Hydraulic Structures

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Hydraulic structures (Irrigation structures)
منشـــآت هايدروليكيـــه (منـشآت الري)

1998/10/4

الأحد

Referenceses :-

1. Design text book in civil Eng.
   By serge Lelivasky

2. Theory of irrigation structures
   By R.S Varsheny

3. Design of small Dams
   B. U.S Bureau of Reclamation

4. Channel and Related structures
   By US. Bureau of Reclamation

5. Open channel Hydraulics
   By ven Tee Chaw

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Types of Hydraulic Structures :

1. Control or Regulating structures منشآت تنظيم او سيطره
   Barrage سد and Regulators نواظم.

2. Conveyance structures منشآت نقل
   خطوط انابيب Pip lines, siphen, Tunnels انفاق, Aqueducts عبارات and culverts.

3. Measuring Structures منشآت بستوم
   هدارات ، وسدود الفائض Weirs, Spill way

4. Protective structures منشآت حماية
   Dams

5. Energy disoipation structures منشآت تشتيت طاقة
   Hydraulic jumps, stilling Basin احواض التهدئة, and Drops المساقط

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التاريخ

Steps for Design an Irrigation Structures:

1. prepare the information for design
   - a. The precise function of design الغاية من التصميم
   - b. Discharge (max and min.)
     use 1.2Q for max discharge
     and 0.7Q for min. discharge.
   - c. Head losses = الفواقد
   - d. upstream (U/S) and downstream (D/S) Canal.

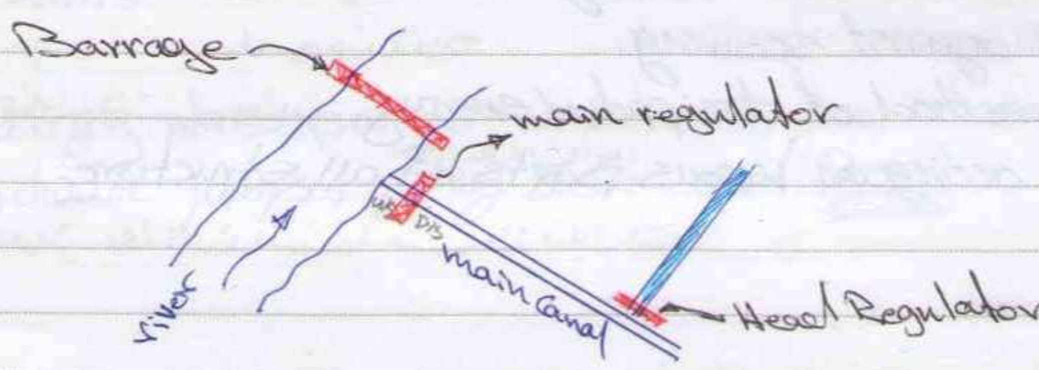
2. Determin the best Location of the structure. إيجاد الموقع لبناء المنشأ
3. The shape of approaches and the other components of the structure شكل التوصيلات لبناء المنشأ والملحقات الأخرى كالمنشأ
4. The requirements of water way متطلبات المجرى المائي
5. protection against scouring. الحماية ضد التعرية
6. The best method of dissipation energy. الطريقة المثلى لتشتيت الطاقة
7. The forces acting on various parts of all structure.
   كل القوى المؤثرة على اجزاء المنشأ حسب ما تتطلب القوى

Regulators :- النواظم

A structure on a water course to regulate the amount of water discharge or its level منشأ مبنا على مجرى مائي لتنظيم تصريف الماء او منسوبه

Regulator across :-
River → its named Barrage سد
canal → its named Cross regulator

Regulator at a head of
main Canal → its named main Regulator ناظم رئيسي
Other Canal → its named Head Regulator ناظم رأسي



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The following data must be given for design of Regulator

1. River data

a. Low discharge الموسم الصيفي

- Water level in the river. منسوب الماء في النهر
- Bed level in the river.
- Depth of water in the river.

b. flood discharge. في حالة الفيضان

- Depth of flow in the river.
- Max. river water level.

2. Main canal Data

a. Peak discharge. منسوب الماء في القناة الرئيسية عند المنظم القريب الذي يوصل للقناة

b. Water level in the main canal at the head Regulator.

c. Bed level in the main canal

d. Depth of water in the main canal (y)

e. Side slope of the main canal (Z)

f. Bed width of the main canal (B)

g. Longitudinal slope of the main canal (S_o)

h. Manning (n) of the main canal (n)

$$Q = \frac{1}{n} A R^{2/3} S_o^{1/2}$$ (Manning Equation)

$$A = By + Zy^2$$

$$P = B + 2y\sqrt{1+Z^2} \quad , \quad R = \frac{A}{P}$$

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Hydraulic of Regulators :-

1. Design discharge (Q)

موسم طلب
Design flow during period of maximum demond.

