10

ثالثة مدني

تصميم منشآت الري

Final Revision

* قسم / ري وهيدروليكا * الفرقة / الثالثة امتحان آخر العام 2014
المادة / تصميم اعمال الري

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
IRRIGATION & HYDRAULICS DEPARTMENT
3rd Year, Civil Section

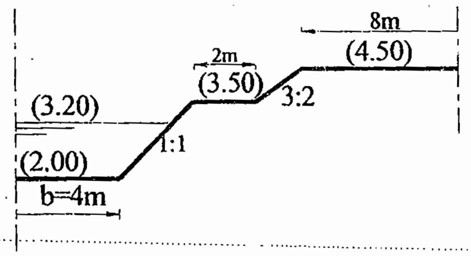
2nd Semester, 2013-2014 — ***Time : 3.00 Hrs***

Design of Irrigation Works [1] - CEI 311

The Exam Consists of **THREE** Questions in Three Pages. Max: **55** Marks
Answer **ALL** Questions.
Any missing data can be reasonably assumed.

Question (1) [27 marks]

An R.C. bridge is constructed to join the banks of the given canal ($Q=3.4m^3/sec$), bridge width = 8m + 2 sidewalks 1m each.



TWO SOLUTIONS ARE PROPOSED:

SOLUTION [1]: The *allowable heading-up is 5cm*, the bridge is *one vent*, t_{slab}=15cm, t_{girder}=40cm, haunch in girder = 18cm, B_1=30cm, t_V = t_H for abutment = 25 cm, width of R.C. base of abutment = 3 m.

SOLUTION [2]: *No H.U. is allowed*

For solution [1] it is required:

1.1 Calculate the vent span and check heading-up. [3 marks]

1.2 Calculate using the following equations: [8 marks]

- The total scour,
- The riprap size, thickness and width,
- The piles unsupported length.

Critical velocity: $V_c = 6.19\, Y^{1/6} D^{1/3}$ $D_{50} = 0.5$ mm

Contraction scour:

For live bed contraction scour:

$$Y_2 = Y_1 \left[\frac{W_1}{W_2}\right]^{0.64}$$

For clear water contraction scour:

$$Y_2 = \left[\frac{0.025\, Q^2}{D_m^{2/3} W^2}\right]^{3/7}$$

Local scour at abutments:

$$Y_s = 2.15\, Y_1 \left[\frac{a}{Y_1}\right]^{0.4} F_{r1}^{\;0.33}$$

Sizing riprap

$D_{50} = 0.062\, V^2$ Angle of repose (Φ) = 45°

1.3 **Draw** *a cross-section showing the bridge vent*, **show** *the riprap position and the piles* (scale 1:100) [4 marks]

For solution [2] it is required:

2.1 **Calculate** S, l, t_{slab}, t_{girder}, $h_{wing\ wall}$.

Select wing walls type and **calculate** t_v for wing wall [5 marks]

2.2 **Draw** *½ sectional elevation & ¼ plan with earth* for the ***upstream*** side of the bridge (scale 1:100). [8 marks]

Question (2) [21 marks]

a) **Show** using sketches how the inlet & outlet can control flow through culverts. [3 marks]

b) A road 8 m width, (7.00) m level and 2:1 side slopes crosses a drain of 5.0 m wide, bed level (3.40) m, water level (5.00) m, berm level (6.50) m, inner side slopes 3:2, bank level (7.50) m and outer side slopes 2:1. The discharge of the drain = 4.6 m^3/sec and soil characteristics at site are as follows:

- Specific weight of dry soil (γ_{dry}) = 1.8 t/m^3,
- Specific weight of saturated soil ($\gamma_{sat.}$) = 2.1 t/m^3,
- Angle of internal friction (Φ) = 30°, and
- Maximum bearing capacity of soil = 1.8 kg/cm^2.

Two alternatives are proposed for the above intersection:

a) R.C. Box Culvert
b) Steel Pipe Culvert

It is required to:

1. **Conduct** hydraulic design for both proposed crossing works considering that the heading up for box culvert should not exceed 5 cm and for pipe culvert should not exceed 13 cm. [4 marks]

Material	a	b (m)
Steel	0.00497	0.0256
R.C.	0.00316	0.0305

Where: a & b coefficients depending on roughness of internal surface

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The Exam Consists of **THREE** Questions in Two Pages. Max: **55** Marks

Answer **ALL** Questions.

Any missing data can be reasonably assumed.

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2. **Give** empirical design for both of box & pipe culverts. [2 marks]
3. **Calculate** all loads intensities that acting on the box culvert only then **check** the soil capacity to carry out these loads. The intensity of uniform live load = 0.6 t/m^2. The culvert is designed to pass rolling load = 60 ton lorry, the following table shows the main dimensions of 60 ton lorry that is considered in the design. [7 marks]

lorry	e (cm)	b (cm)	c (cm)	R (cm)	Wheel load (t)
60t	60	20	140	160	10

Where: e = wheel width, b = contact area, c = spacing between wheels and R = axe spacing.

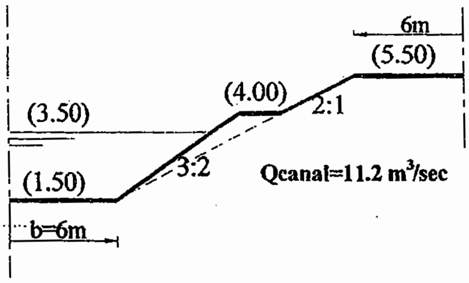
The impact factor (I) according to depth of soil above culvert (d)

d (m)	0 → 0.3	0.3 → 0.6	0.6 → 1	>1
I	0.3	0.2	0.1	0

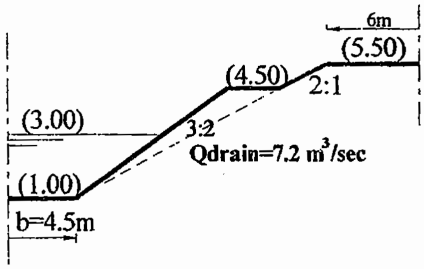
4. **Draw** plan half earth removed for the box culvert. [6 marks]

Question (3) [7 marks]

1. **Propose** a solution for the crossing of the given canal and drain with 60 degree angle, **estimate** the vents dimensions for the proposed solution and **calculate** the heading up due to friction loss only. [4 marks]



2. **Draw** ½ sectional elevation for the U.S. side of the proposed solution (scale 1:100) [4 marks]



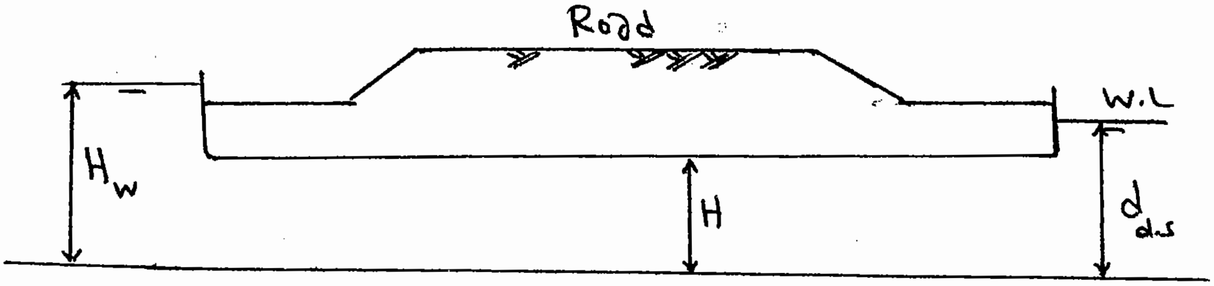
GOOD LUCK

Prof. Dr. Nahla AboulAtta
Dr. Mohamed Seddik
Dr. Ayman Zakaria

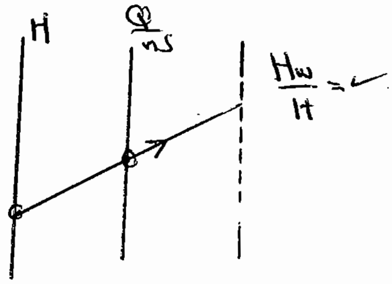
Question (2) :-

a) * Check for type of operation in R.C Box Culvert :-

[1] For outlet Control :-



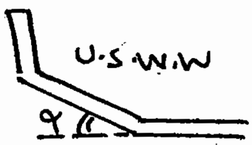
$$H_w = d_{d.s} + H_{up}$$



[2] For inlet Control :-

Using Charts for Head water Depth for Culverts with inlet Control by values of

- $H = ✓$ (mm)
- $\frac{Q}{nS} = ✓$ $m^3/s/m$
- Select scale according to α wing wall angle ≃ 30°

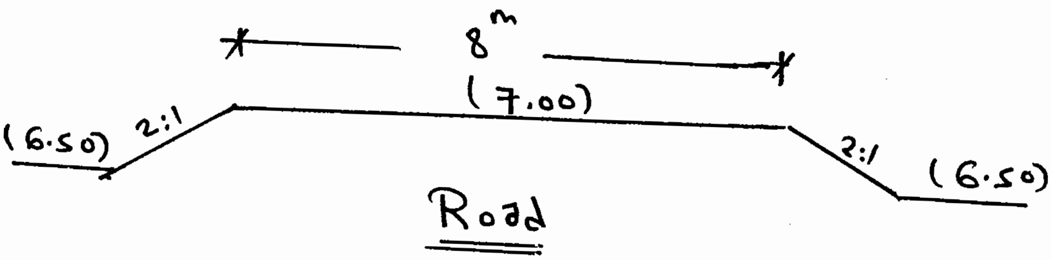


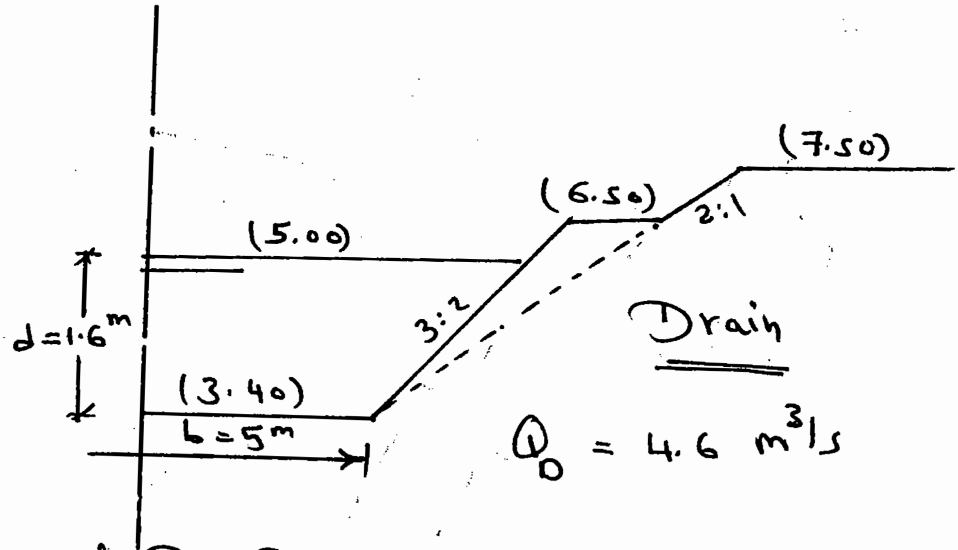
$\Longrightarrow$ get $\frac{Hw}{H} = ✓$ $\Rightarrow$ $H_w = ✓$ m

if $(H_w)_{outlet\ control} > (H_w)_{inlet\ control}$ ⇒ Then Culvert is operating under outlet Control

if $(H_w)_{outlet\ control} < (H_w)_{inlet\ control}$ ⇒ Then Culvert is operating under inlet Control

b)





$Q_o = 4.6 \ m^3/s$

1) Hydraulic Design of R.C Box Culvert :-

$H_{up\ all} = 5 \ cm$

* $A = bd + z_1 d^2 = 5*1.6 + 1.5(1.6)^2 = 11.84 \ m^2$

* $v = \frac{Q}{A} = \frac{4.6}{11.84} = 0.388 \ m/s$

* $V = (2 \rightarrow 3)\, v = (2 \rightarrow 3) * 0.388 = (0.78 \rightarrow 1.164) \ m/s$

take $V = 1.1 \ m/s$

$a = \frac{Q_o}{V} = \frac{4.6}{1.1} = 4.18 \ m^2 = n\,SH$

$H = d - 0.1 = 1.6 - 0.1 = 1.5^m$

$$nS = \frac{4.18}{1.5} = 2.787 \quad , \quad \text{take } n = 2$$

$$S = 1.4^m \Rightarrow \text{take } S = H = 1.5^m, \; n = 2$$

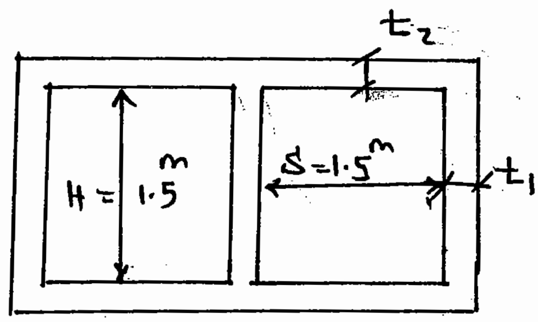
finally $\boxed{n=2}$ & $\boxed{S = 1.5^m}$ & $\boxed{H = 1.5^m}$

$$\Rightarrow V = \frac{Q}{a_{act}} = \frac{4.6}{2*1.5*1.5} = \underline{1.02 \text{ m/s}} \quad \text{o.k}$$

$$t_1 = \frac{H}{5 \to 7} = \frac{1.5}{5 \to 7} = 0.2 \to 0.3$$

$$t_2 = \frac{S}{5 \to 7} = \frac{1.5}{5 \to 7} = 0.2 \to 0.3$$

take $t_1 = t_2 = 0.3^m$



$$b_{st} = nS + (n-1)\,t_1 = 2*1.5 + 1*0.3 = 3.3^m$$

$$b = 5$$

$$\Delta = \frac{b - b_{st}}{2} = \frac{5 - 3.3}{2} = 0.85^m > 0.5^m$$

use splayed box type in U.S.W.W & D.S.W.W

$C_e = 0.25$ $\qquad\qquad$ $C_o = 0.5$

$$H_{up} = (C_e + C_o + C_f)\frac{V^2}{2g} + C_r \frac{v^2}{2g}$$

$$C_f = f * \frac{L}{R} = a\left(1 + \frac{b}{R}\right)\frac{L}{R} \;, \quad R = \frac{SH}{2(S+H)} = \frac{1.5*1.5}{2(1.5+1.5)} = 0.375^m$$

$$L = 2\left[\frac{8}{2} + (7.00 - 6.50) * \frac{2}{1} + 1.5\right] = \underline{\underline{13^m}}$$

$$\therefore \xi_f = 0.00316\left(1 + \frac{0.0305}{0.375}\right) * \frac{13}{0.375} = 0.118$$

