheading UP

$$h_{UP} = \frac{V_{US}^2}{2g C^2}\left[\left(\mu \frac{A_{US}}{A_{WW}}\right)^2 - \cos^2\theta\right]$$

* $\xi_1 = \frac{Q_1}{QT}$
* $\xi_3 = \frac{Q_3}{QT}$
* $\xi_2 = \frac{Q_2}{QT}$

Where

θ ← هى زاوية ميل الفرع على المجرى الرئيسى

أى فرع (1) ← θ_1

فرع (2) ← $\theta = 0.0$

فرع (3) ← θ_2

* ← يتم حساب (V_{US} ، A_{US}) للمجرى الرئيسى (Q_T)

example

Exercise No. (1)

1. Figure (1) shows a main canal cross section in which a reinforced concrete regulator will be constructed. The maximum discharge passing through the regulator is 50 m^3/sec and the maximum allowable heading up is 10 cm. It is required give a complete hydraulic design of the regulator (5 points).

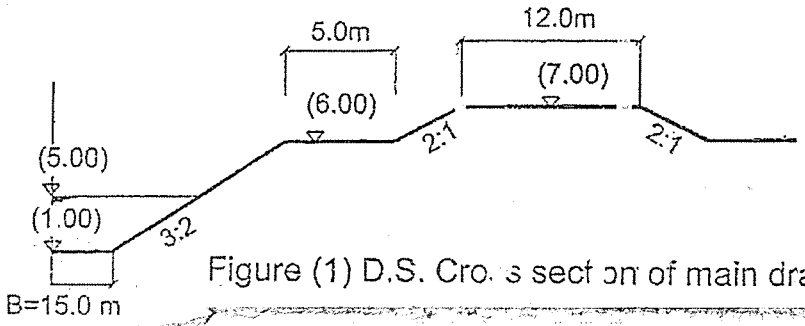


Figure (1) D.S. Cross section of main drain

Given

$Q_{Max} = 50\ m^3/sec$

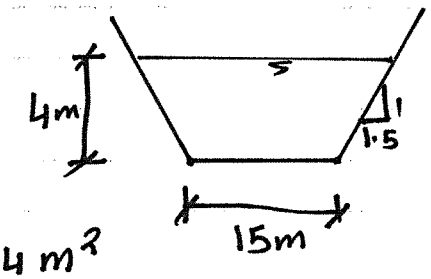
$h_{all} = 10\ cm$

Req.

* give a complete hydraulic Design of the regulator ? (N, S)

الحل

1) $A_{ds} = (b + y_{ds} Z)\, y_{ds}$



$A_{ds} = (15 + 4 * 1.5) * 4 = 84\ m^2$

2) $V_{ds} = \frac{Q_{Max}}{A_{ds}} = \frac{50}{84} = 0.595 \text{ m/sec}$

3) V_r

$$2 V_{ds} \leq V_r \leq 3 V_{ds}$$

$$2 * 0.6 \leq V_r \leq 3 * 0.6$$

$$1.2 \leq V_r \leq 1.8$$

$$1 \leq V_r \leq 2 \quad \text{ok}$$

4) A_{ww}

$$A_{ww} = \frac{Q_{Max}}{V_r} = \frac{50}{1.2 - 1.8}$$

$$41.67 \geq A_{ww} \geq 27.7$$

5) B_{e_1}

$$B_{e_1} = \frac{A_{ww}}{y_{d.s}}$$

$$\frac{41.67}{4} \geq B_{e_1} \geq \frac{27.7}{4}$$

$$10.41 \text{m} \geq B_{e_1} \geq 6.94 \text{ m}$$

Contraction Condition

$$Be_2 \geq 0.5 \frac{Ads}{yds}$$

$$Be_2 \geq 0.5 * \frac{84}{4} = 10.5\ m$$

يتم اختيار Be تحقق $(Be_2 \ , \ Be_1)$

$$\therefore Be = 10.5\ m$$

$$10.5 = N * S$$

S (عرض الشريط) assume

$$\rightarrow S = 4\ m \quad \therefore N = 3$$

$$S = 5\ m \quad \therefore N = 2.1 \simeq 2$$

take $S = 5m$, $N = 2\ m$

حساب السرعة.