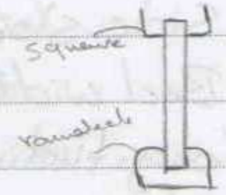
2. Water way of the regulator (S_w)

The dimension of the gate are determined for the case when the gate has been lifted completely out of water and there is minimum head loss (ΔH) between the upstream and down stream regions of flow. The discharge formula appropriate to this case is given by the following Equation :-

$$Q = C * S_w * y_t \sqrt{2gH_1}$$ (The gate is fully open)

Q :- discharge

* C :- 0.82 for square entrance
  0.92 for rounded enterance



* $C = 0.6 + 0.08\, S_w \leq 0.92$
* y_t = D/S water level - bed level under the gate
* $H_1 = \Delta H + h_v$
* ΔH = U/S water level - D/S water level
* h_v :- approach velocity $= \frac{v^2}{2g}$

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الثلاثاء

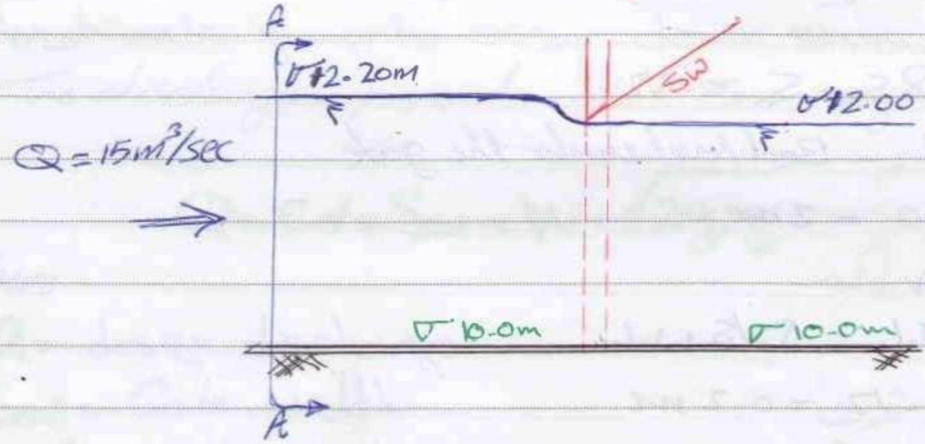
Ex: Gives an irrigation regulator with the following properties:

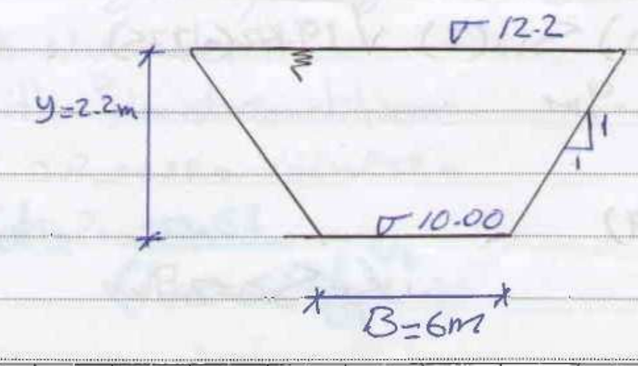
- U/S Canal bed level = 10.00 m
- U/S Canal water level = 12.20 m
- D/S Canal bed level = 10.00 m
- D/S Canal water level = 12.00 m
- Side slope (Z) of the Canal = 1:1
- U/S Canal bed width (B) = 6 m
- Supply design discharge (Q) = 15 m^3/sec

Required:

1- How much is the head of approach velocity (h_v)

2. How much is the needed regulator width (S_w)





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Solution :-

1. $h_v = \frac{U^2}{2g}$

$U = \frac{Q}{A}$, $A = By + Zy^2$

$= 6(2.2) + 1(2.2)^2 = 18.04\ m^2$

$U = \frac{15}{18.04} = 0.831\ m/sec$

$\therefore h_v = \frac{(0.831)^2}{2(9.81)} = 0.035\ m$

2. $Q = C * S_w * y_t \sqrt{2gH_1}$

$C = 0.6 + 0.08 S_w \leq 0.92$

y_t = D/S w.l. – Bed level under the gate

$12 - 10 = 2m$

$H_1 = \Delta H + h_v$

ΔH = U/S w.l. – D/S w.l.