<u>Trash rack losses:-</u>

$$C_r = 1.79\left(\frac{t}{b}\right)^{4/3} \sin\alpha = 1.79\left(\frac{1.2}{10}\right)^{4/3} \sin 70^\circ \cong 0.1$$

$$\therefore H_{up} = (0.25 + 0.5 + 0.11) * \frac{(1.02)^2}{2*9.81} + 0.1 * \frac{(0.388)^2}{2*9.81} = 0.0468^m$$

$$\# \ H_{up} = \underline{\underline{4.68 \text{ Cm}}} < 5^{Cm} \ (\text{o.K})$$

* <u>Hydraulic Design of steel pipe Culvert</u> $H_{up_{all}} = 13^{Cm}$

$A = 11.84 \ m^2$ & $v = 0.388$ m/s & $V = 1.1$ m/s

$$a = \frac{Q}{V} = \frac{4.6}{1.1} = 4.18 \ m^2 = n\frac{\pi D^2}{4}$$

$$D_{max} = d - 0.3 = 1.6 - 0.3 = 1.3^m$$

$$n\frac{\pi}{4}(1.3)^2 = 4.18 \Rightarrow n = 3.14$$

take $n = 3$, $V_{act} = \dfrac{4.6}{3\frac{\pi}{4}(1.3)^2} = 1.15$ m/s < 2 m/s o.k

Finally $\boxed{n = 3}$, $\boxed{D = 1.3^m}$

$b_{st} = nD + (n-1)t_1 = 3*1.3 + 2*0.5 = 4.9^m$

$\Delta = \frac{b - b_{st}}{2} = \frac{5 - 4.9}{2} = 0.05^m < 0.5^m$

Use square box wing wall at U.S , D.S

$C_e = 0.45$ & $C_o = 0.9$

Friction losses:-

$$C_f = f * \frac{L}{R} = a\left(1 + \frac{b}{R}\right)\frac{L}{R}$$

$R = \frac{D}{4} = \frac{1.3}{4} = 0.325^m$

$L = 13^m$

$$C_f = 0.00497\left(1 + \frac{0.0256}{0.325}\right) * \frac{13}{0.325} = 0.214$$

$$H_{up} = (0.45 + 0.9 + 0.214) * \frac{(1.15)^2}{2*9.81} + 0.1 * \frac{(0.388)^2}{2*9.81} = 0.106\,m = 10.6\,cm < 1\ldots$$

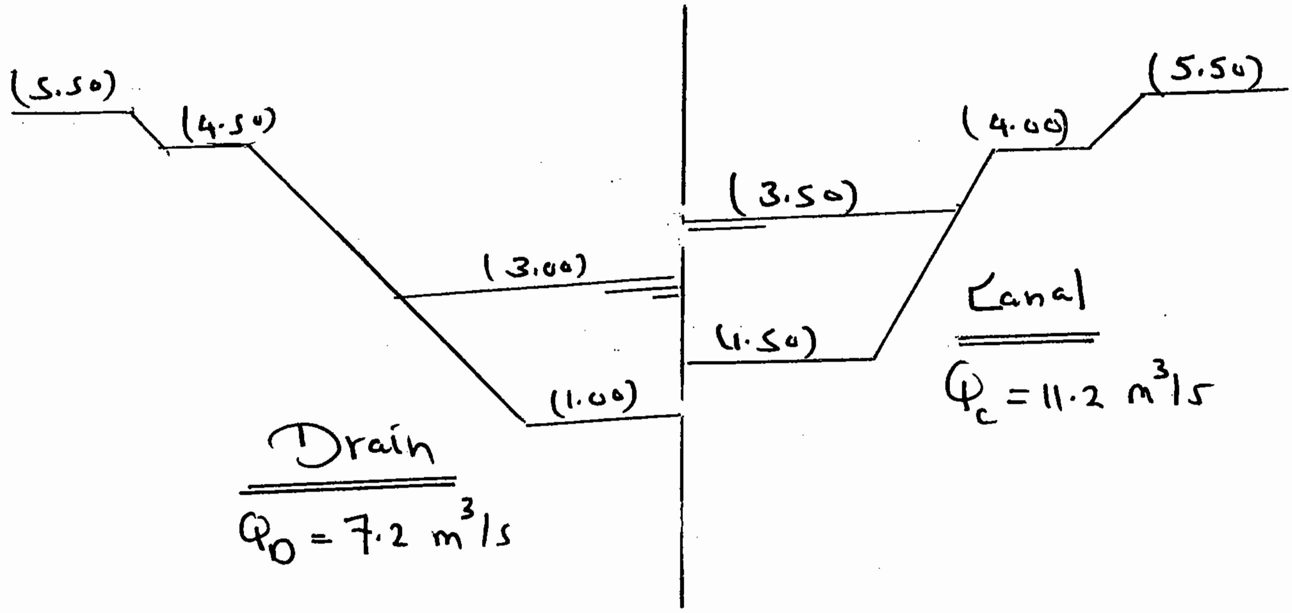
ok

2) Empirical Dimensions :-

$t_1 = 0.3^m$

$t_2 = 0.3$

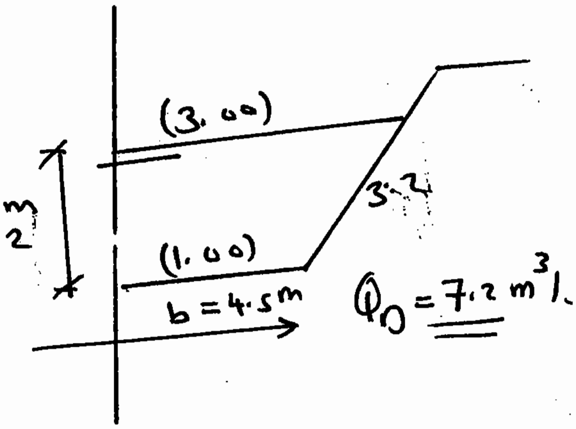
Question (3) :-



$Q_D < Q_c$ & $(W.L)_D < (W.L)_c$

∴ Drain will pass through Syphon below Canal

$A = bd + z_1 d^2$



$* \ A = 4.5 * 2 + 1.5 (2)^2 = 15\ m^2$

$v = \frac{Q}{A} = \frac{7.2}{15} = 0.48\ m/s$

$V = (2 \rightarrow 3)\, v = (0.96 \rightarrow 1.44)\ m/s$

take $V = 1.2\ m/s$

$a = \frac{Q}{V} = \frac{7.2}{1.2} = 6\ m^2 = n S H$

$H = d - 0.1 = 2 - 0.1 = 1.9\ m/s$

$nS = \frac{6}{1.9} = 3.16$, take $n = 1$

$S = 2.8\ m$

$H = 1.9\ m$

$$V_{act} = \frac{Q}{n S H} = \frac{7.2}{1*2.8*1.9} = 1.35 \text{ m/s (Safe)}$$

* **Hup due to Friction only :-**

$$h_F = C_f * \frac{L}{R} = a\left(1+\frac{b}{R}\right)\frac{L}{R}$$

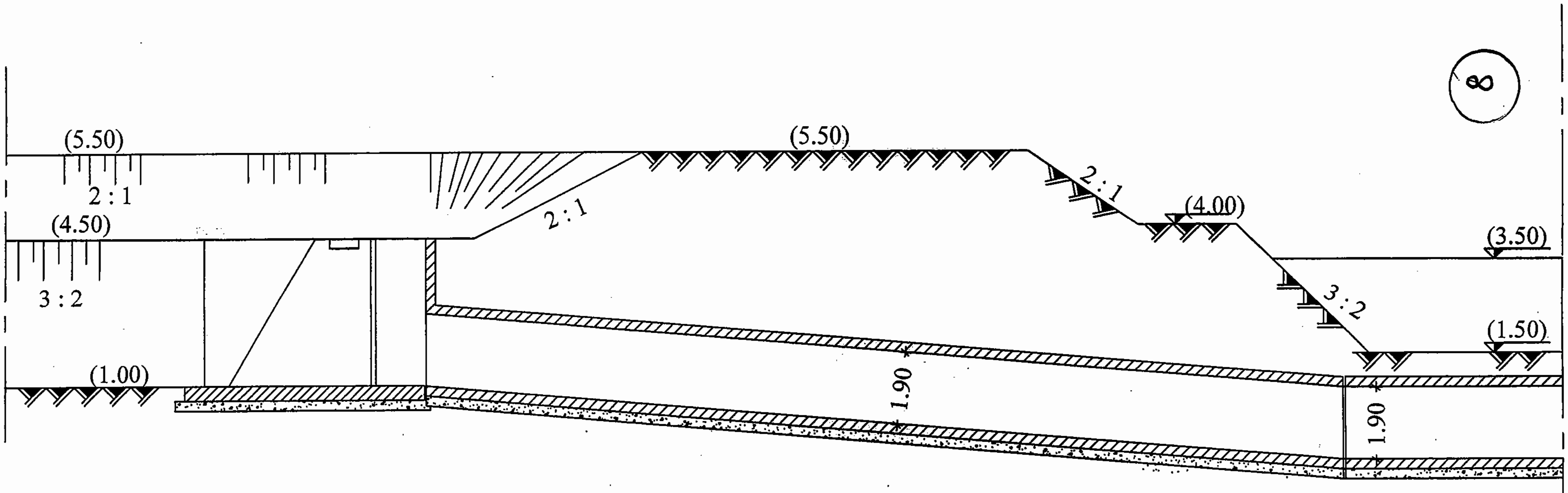
$$R = \frac{SH}{2(S+H)} = \frac{2.8*1.9}{2(2.8+1.9)} = 0.566 \text{ m}$$

$$L = 2\left[\frac{6}{2} + (4.00-1.50)*1.5 + \frac{1}{2}(4-1.5) + (5.5-4)*2 + 6 + (5.5-4.5)*2 + 1.5\right] = 41^{m}$$

$$L_{Req} = \frac{L}{\sin 60^\circ} = \frac{41}{\sin 60^\circ} = 47.34^{m}$$

$$\therefore C_f = 0.00316\left(1+\frac{0.0305}{0.566}\right)*\frac{47.34}{0.566} = 0.278$$

$$Hup_F = C_f \frac{V^2}{2g} = 0.278*\frac{(1.35)^2}{2*9.81} = 0.0258^{m} = 2.58^{cm}$$



Half Sectional Elevation

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
IRRIGATION & HYDRAULICS DEPT

جامعة عين شمس
كلية الهندسة
قسم الري والهيدروليكا

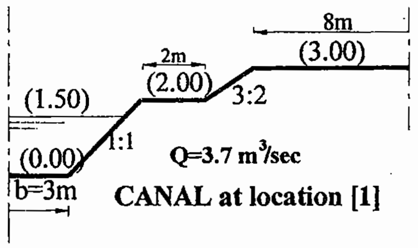
THIRD YEAR CIVIL

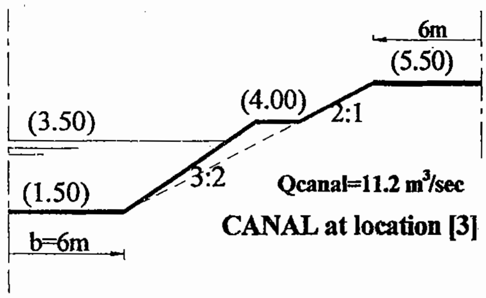
FINAL EXAM. JUNE. 2012 — ***TIME: 3 HOURS***

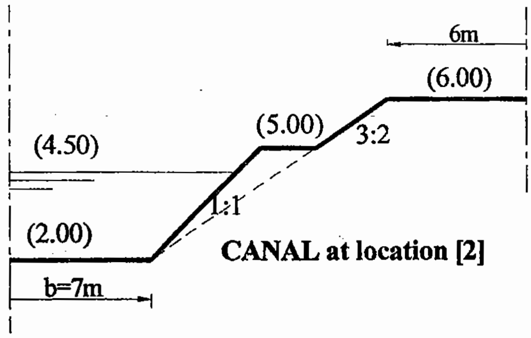
DESIGN OF IRRIGATION WORKS [1]

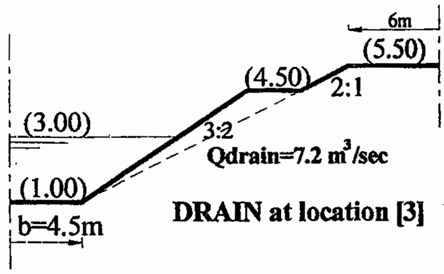
The exam consists of THREE questions in THREE pages
Any missing data can be reasonably assumed

ATTEMPT ALL QUESTIONS (55 MARKS)









QUESTION 1: [36 Marks]

Three solutions are proposed to join the canal banks at location [1]:

A] **An R.C. Bridge: [6 Marks]**
No H.U. is allowed, bridge width = 6 m + 2 sidewalks 1m each.