$$V_{raet} = \frac{Q}{N*S*yds} = \frac{50}{2*5*4} = 1.25\ (1:2)\ m/sec$$

ok

$$\therefore N = 2 \ \& \ S = 5\ m$$

Check of heading up

$$h_{up} = \frac{V_{us}^2}{2g * C^2}\left(\left(\frac{A_{us}}{A_{ww}}\right)^2 - 1\right)$$

$\therefore y_{us} = y_{ds} + 0.1 = 4 + 0.1 = 4.1\ m$

$\therefore A_{us} = (b + y_{us} Z)\, y_{us} = (15 + 1.5 * 4.1)\, 4.1 = 86.7 m^2$

$\therefore V_{us} = \frac{Q_{max}}{A_{us}} = \frac{50}{86.7} = 0.58\ m/sec$

$\therefore$ at $S = 5m \Rightarrow C = 0.92$

$A_{ww} = N * S * y_{ds} = 5 * 2 * 4 = 40\ m^2$

$$h_{up} = \frac{(0.58)^2}{2 * 9.81 * 0.92^2}\left[\left(\frac{86.7}{40}\right)^2 - 1\right] = 0.074\ m$$

$\therefore h_{up} = 7.4\ cm < 10\ cm$ **ok**

Alexandria University
Faculty of Engineering
Irrigation Eng. and Hydraulics Dept.

Sheet (1)
Hydraulic Design of Regulators

1. Figure (1) shows a main canal D.S cross section in which a reinforced concrete regulator will be constructed. The regulator consists of 4 vents each 3.0 m width. The maximum discharge through the regulator is Q = 50 m^3/sec and the maximum allowable heading up is 10 cm.. The following data are also considered in the design: (i) The bridge width = 10.0 m and 2 sidewalks of 1.25 m each, (ii) The pier width = 1.0 m, (iii) Box and sloping wing walls are used for upstream and downstream sides, respectively, and (iv) CB = 14.

   It is required to:
   a) Check the heading up.
   b) Give the required floor length and thickness for percolation and scouring.
   c) Draw using a suitable scale each of the following items:
      i. Plan (H.E.R.)
      ii. Longitudinal section through a vent centerline, and
      iii. Section Side View through the bridge centerline.

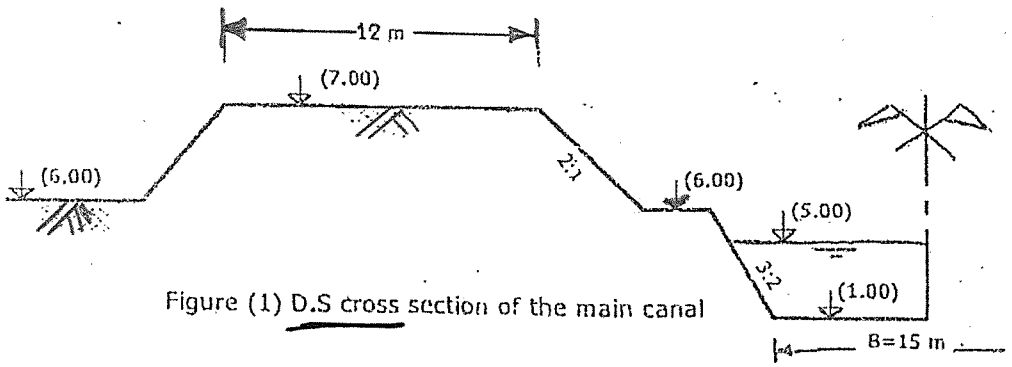


Figure (1) D.S cross section of the main canal

Given

معطى

$S = 3\ m$

$N = 4$

$Q_{Max} = 50\ m^3/sec$

الحل

a/ *check of heading up :-

$$h_{up} = \frac{V_{us}^2}{2g\,C^2}\left(\left(\frac{A_{us}}{A_{ww}}\right)^2 - 1\right)$$