$= 12.2 - 12 = 0.2m$

$\therefore H_1 = 0.2 + 0.035 = 0.235m$

$15 = (0.6 + 0.08 S_w) S_w (2) \sqrt{19.62(0.235)}$

$\Rightarrow S_w = 3.9m$

Chack C

اذا كانت قيمه C اكبر من 0.92 ناخذ قيمه 0.92

ونستنتج قيمه Sw من جديد

$C = 0.6 + 0.08(3.9)$

$= 0.912 < 0.92$

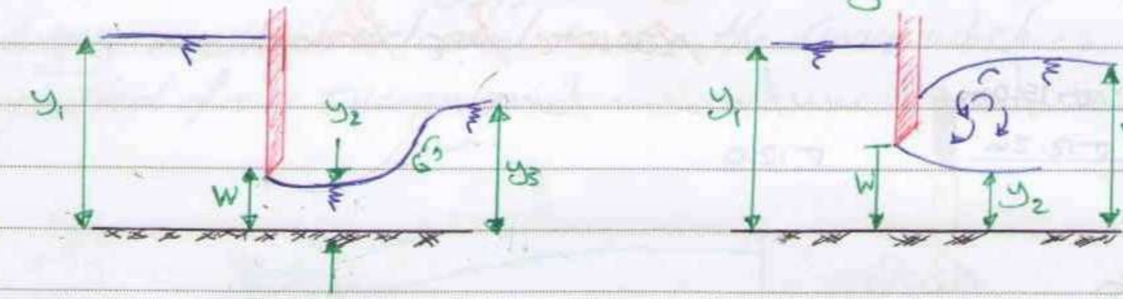
$\therefore ok$

$\therefore$ use $S_w = 3.9m$

Discharge of Regulators with partial opening :-

There are two cases of flow under gate :-

a. Free Flow b. Submerged flow



a. Free Flow

Free flow condition under vertical gate occurs when the tail water (y_t) is تقريباً Sufficiently low to allowe hydraulic jump to occur down stream of the gate. The discharge formula in this case is given by :-

$$Q = C_d * S_w * W * \sqrt{2g * y_1}$$

الماء الموجود بعد البوابة نوعاً قليل
كميته ان يندفع الماء وتحدث
بعدها ما يسمى بالقفزة الهيدروليكية

where

Q = design discharge

S_w = Gate width

W = vertical gate opening

y_1 = U/S water depth. with flood condition

في حالة وجود فيضان ونريد تغيير التصريف
او عدم وجود فيضان ونريد تغيير التصريف

$$C_d = \frac{0.61}{\left(1 + 0.61 \frac{W}{y_1}\right)^{1/2}}$$

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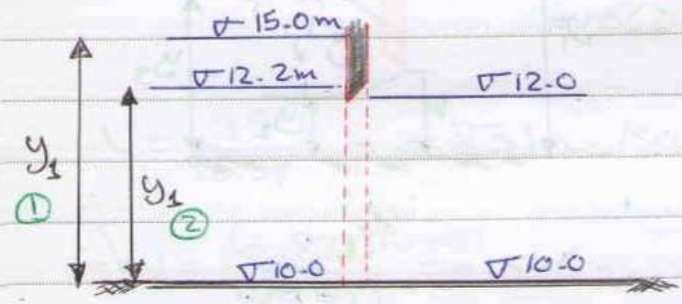
Ex: ① For previous example if the flood water level is 15m Find W which needed to pass the same design discharge ($15 m^2/sec$)
② with normal U/S water level; find W which needed to pass a discharge equal to ($5 m^3/sec$)
Assume free flow



Solution:

1. $Q = C_d S_w W \sqrt{2g y_1}$

$y_1 = 15 - 10 = 5m$

$$15 = \frac{0.61}{\left(1 + 0.61\frac{W}{5}\right)^{1/2}} (3.9) \times W \times \sqrt{19.62(5)} \Rightarrow W = 0.66m$$

2. $Q = C_d S_w W \sqrt{2g y_1}$

$y_1 = 12.2 - 10 = 2.2m$

$$5 = \frac{0.61}{\left(1 + 0.61\frac{W}{2.2}\right)^{1/2}} (3.9) \times W \times \sqrt{19.62(2.2)}$$