Select the type of wing walls, **calculate** $t_{wing\ walls}$, then **draw** *¼ plan with earth* for *the upstream side* of the bridge (scale 1:100)

B] **One square vent R.C. Box Culvert: [15 Marks]**
Take $V_{culvert}$ = 1.28 m/sec

1. **Estimate** vents dimensions, then **calculate** the heading-up using the following formula: $H.U. = \frac{V^2_{culvert}}{2g}\left[0.75 + 0.004 * \frac{L}{R}\right]$ (t_1=t_2=30 cm, crossing width=8 m) [3 marks]

2. **Draw** ½ *sectional elevation* for the *upstream side* (scale 1:100). [4 marks]

3. **Calculate** the intensity of loads resulting from: [4 marks]
   - Weight of embankment $\gamma_{dry} = 1.8$ t/m^3
   - Rolling load (60t lorry)
   - Dry earth pressure. $\varphi = 30^o$
   - Internal water pressure

   Take: Own weight of culvert $g_2 = 1.5$ t/m^2
   Wet earth pressure $e_{wet} = 2.24$ t/m^2

4. **Calculate** *the maximum straining actions* at *mid-span of the deck*, **use** the following equations: [4 marks]

For vertical load (w):	*For Horizontal load (e):*	*For water pressure(p)*
$M = w/3$	$M = - e/6$	$M = - p/6$
$N = zero$	$N = - e$	$N = p$

C] **Two vents Steel Pipe Culvert: [15 Marks]**

1. **Estimate** the pipes diameter, **do not use** a drop in the bed, then **calculate** the heading-up using: $H.U. = \frac{V^2_{culvert}}{2g}\left[1.2 + 0.01 * \frac{L}{R}\right]$ (crossing width = 8 m) [2 marks]
2. **Draw** ½ *sectional elevation* for *the downstream side* (scale 1:100). [3 marks]

3. **Calculate** the intensity of loads resulting from: [4 marks]
   - Weight of embankment $\gamma_{dry} = 1.8$ t/m^3 $\varphi = 30^o$
   - Own weight of culvert t=1.5 cm, $\gamma_{steel} = 7.85$ t/m^3
   - Rolling load equivalent to a uniformly distributed load = 3.3 t/m^2
   - Dry earth pressure

4. **Calculate** the *maximum compressive stresses* in the pipe. [3 marks]

5. **Compare** between the construction costs of the *R.C. box culvert* and the *steel pipe culvert* given that: 1 m^3 P.C. = 250 L.E.
   1 m^3 R.C. = 1200 L.E.
   1 ton Steel = 2800 L.E. [3 marks]

QUESTION 2: [18 Marks]

At location [2] where a road 10 m width, (6.50) level crosses the canal, a ***one vent*** R.C. bridge is constructed:

- Discharge = 15 m^3/sec,
- Span of vent = 5 m,
- Bridge width = 8 m + 2 sidewalks 1 m each,
- Spacing between girders l=1.6m,

- Haunch in girder = 18 cm,
- $t_V = t_H$ for abutment = 35 cm,
- Width of R.C. base of abutment = 4.2 m,
- For soil at bridge site: D_{50} = 0.004 mm, angle of repose (Φ) = 30°

It is required to:

1. **Calculate** the *heading up*. [2 marks]
2. **Calculate** using the following equations: [10 marks]
   - The contraction scour,
   - The local scour at abutments,
   - The riprap size, thickness and width,
   - The piles (if any) unsupported length.

Critical velocity: $V_c = 6.19\, Y^{1/6}\, D^{1/3}$

Contraction scour:

For live bed contraction scour:

$$Y_2 = Y_1 \left[\frac{W_1}{W_2}\right]^{0.64}$$

For clear water contraction scour:

$$Y_2 = \left[\frac{0.025\, Q^2}{D_m^{2/3} W^2}\right]^{3/7}$$

Local scour at abutments:

$$Y_s = 2.15\, Y_1 \left[\frac{a}{Y_1}\right]^{0.4} F_{r1}^{\;0.33}$$

Size of riprap Abutments

$$D_{50} = 0.062\, V^2$$

3. **Calculate** t_{slab}, t_{girder}, B_1, then **draw** *a dimensioned cross section of the bridge* (scale 1:100), **show** the riprap location. [6 marks]

QUESTION 3: [6 Marks]

1. **Propose** a solution for the crossing at location [3] and **estimate** the vents dimensions for the proposed solution *without* heading-up calculations. [2 marks]

2. **Draw** ½ *sectional elevation* for the *U.S. side* of the proposed solution (scale 1:100) [4 marks]

GOOD LUCK

DR NAHLA

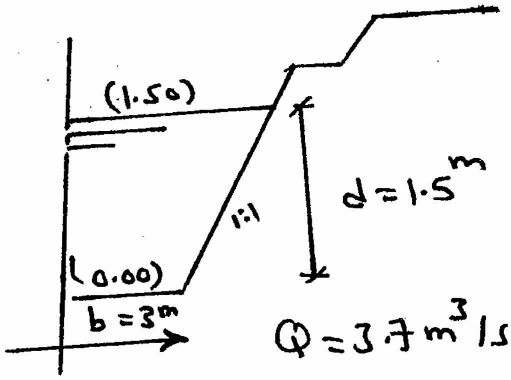
Final Exam June 2012

Question (1):-

B] * one square vent R.C Box Culvert :-

* $V_{culvert} = 1.28$ m/s

* $Q = 3.7\ m^3/s$



Canal at intersection(1)

$\Rightarrow a = \frac{Q}{V} = \frac{3.7}{1.28} = 2.89\ m^2$

$\equiv nSH = nH^2 = 1 * H^2$

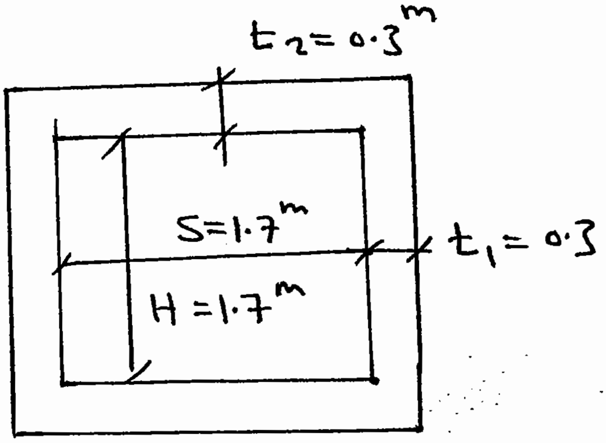
$\therefore H = 1.7$ m

$H_{max} = d - 0.1 = 1.5 - 0.1 = 1.4^m$

$\therefore H > H_{max} \Rightarrow$ use drop in Bed $\equiv 1.7 - 1.4 = 0.3^m$

Finally :- $n = 1$ $S = H = 1.7^m$

drop in Bed $= 0.3^m$

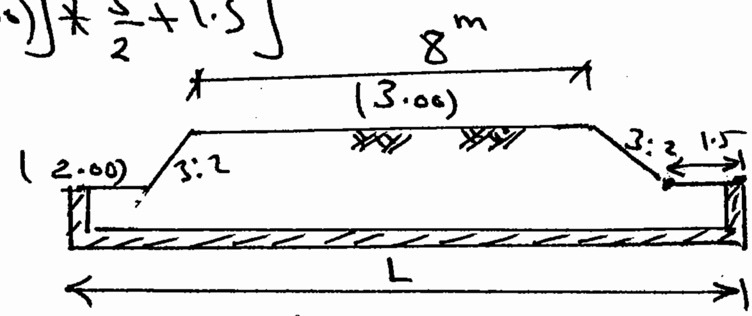


* Heading up :- (2)

$$H_{up} = \frac{V_{culvert}^2}{2g}\left[0.75 + 0.004\frac{L}{R}\right] \leftarrow \text{Given eq}^n$$

$$* \; L = 2\left[\frac{8}{2} + \left[(3.00) - (2.00)\right] * \frac{3}{2} + 1.5\right]$$

$$= 14^m$$



$$* \; R = \frac{SH}{2(S+H)} = \frac{1.7*1.7}{2(1.7+1.7)}$$

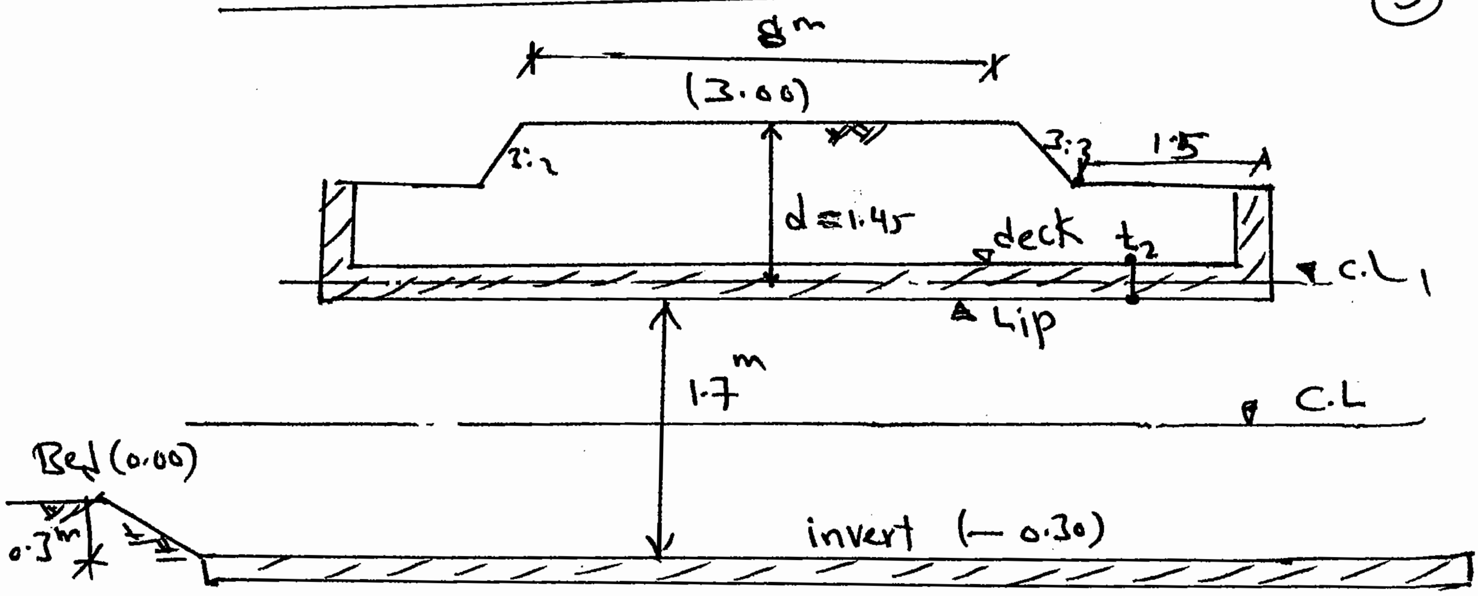
$$= 0.425^m$$

$$\therefore H_{up} = \frac{(1.28)^2}{2*9.81}\left[0.75 + 0.004 * \frac{14}{0.425}\right] = 0.0736^m$$

$$= \underline{\underline{7.36}}^{\,cm}$$

$\therefore$ $H_{up} \Rightarrow 7.36$ cm

③ $g_1 \equiv$ wt of embankment :-

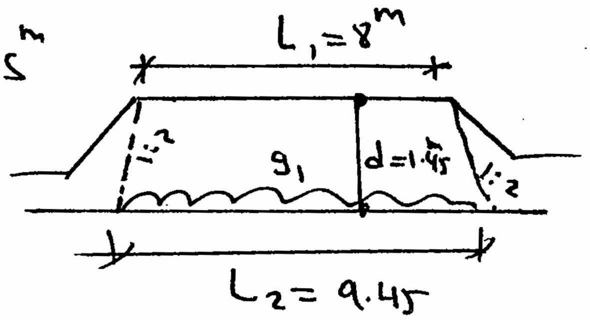


* invert = (0.00) − 0.3 = (−0.30)
* Lip = (1.40) = 1.7 + (−0.30) invert
* deck = (1.40) + 0.3 = (1.70)
* C.L = (1.40) ÷ $\frac{1.7}{2}$ = (0.55)
* C.L1 = (1.70) − $\frac{0.3}{2}$ = (1.55)

$d = (3.00) - (1.55) = 1.45^m$

$L_1 = 8^m$

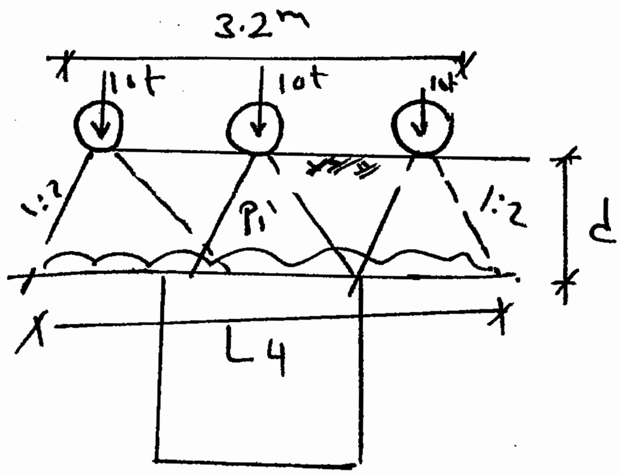
$L_2 = 8 + 1.45 = 9.45^m$



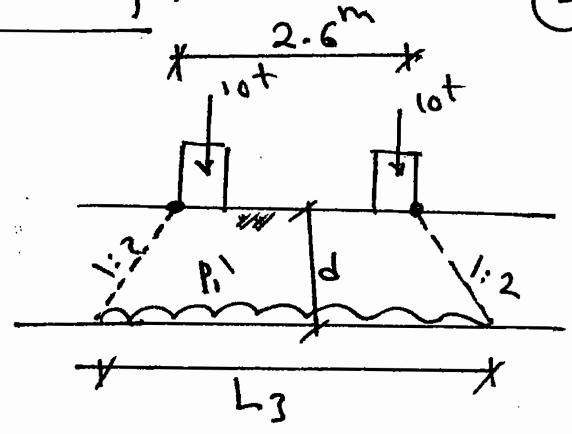
$$g_1 = \frac{\frac{(8+9.45)}{2} * 1.45 * 1.8}{9.45} = 2.4 \ t/m^2$$

$$\boxed{g_1 = 2.4 \ t/m^2}$$

* Rolling loads 60 ton Lorry :- (p_1')