$$y_{us} = y_{ds} + 0.1 = 4 + 0.1 = 4.1\ m$$

$$A_{us} = (b + y_{us}\,z)\,y_{us} = (15 + 4.1 * 1.5)\,4.1 = 86.7\ m^2$$

$$V_{us} = \frac{Q_{Max}}{A_{us}} = \frac{50}{86.7} = 0.57\ m/sec$$

$$A_{ww} = N * S * y_{ds} = 4 * 3 * 4 = 48\ m^2$$

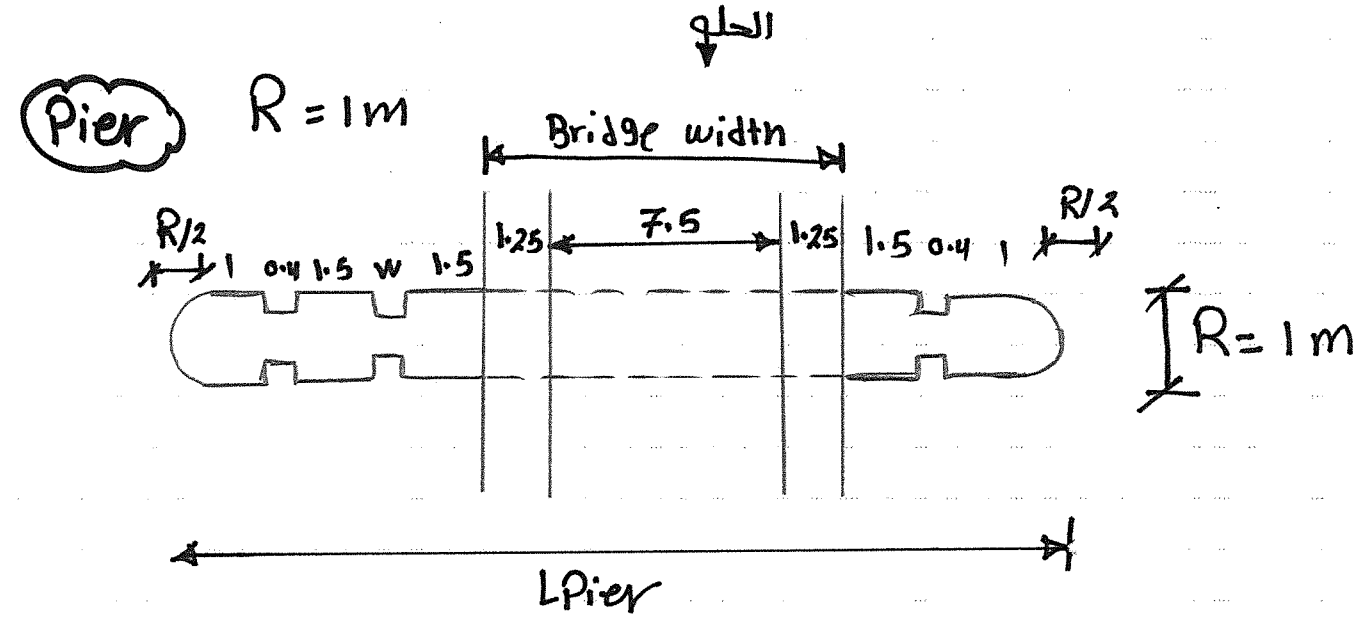
at $S = 3m \rightarrow C = 0.82$

$$h_{up} = \frac{(0.57)^2}{2 * 9.81 * (0.82)^2} * \left(\left(\frac{86.7}{48}\right)^2 - 1\right) = 0.05m$$