$\Rightarrow W = 0.33 m$

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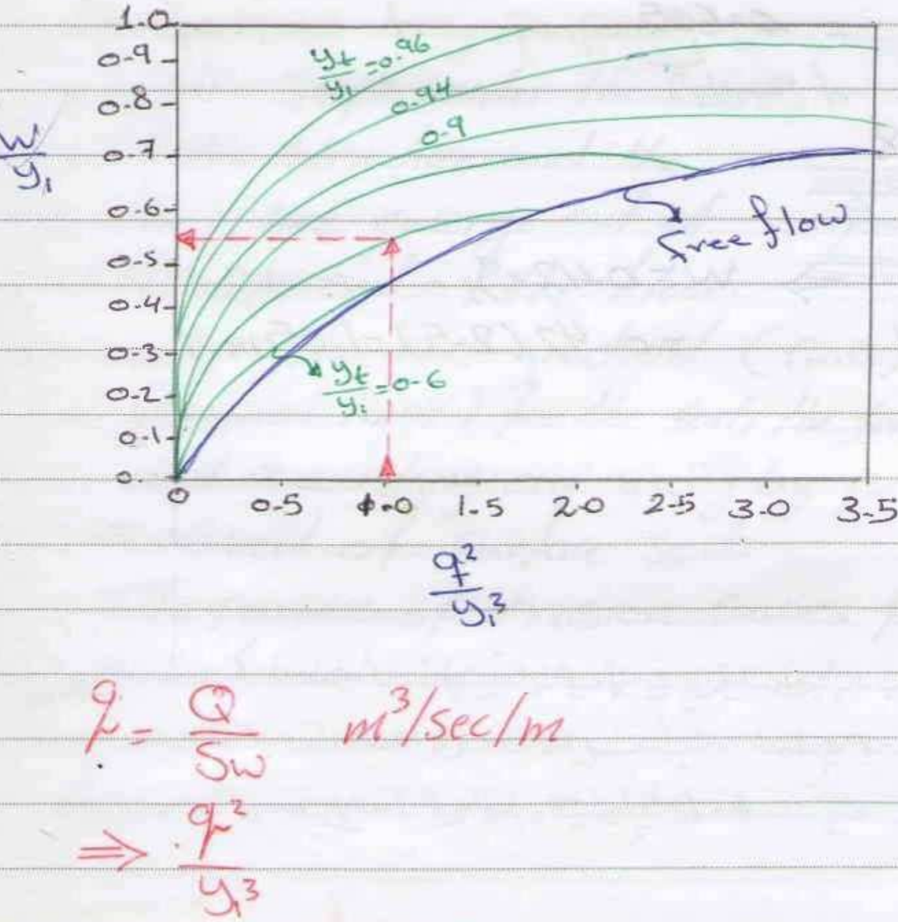
b. Submerged flow

When tail water (1) (y_t) rises, the jump (2) is drowned and flow is (3) submerged and this effect the discharge coefficient (cd).

Easy method adopted to use the curve which is plotted from energy and momentum equations.



$q = \frac{Q}{\Sigma w}$ $m^3/sec/m$

$\Rightarrow \frac{q^2}{y_1^3}$

y_t = D/S W.L. − Bed level under gate

$\Rightarrow \frac{y_t}{y_1}$

$\Rightarrow \frac{W}{y_1} = (?) \Rightarrow W = (?)\, y_1$

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Ex: For the previous example, find (W) if the U/S water level is (12.5m) and the discharge is equal to 12 m³/sec. Assume submerged flow.

Solution:

$$q = \frac{Q}{Sw} = \frac{12}{3.9} = 3.076 \ m^3/sec/m$$

$$y_1 = 12.5 - 10 = 2.5m$$

$$\frac{q^2}{y_1^3} = \frac{(3.076)^2}{(2.5)^3} = 0.605$$

$$\frac{y_t}{y_1} = \frac{2}{2.5} = 0.8 \quad (12-10)$$

$$\Rightarrow \frac{W}{y_1} = 0.42 \Rightarrow W = 0.42 * y_1$$

$$= 0.42(2.5) = 1.05m$$

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Design of floors :-

water seeps under structures causes of failure of this structures by:-
الماء المتسرب اسفل المنشأ قد يسبب انهيار المنشأ

1. piping النحر الانبوبي
2. Rubture of the floor due to uplift pressure.

عشان تصميم ارضية تعرف البوابة نعملها

1. failure by piping :-

water seeps under the base of the structure and the flow line emerge out of the D/s end of the floor.

when the exit gradient (G.e) exceed a certain limit (critical limit) for the soil, the surface soil start boiling and is washing out away by percolating water with removed of surface soil.
The process of erosion causes piping.

الماء المتسرب اسفل المنشأ وخط التسرب او الجريان يخرج في نهاية الارضية للمنشأ عندما يكون تدرج الخروج يتعدى المقاوم للتربة يبدأ سطح التربة بالغليان boiling وتبدأ غسل التربة وازالة التربة الموجودة في النهاية التخلص من هذه الحالة اطول الارضية او اضع sheet في البداية والنهاية لتقليل سرعة وقوة المياه الخارجة من الطرف الاخر