S.V



elevation

$$L_3 = 3.2 + 1.45 = 4.65^m$$

$$L_4 = 2.6 + 1.45 = 4.05^m$$

$$p_1' = \frac{60}{4.65 * 4.05} = 3.18 \ t/m^2 \Rightarrow \boxed{p_1' = 3.18 \ t/m^2}$$

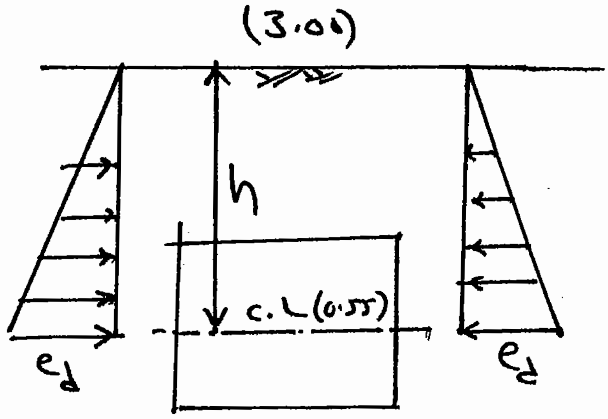
* Dry earth Pressure (e_d)

$$h = (3.00) - (0.55) = 2.45^m$$

$$e_d = K_a \gamma_d h$$

$$= \frac{1}{3} * 1.8 * 2.45$$

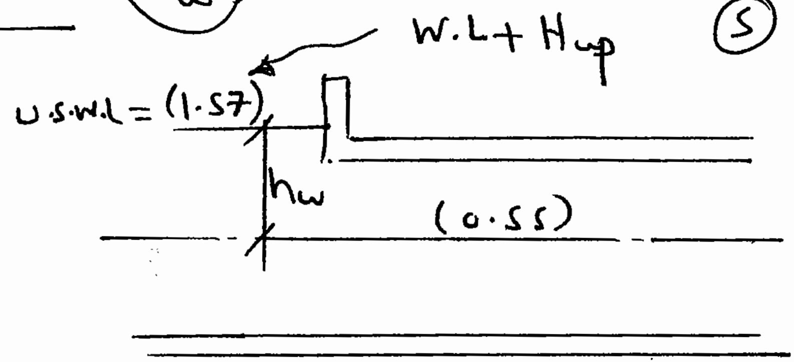
$$= 1.47 \ t/m^2$$



$$\boxed{e_d = 1.47 \ t/m^2}$$

* internal Water Pressure (P_w) :-

(5)



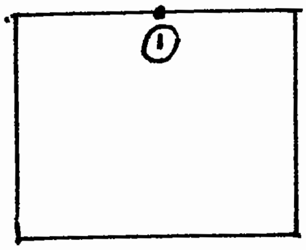
$$P_w = \gamma_w h_w$$

$$h_w = (1.57) - (0.55)$$

$$= 1.02^{m}$$

$$P_w = 1 * 1.02 = 1.02\ t/m^2 \Rightarrow \boxed{P_w = 1.02\ t/m^2}$$

(4) Max straining action at mid span of the deck :-



Vertical Loads

$$M_1 = +\frac{W}{3}, \quad N_1 = 0$$

$$W = g_1 + g_2 + P_1' = 2.4 + 1.5 + 3.18$$

$$= 7.08\ t/m^2$$

$$\Rightarrow M_1 = +\frac{7.08}{3} = +2.36\ mt/m'$$

$$N_1 = 0$$

Horizontal Loads

$$M_1 = -\frac{e_d}{6}, \quad N_1 = -e_d$$

$$M_1 = -\frac{1.47}{6} = -0.245\ mt/m'$$

$$N_1 = -1.47\ t/m'$$

$\therefore M_{1\,max} = +2.36 - 0.246 = +2.11$ mt/m' ⑥

$$M_{1\,max} = +2.11 \text{ mt/m'}$$

$$N_{1\,max} = 0 - 1.47 = -1.47 \text{ t/m'}$$

[C] Two vents steel pipe Culvert with No drop in Bed

$n = 2$ $D = D_{max} = d - 0.3 = 1.5 - 0.3 = 1.2^m$

$n = 2$ $D = 1.2^m$

$$V_{culvert} = \frac{Q}{\frac{n\pi D^2}{4}} = \frac{3.7}{\frac{2 * \pi (1.2)^2}{4}} = 1.635 \text{ m/s} < 2 \text{ m/s} \quad \text{safe}$$

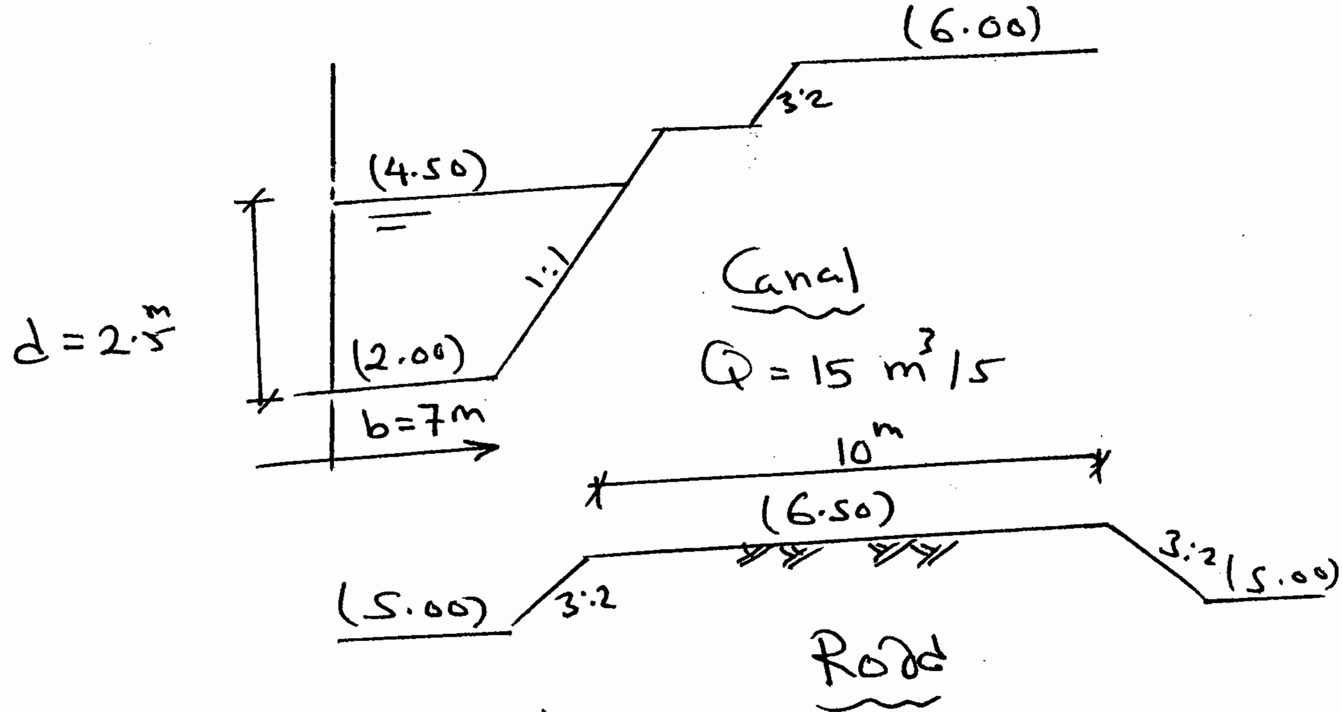
$$H_{up} = \frac{V_{culvert}^2}{2g}\left[1.2 + 0.01 \frac{L}{R}\right]$$

$$R = \frac{D}{4} = \frac{1.2}{4} = 0.3^m \quad \& \quad L = 14^m$$

$$\Rightarrow H_{up} = \frac{(1.635)^2}{2 * 9.81}\left[1.2 + 0.01 * \frac{14}{0.3}\right] = 0.227^m = 22.7 \text{ cm}$$

$$H_{up} = 22.7 \text{ cm}$$

Question [2] :- at Location (2)



One Vent R.C Bridge

$n = 1$ | $S = 5^m$ → Given | $l = 1.6\ m$

① **Heading up :-**

$$H_{up} = \frac{v^2}{2gc^2}\left[\left(\frac{A}{a_{act}}\right)^2 - 1\right] * 100$$

$$A = bd + z_1 d^2$$

$$= 7*2.5 + 1.5(2.5)^2 = \underline{\underline{26.87}}\ m^2$$

$$v = \frac{Q}{A} = \frac{15}{26.87} = 0.558\ m/s$$

$$a = nsd = 1*5*2.5 = \underline{\underline{12.5}}\ m^2$$

$C = 0.92$; $S = 5m > 4^m$

(8)

$\therefore H_{up} = \frac{(0.558)^2}{2 * 9.81 * (0.92)^2} \left[\left(\frac{26.87}{12.5}\right)^2 - 1 \right] * 100 = 6.78^{c}$

$H_{up} \simeq 6.8\ cm$

(2) Scour Calculations :-

* Critical Velocity (V_c) :-

$V_c = 6.19\ y^{1/6}\ D^{\frac{1}{3}}$

$y = y_o + H_{up} = 2.5 + \frac{6.8}{100} = 2.568^m$

$\therefore V_c = 6.19 (2.568)^{\frac{1}{6}} (0.004 * 10^{-3})^{1/3} = 0.114\ m/s$

$\therefore v > v_c \Rightarrow$ Live-Bed Contraction Scour

$\Rightarrow$ use eq^n $y_2 = y_1 \left(\frac{W_1}{W_2}\right)^{0.64}$

$W_1 = b = 7^m$

$W_2 = nS = 1 * 5 = 5^m$

$y_1 = 2.568^m$

$\therefore y_2 = 2.568 \left(\frac{7}{5}\right)^{0.64} = 3.18^M$

$$Y_s = Y_2 - Y_o = 3.18 - 2.5 = 0.68^m$$

$$\boxed{Y_s = 0.68^m}$$

* Local Scour at Abutment :-

$$Y_s = 2.15\, Y_1 \left(\frac{a}{Y_1}\right)^{0.4} F_{r_1}^{0.33}$$

$$V_1 = \frac{Q}{b y_1} = \frac{15}{7 * 2.568} = 0.83 \text{ m/s}$$

$$F_{r_1} = \frac{V_1}{\sqrt{g y_1}} = \frac{0.83}{\sqrt{9.81 * 2.568}} = 0.165$$

$$a = \frac{(b - b_{bridge})}{2} + Z_1 y_1 = \frac{(7-5)}{2} + 1 * 2.568 = 3.568^m$$

$$\therefore Y_s = 2.15 * 2.568 \left[\frac{3.568}{2.568}\right]^{0.4} * (0.165)^{0.33} = 3.47^m$$

$\therefore$ total Scour at Abutment = $0.68 + 3.47 = 4.15^m$

Take Foundation level = $(2.00) - 0.68 = (1.32)$

and use RipRap with D_{50}, y_R, W_R

and Piles as follows:-

Riprap:-

$$D_{50} = 0.062 V^2$$

$$V = \frac{Q}{n S d} = \frac{15}{1 * 5 * 2.5} = 1.2 \text{ m/s}$$

$\therefore D_{50} = 0.062(1.2)^2 = \underline{0.089}^m \Rightarrow \boxed{D_{50} = 0.089^m}$

* $y_R \equiv$ Contraction scour $= 0.68^m \Rightarrow \boxed{y_R = 0.68^m}$

* $W_R = X + 0.45 + y_R \cot\phi$

$X = B_{toe} - t_v$, $t_v = 0.35^m$, $B_t = \frac{B}{3} = \frac{4.2}{3} = 1.4^m$

$\Rightarrow X = 1.4 - 0.35 = 1.05m \Rightarrow W_R = 1.05 + 0.45 + 0.68 \cot 30^\circ = 2.67^m$

$\Rightarrow \boxed{W_R = 2.67^m}$

*The unsupported length of Pile $\equiv 3.47 - 0.35 = \underline{3.12}^m$

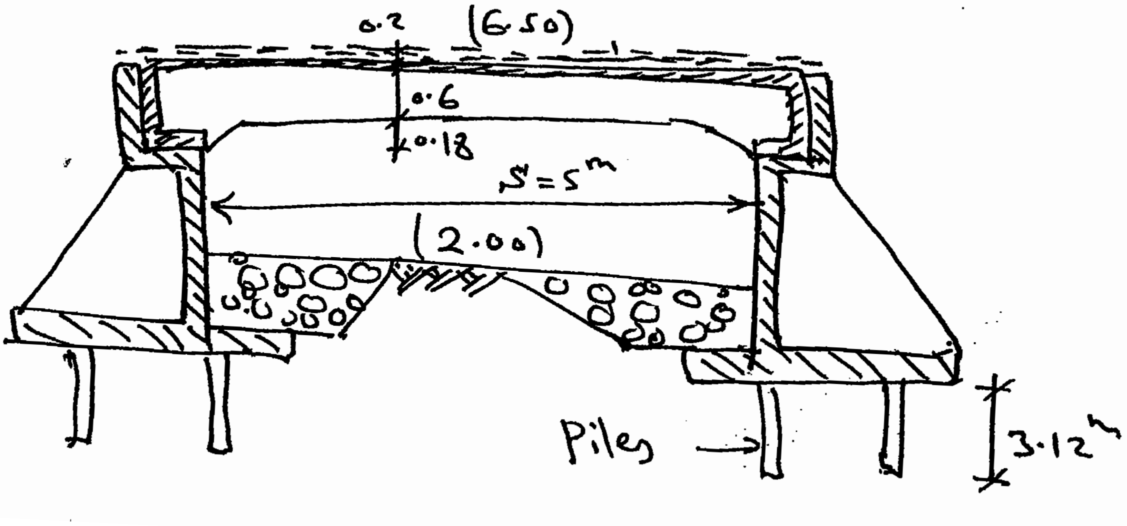
(3) $t_s = \frac{l}{8 \to 10} = \frac{1.6}{8 \to 10} = 0.16 \to 0.2 \Rightarrow \boxed{t_s = 0.2}$