$\therefore h_{up} = 5\ cm \not> 0.1$

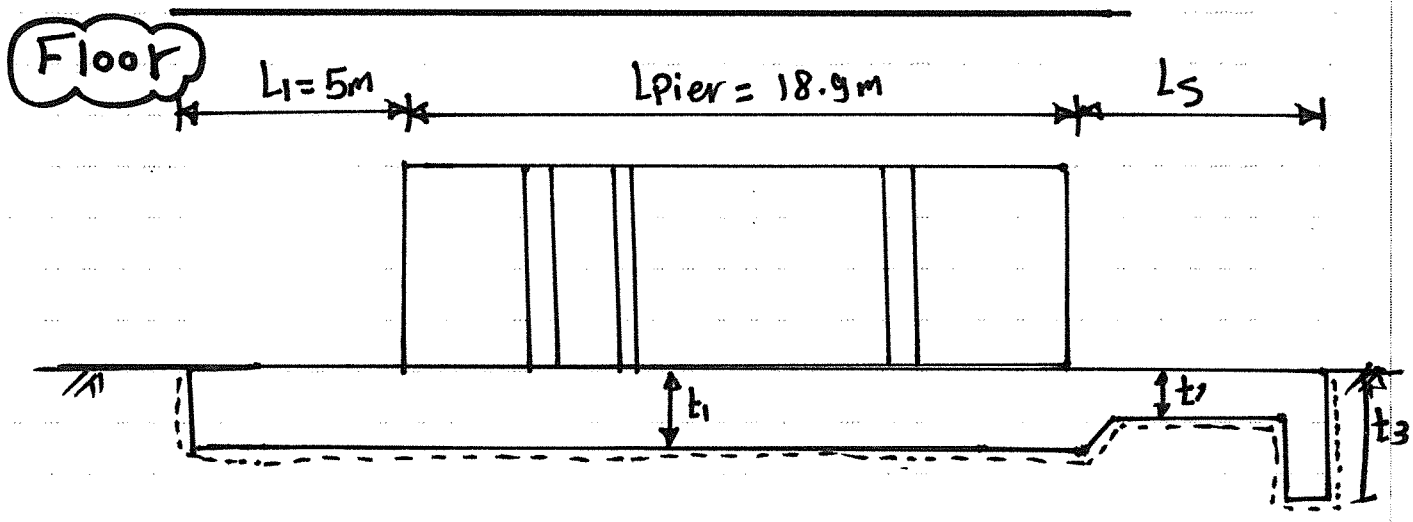
ok

b) Given the required floor Length and thickness For Percoulation and scouring ?



at $S = 3\,m$ $\therefore W = 0.6\,m$

$$L_{Pier} = 10 + 2*1.5 + 0.6 + 0.4 + 1 + 1.5 + 0.4 + 1 + 2*R/2 = 18.9\,m$$



$\therefore$ Σ USWL = Σ DSWL + h_{up} = 5 + 0.05 = 5.05 m

$H_{Max} = \Sigma USWL - \Sigma bed = 5.05 - 1 = 4.05$ m

$$L_S = 2.1\ C_B \sqrt{\frac{H_{Max}}{3.9}} = 2.1 * 14 * \sqrt{\frac{4.05}{3.9}} = 29.9$$