Treatments:-

1. Increase the depth of sheet pile at U/s and D/s
2. Increase the length of the floor.

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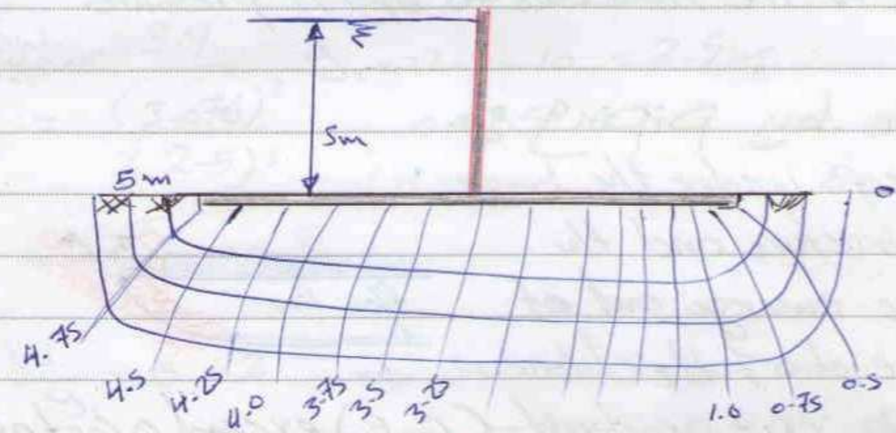
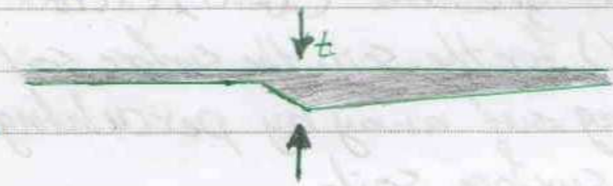
2. Rubture of floor due to uplift pressure:

If the uplift pressure in counter balance by the weight of concrete of floor above it, the floor will fail by rubture of part of floor

اذا ضغط الماء غير موازي او متساوي بجهد وضع مايوازي
هذا الضغط يمنع انهيار المنشأ أسفل الارضية





$$t = \frac{h}{G-1} \times \frac{4}{3}$$

Treatments:

1. provide flow of sufficient length تقوية الارضية
2. Increase the upstream pile inorder to decrease the uplift pressure
3. Increas the thickness of floor

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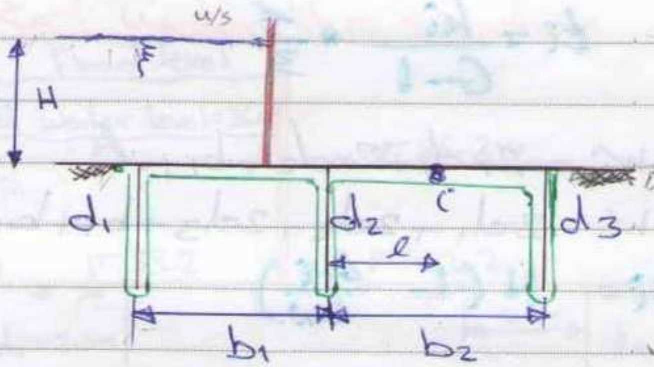
الثلاثاء

1. Bligh's Creep Theory :-

خط الزحف

$$\text{Creepline} = 2(d_1+d_2+d_3)+b_1+b_2$$

L.W. = 2×vertical distances + horizontal distances



خط الزحف
مسار جزيئة الماء بالاحتكاك السطح الاسفل للمنشأ

a. Safety against piping

The hydraulic gradient (i) (الانحدار الهيدروليكي) must be kept under safe limit, in order to ensure safety against piping.

الانحدار الهيدروليكي يجب ان يكون تحت (ضمن) الحد الامن و للتأكد من عدم حدوث piping

$$\text{hydraulic gradient } (i) = \frac{H}{L.W.}$$

(i : save — الحد المسموح

H = U/s w.l − D/s w.l

= U/s w.l. − D/s bed level

The safe limit of Hydrolic gradiant of soils is given in the following table :-

No.	Soil Type	Safe Hyd. gradient
1	Fine sand	$1/15$
2	Coarsegrained Sand	$1/12$
3	Sand mix with bolders and for 100m	$\frac{1}{5} - \frac{1}{9}$

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b. safety against uplift pressure:

$$t_i = \frac{h_i}{G-1} * \frac{4}{3}$$

$* G = 2.4\ ton/m^3$ for conc.

$h_i = H$ عند بداية المسار

zero = عند النهاية

$$L.W_i = 2*d_1 + 2*d_2 + b_1 + l$$

$$L.W = 2d_1 + 2d_2 + 2d_3 + b_1 + b_2$$

$$h_i = H\left(1 - \frac{Lw_i}{Lw}\right)$$

Example: A regulator was constructed on canal with the following site information:

- U/S normal water level = 36.45m
- U/S flood level = 39.2m
- D/S water level = 36.2m
- U/S and D/S floor level = 33.2m
- U/S and D/S bed width of the canal (B) = 8m
- Side slope of the canal Z = 1:1
- Manning (n) of the canal = 0.015
- Longitudinal slope of the canal (S) = 0.00013
- $G_{conc.} = 2.4\ ton/m^3$

1. Find regulator width (Sw)
2. ~~Width~~ with flood condition, the flow under the gate is of this regulator is (free flow), calculate the velocity of flow through the gate opening assume (Sw = 6m)