$t_G = \frac{L_G}{7 \to 10} = \frac{1.05 + 5}{7 \to 10} = 0.75 \to 0.525$

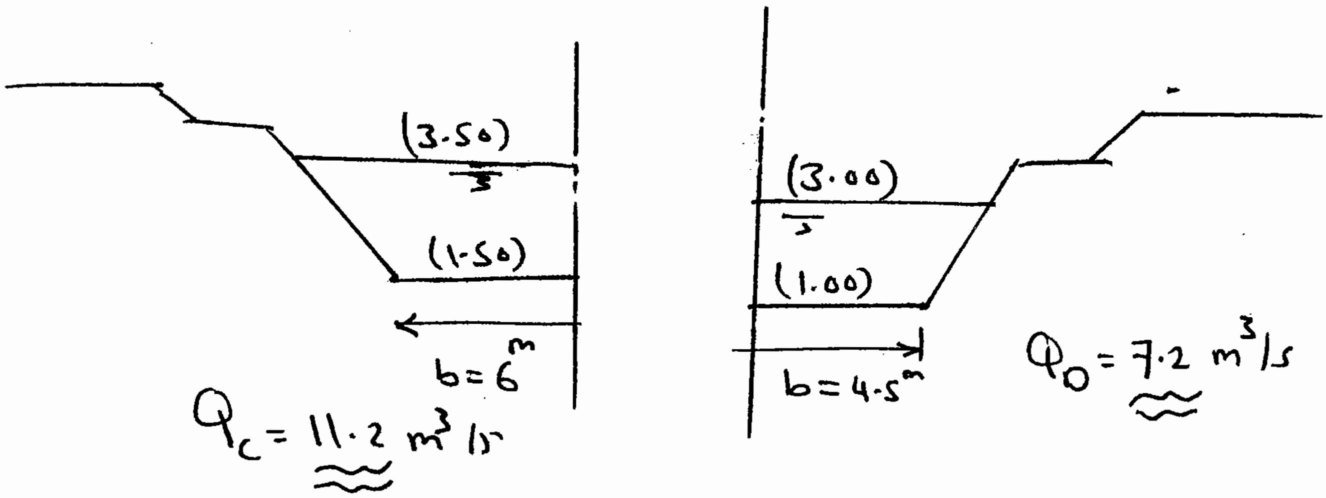
$\boxed{t_G = 0.6^m}$ $\boxed{b_G = 0.3^m}$

$B_1 = 0.1 S = 0.1 * 5 = 0.5^m$

* T



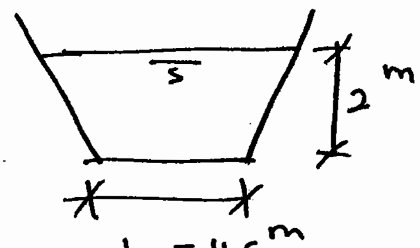
Question (3) :-



$Q_o < Q_c$

$W.L_{Drain} < W.L_{canal}$ ⇒ Drain will pass through

Syphon under the Canal



$Q_o = 7.2 \ m^3/s$

$H = d - 0.1 = 2 - 0.1 = 1.9 \ m$

$A = bd + z_i d^2 = 4.5 * 2 + 1.5(2)^2 = 15 \ m^2$

$v = \frac{Q}{A} = \frac{7.2}{15} = 0.48 \ m/s$

$V = (2 \rightarrow 3) v = (2 \rightarrow 3) * 0.48 = (0.96 \rightarrow 1.44) \ m/s$

take $V = 1.2 \ m/s$

$a = \frac{Q}{V} = \frac{7.2}{1.2} = 6 = nSH = nS * 1.9$

$nS = \frac{6}{1.9} = 3.15^m$

$n = 1$ $\quad S = 1.5H = 1.5 * 1.9 \approx 2.8^m$

$$V_{act} = \frac{Q}{n S H} = \frac{7.2}{1 * 2.8 * 1.9} = 1.35 \text{ m/s}$$

Finally $\boxed{n = 1}$ $\boxed{S = 2.8}$ $\boxed{H = 1.9}$

تصميم أعمال الري

SHAMS UNIVERSITY
FACULTY OF ENGINEERING
IRRIGATION & HYDRAULICS DEPT

جامعة عين شمس
كلية الهندسة
قسم الري والهيدروليكا

THIRD YEAR CIVIL

FINAL EXAM. JUNE. 2008 ***TIME: 3 HOURS***

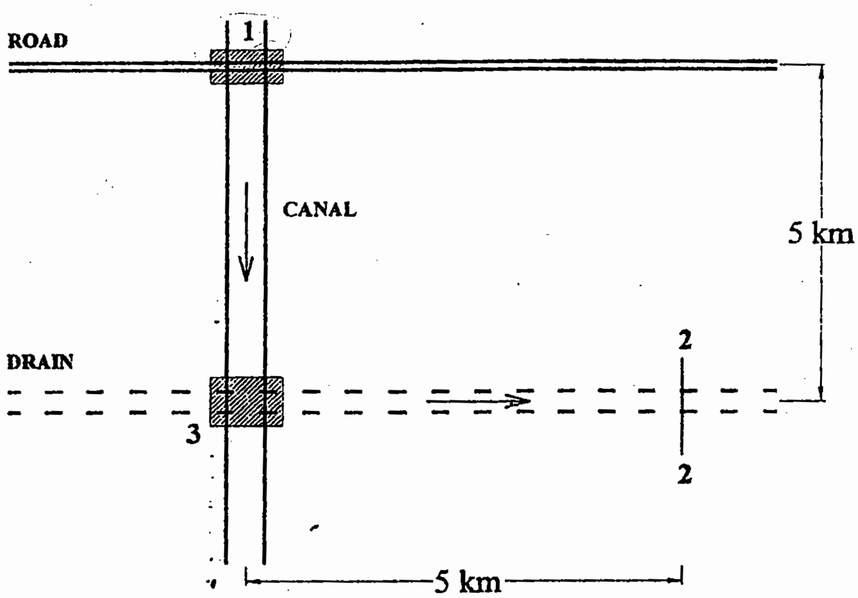
DESIGN OF IRRIGATION WORKS [1]

The exam consists of THREE questions in THREE pages
Any missing data can be reasonably assumed

ATTEMPT ALL QUESTIONS (55 MARKS)

<u>Canal section at crossing 1:</u>

Bed level	(6.00)
Bed width	3 m
Z_1	1
Berm level	(8.00)
Berm width	2 m
Z_2	1.5
Water level	(7.50)
Water slope	10 cm/km
Bank level	(9.00)
Bank width	6 m
Discharge	2.7 m^3/sec



<u>Drain section at section 2-2</u>

Bed level	(2.30)
Bed width	2 m
S:S	3:2
Water level	(3.90)
Water slope	20 cm/km
Berm level	(6.50)
Bank level	(7.50)
Bank width	6 m
Discharge	2.7 m^3/sec

<u>Road</u>

Road level	(9.00)
Road width	7 m

QUESTION 1: (14 MARKS)

It is required to construct a R.C. bridge at crossing [1] where *<u>no heading up is allowed</u>*.
-Bridge width=5m + two side walks 1m each, use 5 girders.
-Rolling load = 60 t lorry, coefficient of impact = 40%

1. **Calculate** the maximum bending moment acting on the girder (**draw** a sketch showing the distribution of girders and location of lorry) (5 marks)
2. **Draw** *½ sectional elevation & ½ plan ½ earth removed* for the upstream side (scale 1:100) (9 marks)

QUESTION 2: (30 MARKS)

If at crossing [1] the maximum allowable heading up were 13 cm, ***two solutions are proposed:***

A one vent R.C. BOX CULVERT t_1=20 cm t_2=30 cm

Two vents STEEL PIPE CULVERT t=1 cm

1. **Calculate** vents dimensions for the two solutions, *do no use a drop in the bed*, then **calculate** heading up using the given formula: $H.U. = \frac{V^2_{culvert}}{2g}\left[1.2 + C_f\right]$ (6 marks)

	a	b
R.C.	0.00316	0.0305
Steel	0.00996	0.0256

2. **Draw** a sectional elevation (scale 1:100), **show** the **box culvert** in the *U.S. side*, and the **pipe culvert** in the *D.S. side.* (8 marks)

3. **Calculate** the intensity of loads acting on **box culvert** resulting from:
   - Weight of embankment $\gamma_{dry} = 1.8$ t/m^3
   - Own weight of culvert
   - Rolling load (20t lorry)
   - Dry earth pressure ϕ=30° (4 marks)

4. **Calculate** the maximum resulting straining actions at *the middle of the top slab* of the **box culvert** using the following formulae:

   For vertical load (w):

   $M = 0.1\, w\, S^2$

   $N = 0$

   For Horizontal load (e):

   $M = -\,0.06\, e\, H^2$

   $N = -\frac{eH^2}{2}$ (4 marks)

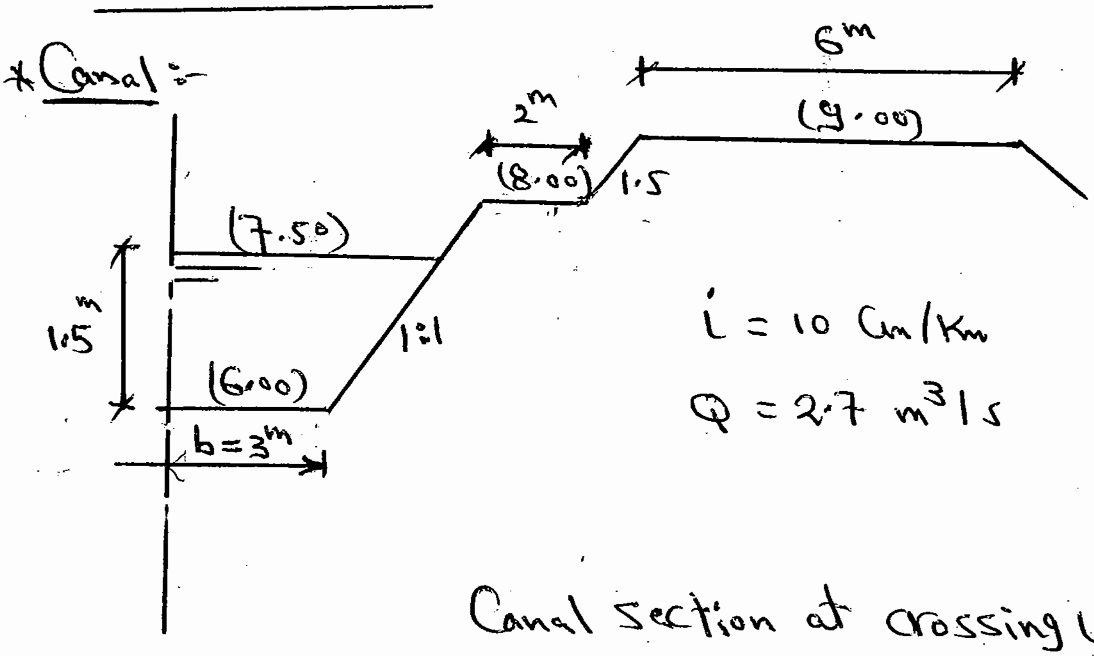
5. **Calculate** the intensity of loads acting on **pipe culvert** resulting from:
   - Weight of embankment
   - Own weight of culvert $\gamma_{steel} = 7.85$ t/m^3
   - Rolling load equivalent to a uniformly distributed load = 1 t/m^2
   - Dry earth pressure (4 marks)

6. **Calculate** the maximum resulting straining actions at the top of the **pipe.** (4 marks)

Final Exam June 2008

Question (1) :-

* Canal :-

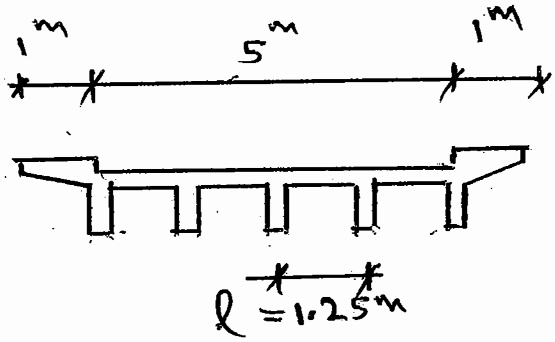


$i = 10$ Cm/Km

$Q = 2.7\ m^3/s$

Canal section at crossing (1)

Bridge :-



* No Heading up
* 60 ton lorry
* $I = 40\%$ XX

$l = \frac{5^m}{4} = 1.25^m$

• D.L :-

Slab :-

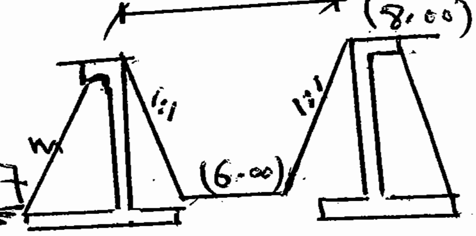
$w_s = t_s \gamma_c + t_{w.s} \gamma_c$

$= 0.2 * 2.5 + 0.12 * 2.2 = 0.764\ t/m^2$

Girder

$S = b + 2zy$

$= 3 + 2*1*(8-6) = 7^m$



Question(2) :-

$Q = 2.7\ m^3/s$

$H_{up} = 13^{cm}$

*** For one vent Box Culvert :-**

$t_1 = 0.2^m$

$t_2 = 0.3^m$

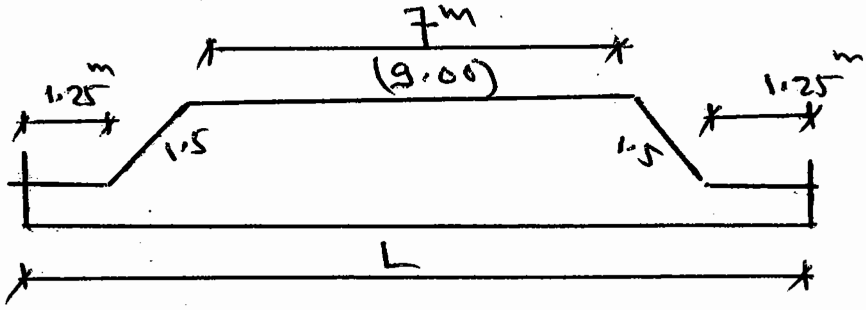
$n = 1$

$H = d - 0.1 = 1.5 - 0.1 = 1.4^m$.

take $V = 1.2\ m/s$.