$\therefore$ $L_S = 30$ m

$t_1 = \sqrt{H_{Max}} = \sqrt{4.05} = 2.01 \simeq 2$ m

$t_2 = 0.7\ t_1 = 0.7 * 2 = 1.4$ m

$t_3 = 1.5\ t_1 = 1.5 * 2 = 3$ m

Check of Percolation

$LP_{req} = C_B\ H_{Max} = 14 * 4.05 = 56.7$ m

$LP_{act} = \Sigma L_V + \Sigma L_H$

$= 2 + 5 + 18.9 + 30 + (2 - 1.4)$

$+ (3 - 1.4) + 3 = 61.1$ m

$\therefore$ $LP_{act} > LP_{req}$ **ok**

Wing Wall

Given US → Box

DS → sloPing

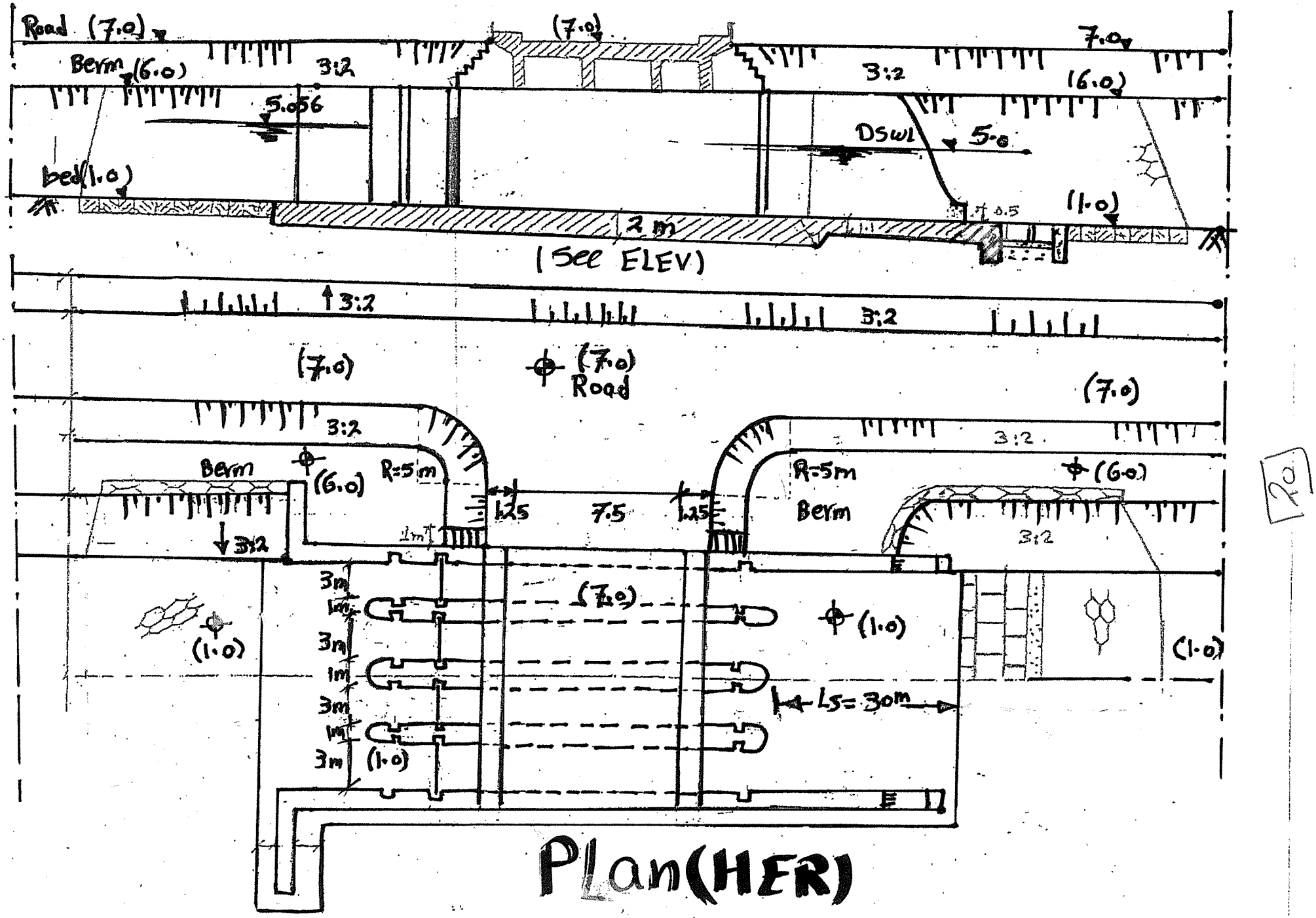
عرض الترعة $b = 15\ m$

عرض المنشأ $= N*S + (N-1)R$

$= 4*3 + (4-1)*1 = 15\ m$

∴ عرض الترعة = عرض المنشأ

لا يوجد توسيع او تضييق.