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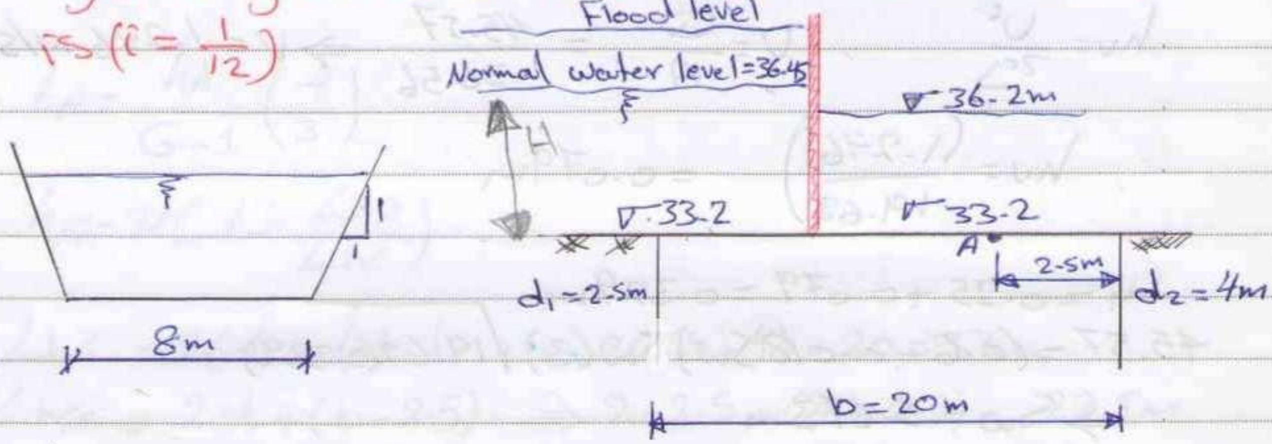
3. Calculate the thickness of floor at point (A) using Bligh Theory (assume $S_w = 6m$)
4. Is this structure safe against piping if the safe limit of Hydrolic gradient of soil under this structure is $(i = \frac{1}{12})$



Solutions:

1. $Q = C\,S_w\,y_t\sqrt{2gH_1}$

$Q = \frac{1}{n} A R^{2/3} S^{1/2}$

$A = By + Zy^2 \Rightarrow A = 8\overbrace{(36.45 - 33.2)}^{y} + 1(36.45 - 33.2)^2$

$= 8(3.25) + (3.25) \Rightarrow A = 36.56\,m^2$

$P = B + 2y\sqrt{1+Z^2}$

$= 8 + 2(3.25)\sqrt{2} \Rightarrow P = 17.19\,m$

$R = \frac{A}{P} = \frac{36.56}{17.19} = 2.127\,m$

$Q = \frac{1}{0.015}\,36.56 * (2.127)^{2/3}(0.00013)^{1/2} \Rightarrow Q = 45.57\,m^3/sec$

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$(36.2-33.2)$

$45.57 = (0.6+0.018S_w)\, S_w (3)\sqrt{19.62\, H_1}$

$H_1 = \Delta H + h_v$

$\Delta H = 36.45 - 36.2 = 0.25\,m$

$h_v = \frac{V^2}{2g}$, $V = \frac{Q}{A} = \frac{45.57}{36.56} \Rightarrow V = 1.246\ m/sec$

$h_v = \frac{(1.246)^2}{19.62} = 0.079\,m$

$H_1 = 0.25 + 0.079 = 0.329\,m$

$45.57 = (0.6+0.018S_w)\, S_w(3)\sqrt{19.62(0.329)}$

$\Rightarrow S_w = 5.673\,m$

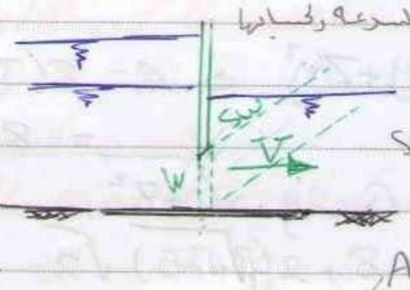
Check C

$C = 0.6 + 0.018\,(5.673) > 1$

use $C = 0.92$

$45.57 = 0.92\,(S_w)(3)\sqrt{19.62(0.329)} \Rightarrow S_w = 6.5\,m$

2. For free flow



المطلوب حساب السرعة ولحسابها يجب نعرف المساحة Sw*W ثم نستخدم $A \times V = Q$

$Q = C_d\, S_w\, W\sqrt{2gy_1}$

$y_1 = 39.2 - 33.2 = 6\,m$

$45.57 = \frac{0.61}{\left(1+0.61\frac{W}{6}\right)^{1/2}} *(6) * W\sqrt{19.62(6)} \Rightarrow W = 1.215\,m$