$\Rightarrow a = n\,S\,H = \dfrac{Q}{V} \Rightarrow 1 * S * 1.4 = \dfrac{2.7}{1.2} \Rightarrow S = 1.6^m$

$n = 1$ $\quad H = 1.4^m$ $\quad S = 1.6^m$



* Road Width $= 5 + 2 = 7^m$

(5 = Bridge Width; 2 = 2 * Side Walk)

* L = Culvert length $= 2\left[\frac{7}{2} + (9-8) * 1.5 + 1.25\right]$

$= 12.5^m$

$$R = \frac{SH}{2(S+H)} = \frac{1.4*1.4}{2(1.4+1.4)} = 0.35^{m}$$

$$C_f = \overset{a}{0.00316}\left(1+\frac{\overset{b}{0.0305}}{\underset{R}{0.35}}\right)*\frac{\overset{L}{12.5}}{\underset{R}{0.35}} = 0.12$$

$$H_{up} = \frac{V^2}{2g}(1.2 + C_f)$$

$$= \frac{(1.2)^2}{2*9.81}(1.2+0.12) = 0.096^{m} = \underline{\underline{9.6}}^{cm} < 13^{cm} \text{ ok}$$

* 2 Vents steel Pipe Culvert :-

$$D = d - 0.3 = 1.5 - 0.3 = 1.2^{m} \quad , n = 2$$

$$V = \frac{Q}{a} = \frac{2.7}{2*\frac{\pi}{4}(1.2)^2} = \underline{1.19 \text{ m/s}} < 1.5 \text{ m/s}$$

$$L = 12.5^{m} \quad \& \quad R = \frac{D}{4} = \frac{1.2}{4} = 0.3^{m}$$

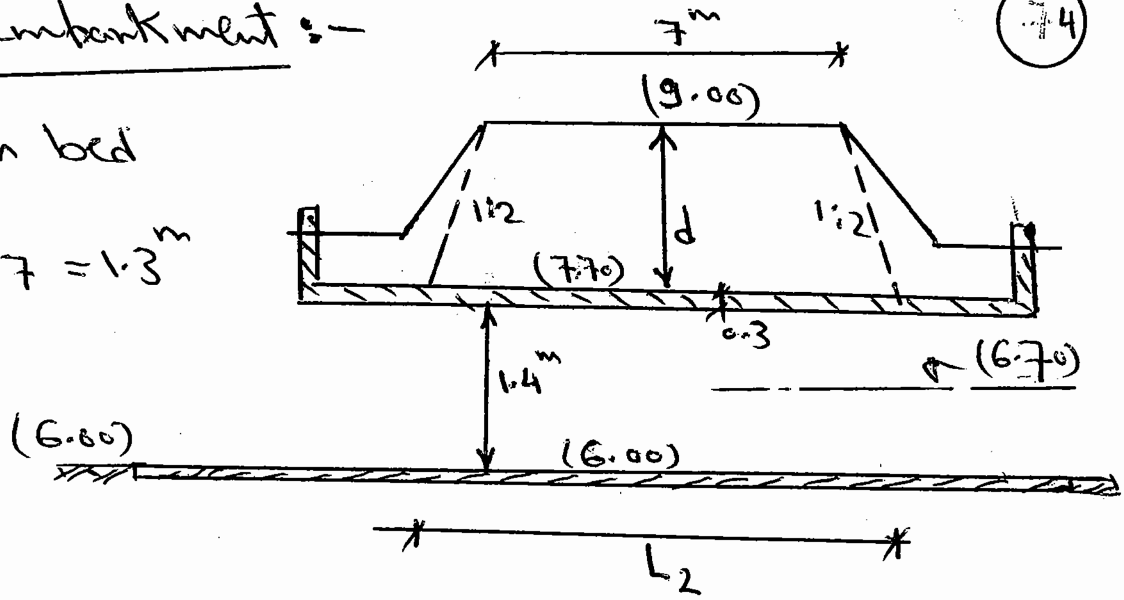
$$C_f = \overset{a}{0.00996}\left(1+\frac{\overset{b}{0.0256}}{\underset{R}{0.3}}\right)*\frac{\overset{L}{12.5}}{\underset{R}{0.3}} = \underline{0.45}$$

$$H_{up} = \frac{(1.19)^2}{2*9.81}(1.2+0.45)$$

$$= 0.119^{m} = 11.9^{cm} < 13^{cm} \text{ o.k}$$

3) • wt of embankment :-

* No drop in bed
* $d = 9 - 7.7 = 1.3^m$



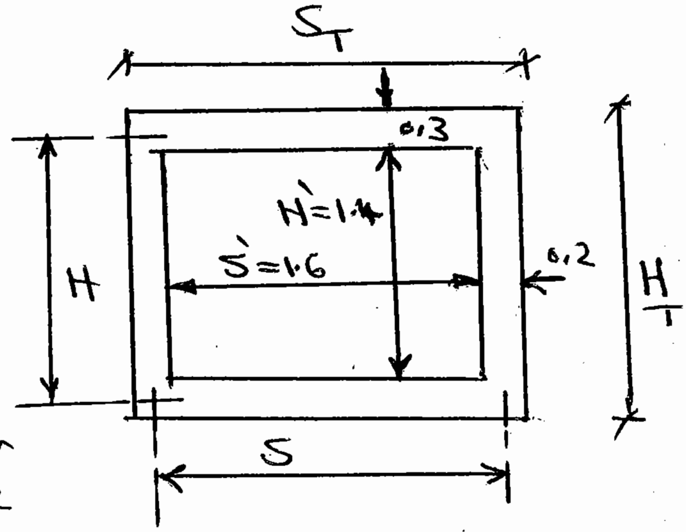
$L_1 = 7^m$

$L_2 = 7 + d = 7 + 1.3 = 8.3^m$

$$\therefore g_1 = \frac{\frac{(L_1 + L_2)}{2} * d * \gamma_d}{L_2} = \frac{\frac{(7 + 8.3)}{2} * 1.3 * 1.8}{8.3} = 2.16 \ t/m^2$$

$$g_1 = 2.16 \ t/m^2$$

• o.w of the Culvert :-



$H' = 1.4^m$

$S' = 1.6^m$

$H = H' + 0.3 = 1.4 + 0.3 = \underline{1.7^m}$

$S = S' + 0.2 = 1.6 + 0.2 = \underline{1.8^m}$

$S_T = nS + t_1 = 1.8 + 0.2 = 2^m$

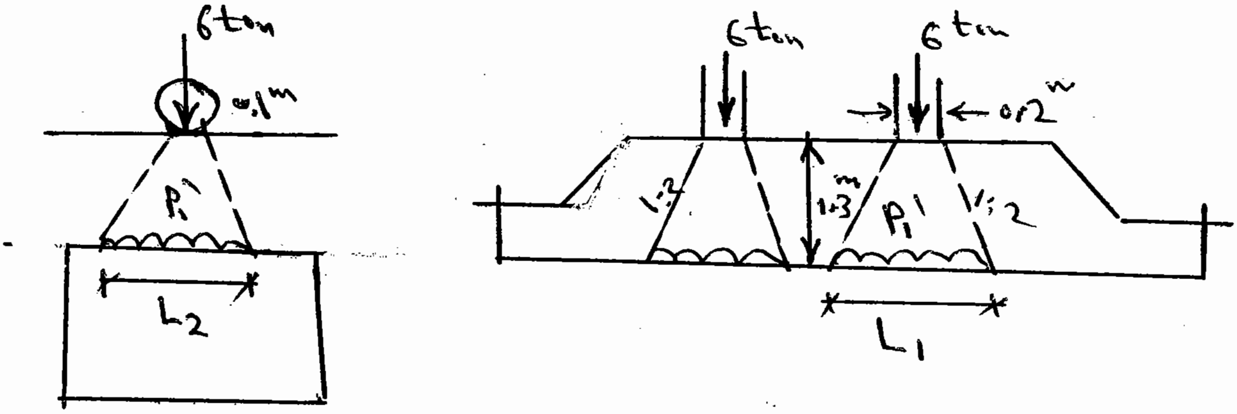
$H_T = H + t_2 = 1.7 + 0.3 = 2^m$

$$g_2 = \frac{1}{2}\,\frac{(S_T H_T - n S' H')\,\gamma_c}{n S}$$

$$= \frac{1}{2}\,\frac{(2*2 - 1*1.6*1.4)*2.5}{1*1.8} = 1.22\ t/m^2$$

$$g_2 = 1.22\ t/m^2$$

- Rolling Load :- 20 ton Lorry



$$L_1 = 0.2 + d = 0.2 + 1.3 = 1.5^m$$

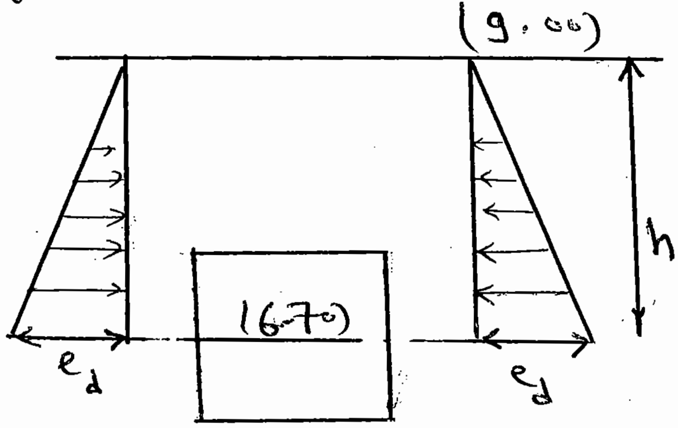
$$L_2 = 0.1 + d = 0.1 + 1.3 = 1.4^m$$

$$P_1' = \frac{P}{L_1 * L_2} = \frac{6}{1.5*1.4} = 2.86\ t/m^2 \quad , \; d > 1^m \Rightarrow I = 0$$

$$P_1' = 2.86\ t/m^2$$

- **Dry Earth Pressure :-**

$$K_a = \frac{1-\sin 30^\circ}{1+\sin 30^\circ} = \frac{1}{3}$$



$$h = 9 - 6.7 = 2.3^m$$

$$e_d = K_a \gamma_d h$$

$$= \frac{1}{3} * 1.8 * 2.3 = 1.38 \ t/m^2$$

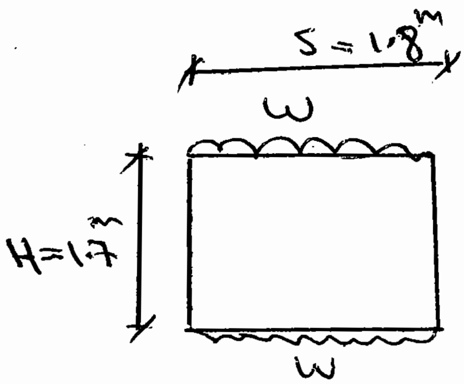
$$e_d = 1.38 \ t/m^2$$

4) $w = g_1 + g_2 + P_1'$

$$= 2.16 + 1.22 + 2.86$$

$$= 6.24 \ t/m^2$$

$$e = e_d = 1.38 \ t/m^2$$

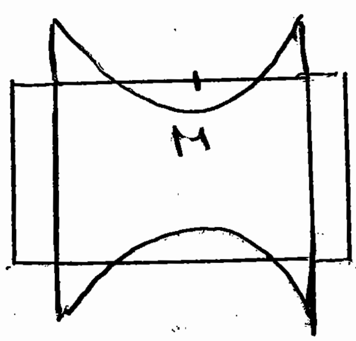


*** For V^l Loads :-**

$$M = 0.1 \, w \, S^2$$

$$= 0.1 * 6.24 (1.8)^2 = 2 \ mt$$

$$N = 0$$



Horizontal loads: $M = -0.06\,eH^2$

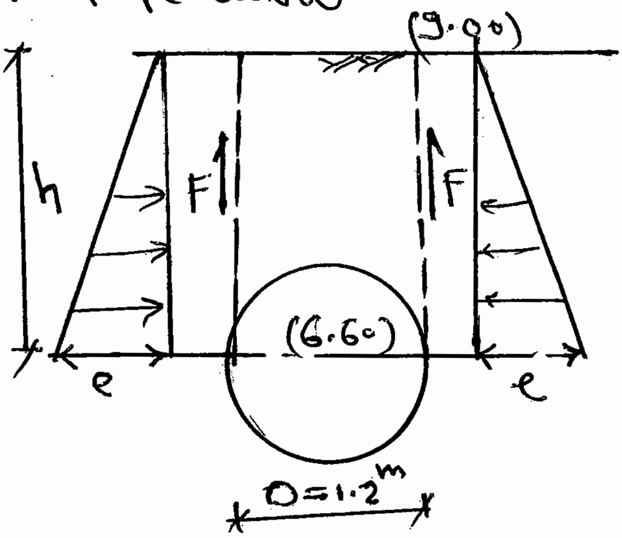
$\therefore M = -0.06 * 1.38 * (1.7)^2 = \underline{-0.24}$ mt