Road (7.0)
(7.0)
7.0
Berm (6.0)
3:2
3:2
(6.0)
5.056
DSWL
5.0
bed (1.0)
2 m
(1.0)
0.5
(See ELEV)
3:2
3:2
(7.0)
(7.0)
Road
(7.0)
3:2
3:2
Berm
(6.0)
R=5m
1.25
7.5
1.25
R=5m
Berm
(6.0)
3:2
3:2
1m
3m
1m
3m
1m
3m
(7.0)
(1.0)
(1.0)
(1.0)
Ls= 30m
(1.0)

Plan (HER)

Sheet No.(2)

Regulator-2

A reinforced concrete control regulator is to be constructed across a main canal at km.1.000. The longitudinal section of the canal is shown in the given figure. The available data for the regulator are:

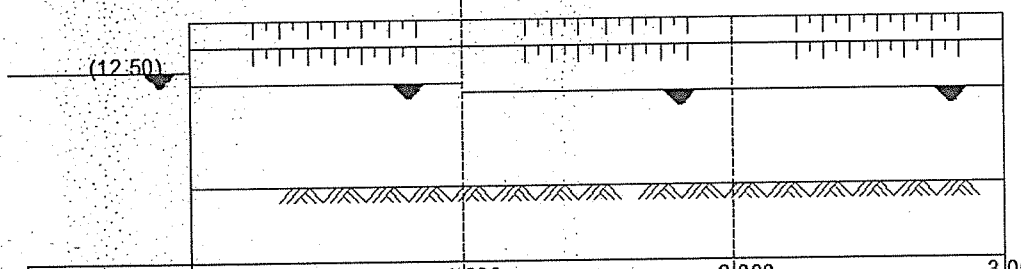
- The bridge width over the regulator is 12.0m and it has two sidewalks of 1.5 m width for each,
- U.S broken and D.S sloping wing walls are used,
- The width of each pier is 1.0 m, and
- The maximum allowable heading up for the case of fully open gates is 10 cm .

Assuming any missing data , It is required to:

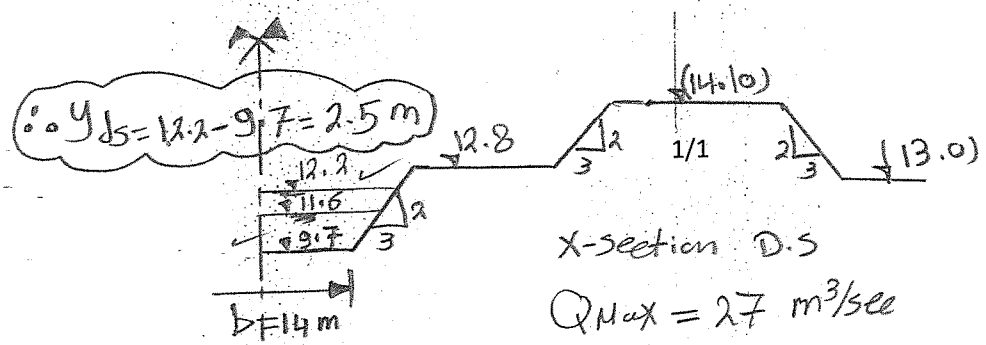
1. Give the ***complete hydraulic*** design of the regulator,
2. Find the required ***floor dimensions*** according to percolation and scouring (C_B=15),
3. Give the ***complete structural design*** of the required ***steel gate*** as a vertical sliding type, and find the required ***lifting force*** for each one,
4. Redesign the ***steel gate as a radial type***, considering the suitable frame work.
5. **Draw** neat sketches for the following views:

i- Plan (H.E.R) ii- Longitudinal section through the regulator.

مكان المنظرة
Regulator Site



Distance, Km	0.000	1.000	2.000	3.000
Ground Level	(13.00)	(13.00)	(13.00)	(9.80)
Road Level	(14.20)	(14.10)	(14.00)	
Berm Level	(12.90)	(12.80)	(12.70)	
High Water Level	(12.40)	(12.30) (12.20)	(12.10)	
Low Water Level	(11.80)	(11.70) (11.60)	(11.50)	
Diischarge,m3/sec	Qmax= 27.0 & Qmin=18.0 m3/sec			
Long. Slope	10cm/km			
Bed Level	(9.80)	(9.70)	(9.60)	(9.50)
Bed Width	14.00m			
Side Slopes	3 : 2			



X-section D.S

$Q_{Max} = 27\ m^3/sec$

* يتم عمل التصميم كامل على مناسيب HWL مع Q_{Max}
* بعد ذلك يتم check على السرعات Vr مع Q_{min} و مناسيب LWL