Q قيمتها من المطلب الاول

Area of flow $= W * S_w$

$= 1.215 * 6 \Rightarrow 7.29\,m^2$

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∴ velocity of flow through the openings:

$$V = \frac{Q}{A} = \frac{45.57}{7.29} = 6.25\ m/sec$$

3. $t_A = \frac{h_A}{G-1}\left(\frac{4}{3}\right)$

$$h_A = H\left(1 - \frac{L.W_A}{L.W.}\right)$$

$$L.W. = 2(d_1 + d_2) + b \Rightarrow 2(2.5 + 4) + 20 = 33\ m$$

$$L.W_A = 2d_1 + (b - 2.5) \Rightarrow 2 \times 2.5 + (20 - 2.5) = 22.5\ m$$

$$H = 36.45 - 33.2 =$$ ناخذ في حال الـ Normal ولا نأخذ التيارات

$$\therefore h_A = (36.45 - 33.2)\left(1 - \frac{22.5}{33}\right)$$

$$h_A = 1.034\ m$$

$$t_A = \frac{1.034}{2.4 - 1}\left(\frac{4}{3}\right) = 0.98\ m$$

4. safe $i = \frac{1}{12}$

$$i = \frac{H}{L.W.} = \frac{3.25}{33} = \frac{1}{10.15} > \frac{1}{12}$$

The structure is not safe against piping

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2. Lane's weighted creep Theory

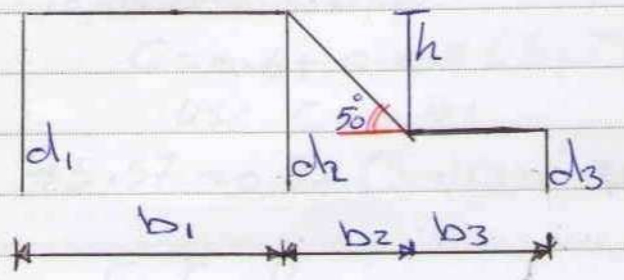
طريقة لين لخط الزحف الموزون

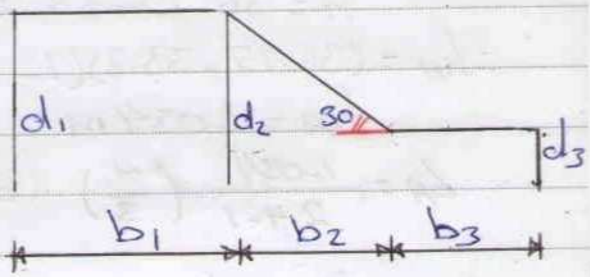
$$L.W. = \frac{1}{3}H + 2V$$

where:

H = Sum of all horizontal distance + The slope Contact less than 45°

V = Sum of all vertical distance + the slope Contact more than 45°





$$L.W. = \frac{1}{3}(b_1 + b_3) + 2(d_1 + d_2 + d_3) + h$$

لأن الزاويه اكبر من 45 نعتبر الجزء هذا [illegible]

$$L.W. = \frac{1}{3}(b_1 + b_2 + b_3) + 2(d_1 + d_2 + d_3)$$

لأن الميل اقل من 45 [illegible] 45 [illegible]

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a. Safe against piping

$L.W. = C*H$

C = coefficient

The coefficient (C) must be kept agreater than the safe limit, in order to ensure safety against piping

قيمة C المستخرجة تكون اكبر من C المستخرجة من الجدول حسب الطريقة السابقة

NO.	Soil Type	C
1	Very fine Sand or Silt	8.5
2	Fine sand	7
3	Coarse Sand	5
4	Gravel and Sand	3.5 – 5
5	Bolder and gravel Sand	2.5 – 3
6	Clay	1.5 – 3

Ex: For the previous example chack the structure is safe against piping using Lane's theory

Solution Coarse sand, from table $C = 5$.

$$L.w. = \frac{1}{3}H + V$$

$$= \frac{1}{3}(20) + 2(2.5+4) \Rightarrow Lw. = 6.67 + 13 = 19.67\,m$$

$$L.W. = C*H \Rightarrow C = \frac{Lw.}{H} = \frac{19.67}{3.25} = 6.052 > 5$$

$\therefore ok$

Notebook

b. Safety against uplift pressure.