$N = -\dfrac{eH^2}{2} = \dfrac{-1.38\,(1.7)^2}{2} = \underline{-1.99}$ mt

5. wt of embankment: For Pipe Culvert

$\underline{C.L}$ = (6) + $\dfrac{D}{2}$ = $6 + \dfrac{1.2}{2}$

= (6.60)



$h = 9 - 6.6 = 2.4^m < 5.2D$

$e = K_a \gamma_d h$

$= \frac{1}{3} * 1.8 * 2.4 = 1.44$ t/m²

$E = \frac{1}{2} e h = \frac{1}{2} * 1.44 * 2.4 = 1.728$ t/m'

$F = \mu E = \tan\phi E = \tan 30° * 1.728 = 1$ t/m'

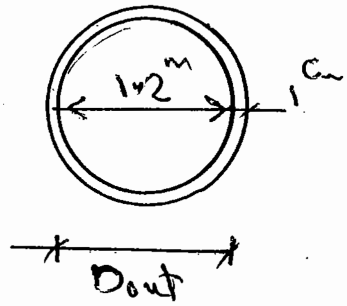
$g_1 = \dfrac{\gamma h D - 2F}{D}$

$= \dfrac{1.8 * 2.4 * 1.2 - 2 * 1}{1.2}$

$= \underline{\underline{2.65 \text{ t/m}^2}}$

- **O.W of Culvert:**

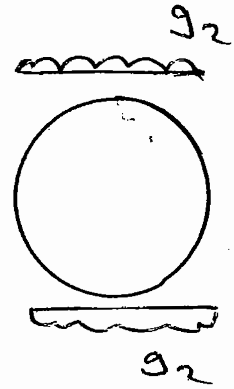
$D_{out} = D + t = 1.2 + 0.01 = 1.21^m$



$$g_2 = \frac{\frac{1}{2}\frac{\pi}{4}\left(D_{out}^2 - D^2\right) * \gamma_s}{D}$$

$$= \frac{\frac{1}{2} * \frac{\pi}{4}\left((1.21)^2 - (1.2)^2\right) * 7.85}{1.2}$$

$$= 0.062 \ t/m^2$$



- **Rolling Load** $P = 1 \ t/m^2$

$h = 2.4^m < 3^m$

$\Rightarrow P' = P = 1 \ t/m^2$

- **Dry earth Pressure**

$e_d = K_a \gamma_d h$

$= \frac{1}{3} * 1.8 * 2.4 = 1.44 \ t/m^2$

6) **Max straining action at top of Pipes.**

$w_{max} = g_1 + g_2 + P'$

$= 2.65 + 0.062 + 1 = 3.7 \ t/m^2$

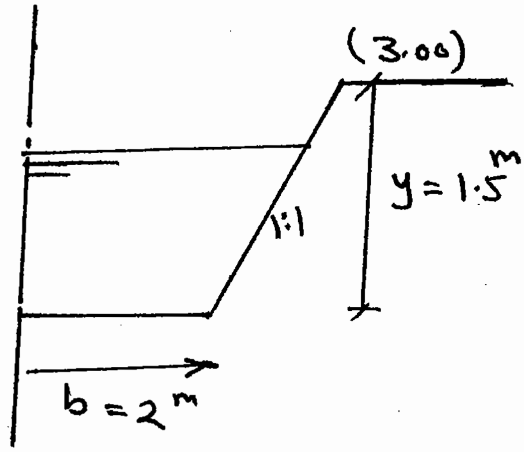
$e_{min} = e_d = 1.44 \ t/m^2$

$$M_{max} = \frac{(w_{max} - e_{min}) D^2}{16}$$

$$= \frac{(3.7 - 1.44)(1.2)^2}{16} = \underline{\underline{0.2 \text{ mt}}}$$

MidTerm April 2012

Question (1) :-



1.1) * $S = b + 2 Z_1 y$

$= 2 + 2 * 1 * 1.5 = 5^m$

$\therefore S = 5^m$

* $t_s = \frac{l}{8 \to 10} = \frac{2.4}{8 \to 10} = 0.3 \to 0.24$

$t_s = 0.3^m$

* $t_G = \frac{L}{7 \to 10}$, $L = 1.05\ S = 1.05 * 5 = 5.25^m$

$t_G = \frac{5.25}{7 \to 10} = 0.525 \to 0.75$

$t_G = 0.6^m$

* $B_1 = 0.1 S = 0.1 * 5 = \underline{0.5}^m$

* No. of Girders = $\frac{\text{Bridge width}}{l} + 1 = \frac{7.2}{2.4} + 1$

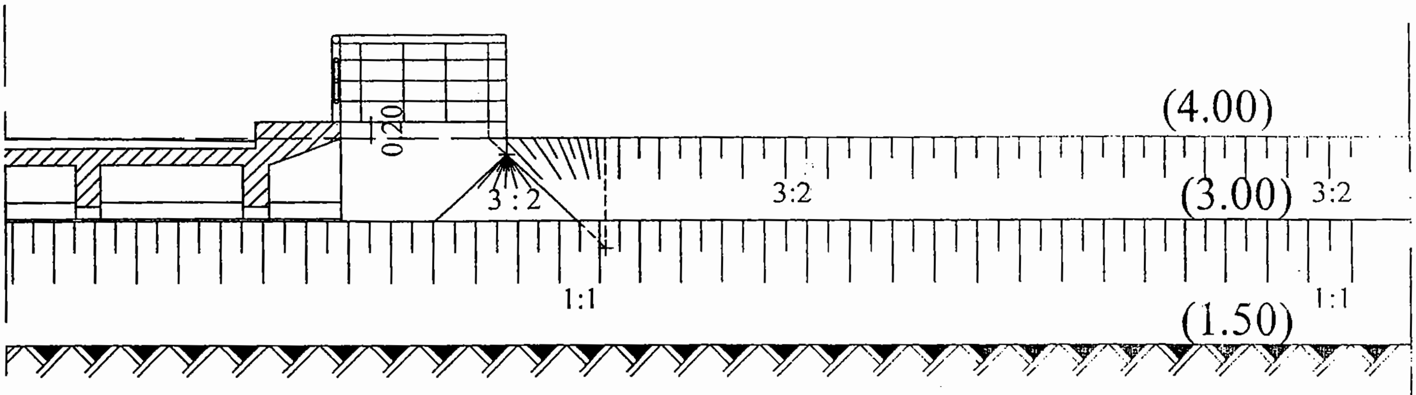
= 4 Girders

* $B = 2^m$

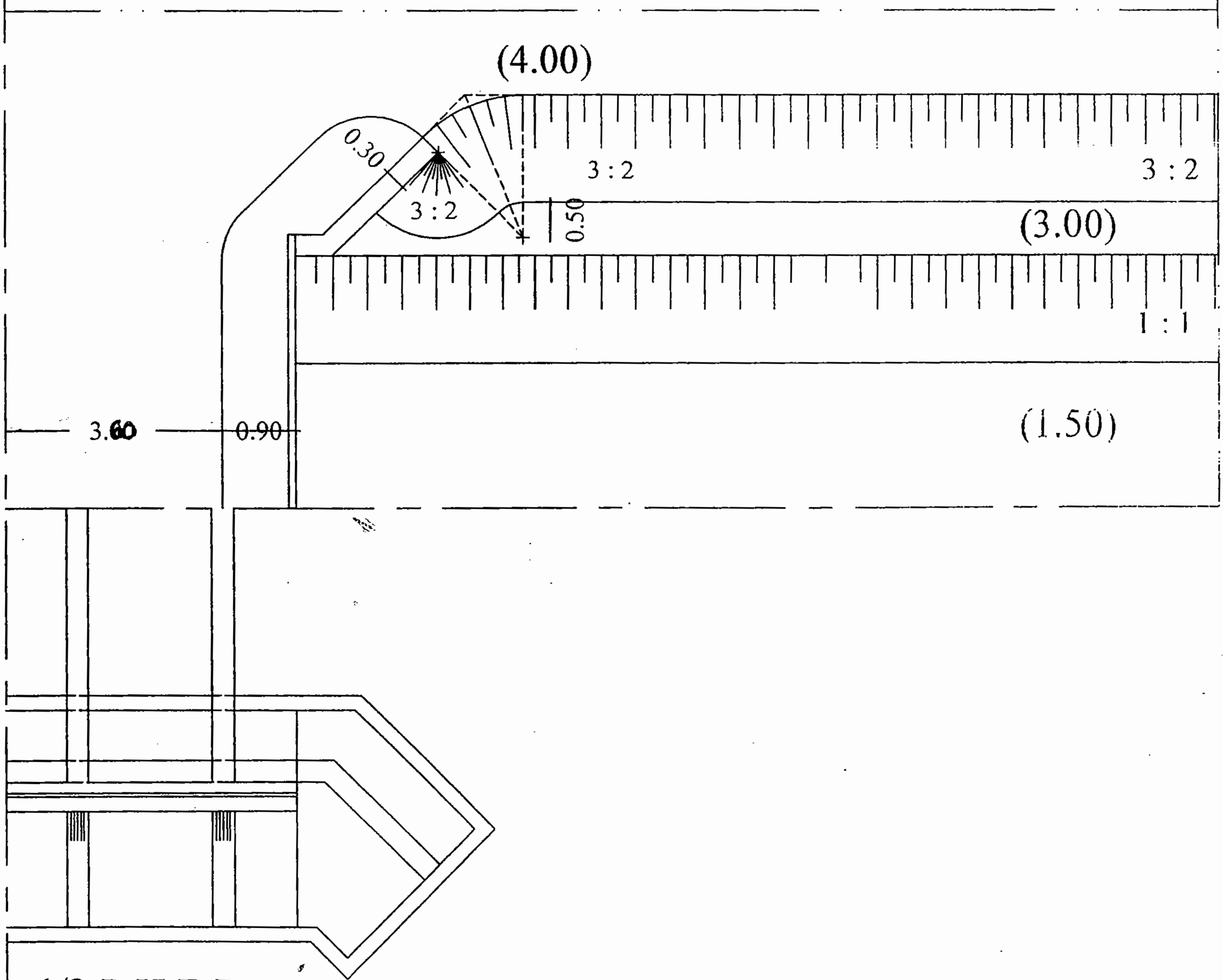
$B_t = \frac{1}{3} B = \frac{2}{3} = 0.67^m$

$B_h = \frac{2}{3} B = 1.33^m$

1.2)



1/2 Sectional Elevation

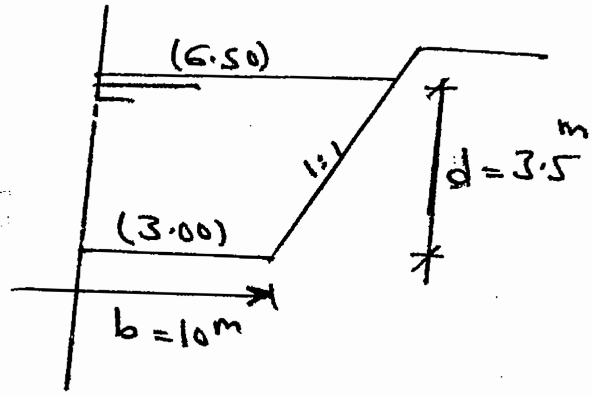


1/2 P.H.E.R

Question (2) :-

$Q = 23.1 \; m^3/s$

$V = 1.1 \; m/s$, $n = 2$



2.1) $a = \frac{Q}{V} = \frac{23.1}{1.1} = 21 \; m^2$

$\therefore 21 = n S d = 2 * S * 3.5$

$\Rightarrow S = 3^m \Rightarrow \boxed{n = 2} \quad \boxed{S' = 3^m}$

$* \; H_{up} = \frac{v^2}{2g C^2} \left[\left(\frac{A}{a} \right)^2 - 1 \right] * 100$

$A = bd + zd^2 = 10 * 3.5 + 1(3.5)^2 = 47.25 \; m^2$

$v = \frac{Q}{A} = \frac{23.1}{47.25} = 0.49 \; m/s$

$C = 0.82$; $S' = 3^m$

$\therefore H_{up} = \frac{(0.49)^2}{2 * 9.81 * (0.82)^2} \left[\left(\frac{47.25}{21} \right)^2 - 1 \right] * 100 = 7.4 \; cm$

$\therefore H_{up} = 7.4 \; cm$

2.2) $V_c = 6.19\ Y^{1/6}\ D^{1/3}$

$Y = Y_{D.S} + H_{up} = 3.5 + 0.074 = 3.574^m$

$D = D_{50} = 0.004$ mm

$\therefore V_c = 6.19\ (3.574)^{1/6} \left(\frac{0.004}{1000}\right)^{1/3} = 0.11$ m/s

$\Rightarrow v > V_c \Rightarrow$ Live-Bed Contraction Scour

Contraction Scour

$Y_2 = Y_1 \left(\frac{W_1}{W_2}\right)^{0.64}$

$Y_1 = 3.574^m$, $W_1 = b = 10^m$

$W_2 = nS = 2 * 3 = 6^m$

$Y_2 = 3.574 \left(\frac{10}{6}\right)^{0.64} = 4.59^m$

$\Rightarrow Y_s = Y_2 - Y_{D.S} = 4.59 - 3.5 = \underline{1.09}^m$

$\therefore$ Contraction Scour $= \underline{\underline{1.09}}^m$

<u>Local Scour at Pier :-</u>

$Y_s = 2.42\ a^{0.65}\ Y_1^{0.35}\ Fr_1^{0.43}$

$a = t_p = 0.4^m$

$Fr_1 = \frac{V_1}{\sqrt{g y_1}}$, $V_1 = \frac{Q}{b y_1} = \frac{23.1}{10 * 3.574} = 0.646$ m/s

$Fr_1 = \frac{0.646}{\sqrt{9.81 * 3.575}} = 0.1$

$\therefore Y_s = 2.42 * (0.4)^{0.65} * (3.574)^{0.35} * (0.1)^{0.43} = \underline{0.77\ m}$

$\therefore$ Total Scour at pier = $1.09 + 0.77 = 1.86^m$

$\therefore$ Foundation level = Bed level − Total Scour

$= (3.00) - 1.86 = (1.14)$

<u>oR</u> Take F.L = $(3.00) - 1.09 = (1.91)$

and use Riprap with Characteristics { D_{50}, y_R, W_R }

a) $D_{50} = 0.062\ V^2 = 0.062\ (1.1)^2 = \underline{\underline{0.075}}^m = \underline{\underline{75}}^{mm}$

b) $y_R = \begin{cases} 3D_{50} = 3 * 0.075 = 0.225 \\ \text{or} \\ 0.3^m \\ \text{or} \\ \text{Contraction Scour} = 1.09^m \checkmark \end{cases}$

$\Rightarrow \boxed{y_R = 1.09^m}$

c) $W_R \equiv \begin{cases} 2a \\ \text{or} \\ X + 0.45 + y_R \cot\phi \\ \equiv 0.4 + 0.45 + 1.09 \cot 45^\circ = 1.94^m \end{cases}$

$$X = \frac{(b_1 - a)}{2}, \quad b_1 = 1.2^m, \quad a = 0.4^m$$

$$X = \frac{(1.2 - 0.4)}{2} = 0.4^m$$

$\therefore$ $W_R = 1.94^m$

* Local Scour at Abutment

$$Y_s = 2.15\, Y_1 \left(\frac{a}{Y_1}\right)^{0.4} F_{r_1}^{0.33}$$

$$Y_1 = 3.574^m, \quad F_{r_1} = 0.1$$

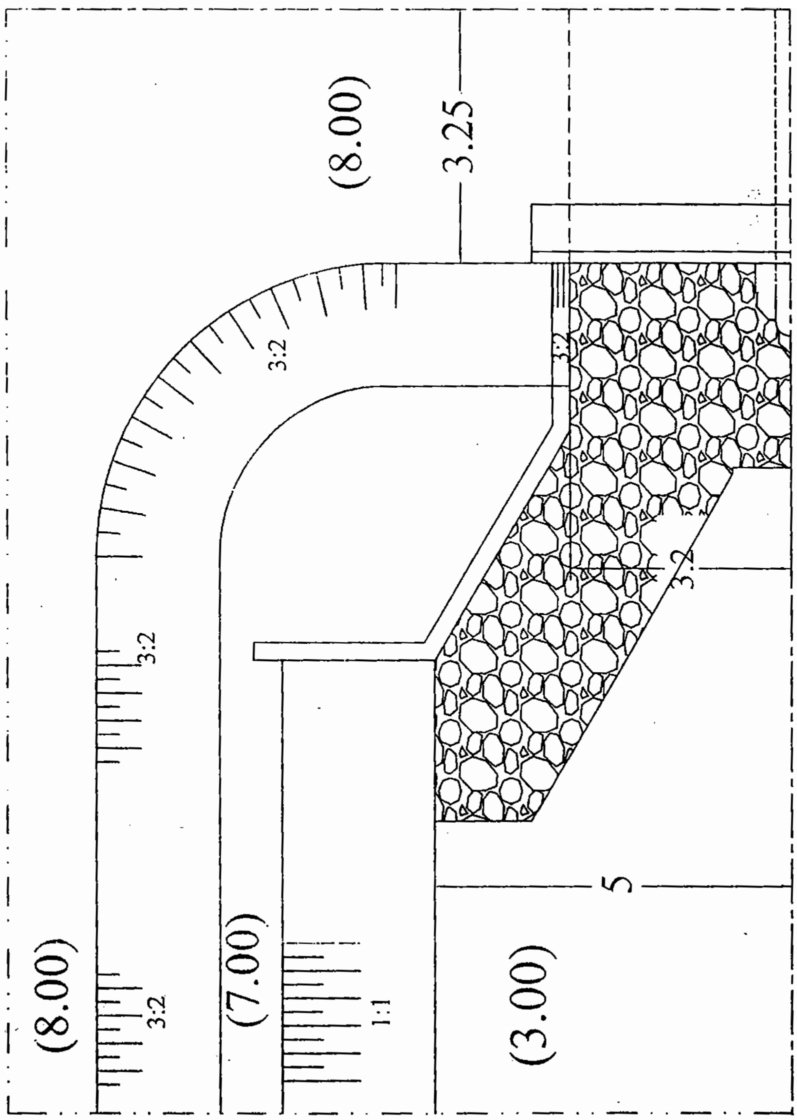
$$a = \frac{(b - b_{bridge})}{2} + Z_1 y_1$$

$$b_{bridge} = nS + (n-1)\, t_p = 2*3 + 1*0.4 = 6.4^m$$

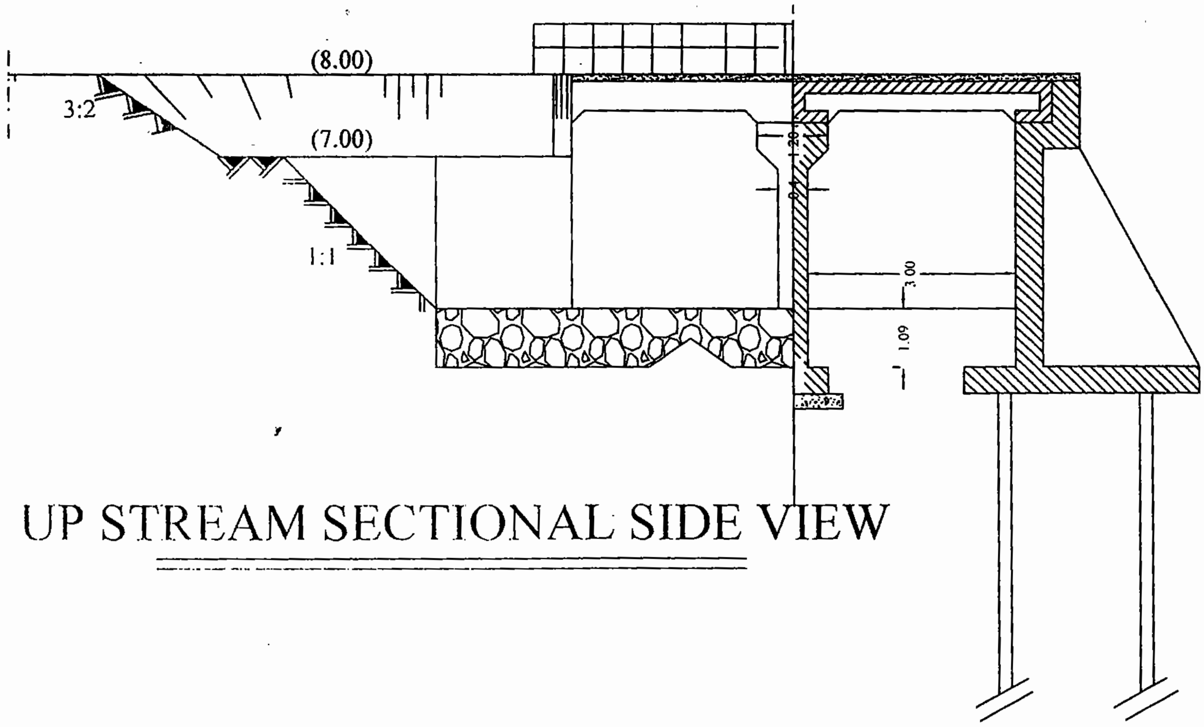
$$a = \frac{(10 - 6.4)}{2} + 1*3.574 = 5.374^m$$

$$Y_s = 2.15 * 3.574 \left(\frac{5.374}{3.574}\right)^{0.4} (0.1)^{0.33} = 4.23$$

$\therefore$ Total Scour at Abutment $\equiv 1.09 + 4.23$
$= 5.32^m > 3^m$



1/4 P.H.E.R



UP STREAM SECTIONAL SIDE VIEW

F.L = (1.41) and use Riprap and Piles under the R.C Foundation with unsupported length = $4.23 - t_{FRC} = 4.23 - 0.35 = \underline{3.88^m}$

Riprap characteristics:-

a) $D_{50} = 0.062\,V^2 = 0.075\ m = \underline{75}\ mm$

b) $Y_R = \underline{1.09^m}$

c) $W_R = X + 0.45 + Y_R \cot\phi$

$X = B_{toe} - t_V = \frac{1}{3} * 3.9 - 0.35 \equiv 0.95^m$ (3.9 = B)

$\therefore W_R = 0.95 + 0.45 + 1.09 \cot 45^\circ = \underline{2.49^m}$

2.3) $t_s = \frac{l}{8 \to 10} = \frac{1.25}{8 \to 10} = 0.15 \to 0.125 < 0.2^m$ ✗

$t_s = 0.2^m$

$t_G = \frac{L}{7 \to 10}$, $L = 1.05\, S_{clear}$

$S_{clear} = S - \frac{(b_1 - tp)}{2} = 3 - \frac{(1.2 - 0.4)}{2} \equiv 2.6^m$

$\therefore L = 1.05 * 2.6 = 2.73^m \Rightarrow t_G = \frac{2.73}{7 \to 10} = .39 \to .27$

$t_G = 0.4^m$

$B_1 = 0.1\,S = 0.1 * 3 = \underline{0.3^m}$

if $n > 1$ ⇒ there is pier

① Pier

* $b_1 = 0.1 * S + 0.85 = b_2$, $S \equiv$ Vent width

* $t_p = \frac{S}{6 \to 12} \nless 0.5^m = a$

* $S_{clear} = S - \frac{(b_1 - t_p)}{2}$

② Girder

* $b_G \equiv$ Girder width $= (0.3 \to 0.4)^m \cong 0.35^m$

* $L_G \equiv L_{eff} \equiv$ Girder Span $= 1.05 * S_{clear}$

* $t_G \equiv$ Girder depth $= \frac{L_G}{7 \to 10} \nless 0.4^m$

Note:- if $n = 1$ ⇒ No Pier

⇒ $L_G = 1.05 * S$

③ Slab

Bridge width = Road width − 2 * side walk

يتم اختيار عدد الكمرات بحيث

- $\frac{L_G}{\ell} \geq 2$ (one way slab)
- $\ell = (1 \to 3)$
- No. of Girders $= \frac{\text{Bridge width}}{\ell} + 1$

* t_s = slab thickness = $\frac{l}{8 \rightarrow 10} \nless 0.20^m$

* $t_{ws} = t_{F.C} = h$ = Wearing surface thickness = $\underline{0.12}^m$

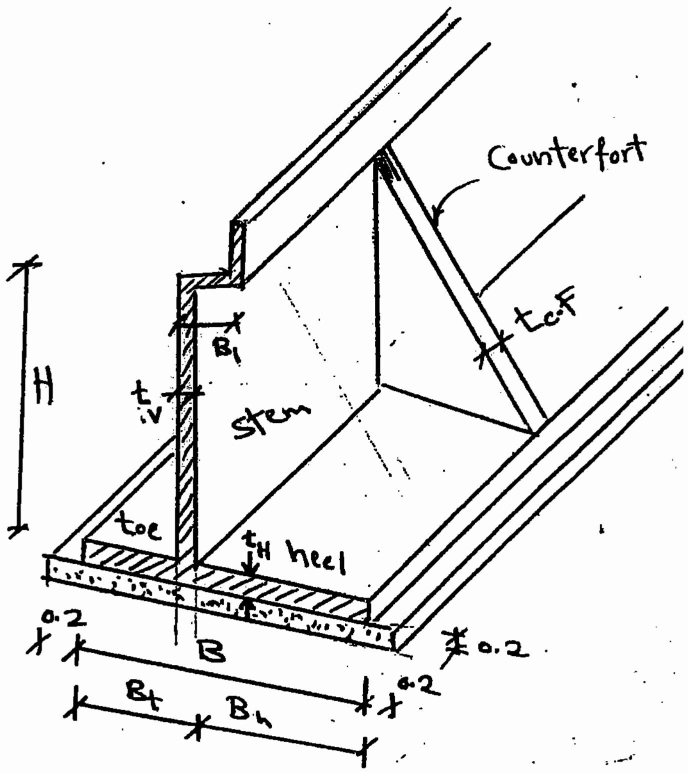
$\gamma_{w.s.} = \underline{2.2} \ t/m^3$

④ <u>Abutment</u> Counterforted type

* H = Abutment Height = Road level $-(t_{ws} + t_G + t_s)$ − Foundation level

* $B_1 = \frac{b_1}{2}$ if $n=1$ (no Pier)

* $B_1 = 0.1 * S$ if $n>1$ (Pier)



* B = Foundation width = $\frac{2}{3} H$

* B_t = toe width = $\frac{1}{3} B$

* B_h = heel width = $\frac{2}{3} B$

* $t_H = t_V = \frac{H}{12 \rightarrow 14}$

* Spacing between Counterforts ≡ l ≡ spacing between girders

* $t_{c.f}$ = Counterfort thickness $\doteq \frac{l}{10} \simeq t_G$