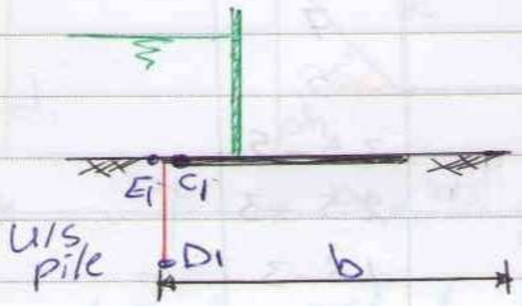
$$h_i = H\left(1 - \frac{L_{wi}}{L_{wc}}\right)$$

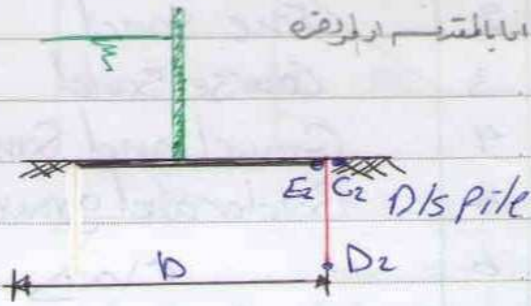
$$t_i = \frac{h_i}{G-1} * \frac{4}{3}$$

3. Khosla's Theory

The cases were analyzed by Khosla are shown below:

a. Straight horizontal floor of negligible thickness with pile at U/s end or at D/s end.
ارضيه افقيه ثخن مهمل
مع pil اما بالمقدمه او المؤخره





E_1, C_1, D_1, E_2, C_2 and D_2 = key points.

b. Straight horizontal floor of negligible thickness with pile at same intermediat point
ارضيه افقيه بدون ثخن مع pil
في اي نقطه وسطيه بالوسط

E_3, C_3 and D_3 = key point

Subject: Hydraulic Structures

27/10/

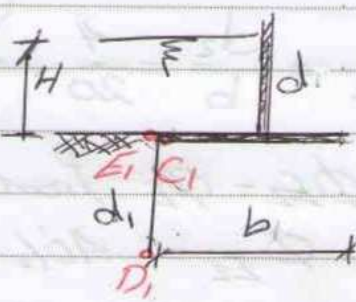
انشاءات

1. For U/S pile

$\phi E_1 = 100\%$

$\phi D_1 = 100\% - \phi_D$ (from curve)

$\phi C_1 = 100\% - \phi_E$ (from curve)

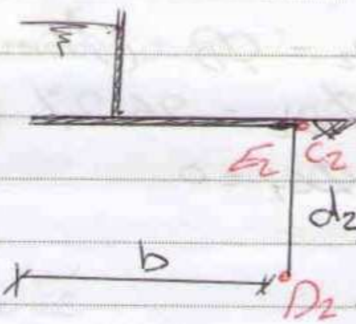


2. For D/S pile

$\phi_{E_2} = \phi_E$ (from curve)

$\phi D_2 = \phi_D$ (from curve)

$\phi C_2 = 0$



EX: $b = 20m$, $d_1 = 2.5m$, $d_2 = 4m$, $H = 4m$

Find ϕ_{E_1}, ϕ_{D_1}, ϕ_{C_1}, ϕ_{E_2}, ϕ_{D_2}, ϕ_{C_2}

$$\frac{1}{\alpha} = \frac{d_1}{b} = \frac{2.5}{20} = \frac{1}{8} = 0.125$$

$\phi_{E_1} = 100\%$

$\phi_{D_1} = 100\% - \phi_D$ (from curve)

ϕ_D from curve $= 22\%$

$\therefore \phi_{D_1} = 100 - 22 = 78\%$

$\phi_{C_1} = 100 - \phi_E$

ϕ_E from curve $= 33\%$

$\therefore \phi C_1 = 100 - 33 = 67\%$

Subject: Hydraulic Structures

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For D/s pile

$$\frac{1}{\alpha} = \frac{d_2}{b} = \frac{4}{20} = 0.2$$

$\phi_{E_2} = \phi_E$ from curve

$\phi_{E_2} = 40\%$

$\phi_{D_2} = \phi_D$ (from curve)

$\phi_{D_2} = 26.2\%$

$\phi_{C_2} = 0$

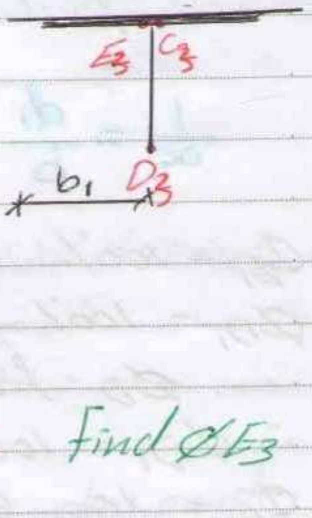
ϕ	%
E_1	100
D_1	78
C_1	67
E_2	40
D_2	26.2
C_2	0

Must be Corrected

النقاط التي يتم إجراء تصحيح لها هي النقاط الواقعة من الخلف فقط

3. For Intermedrat pile

To find ϕ_{E_3} for any value of α and base ratio $\frac{b_1}{b}$



1. read ϕ_C for base ratio $(1-\frac{b_1}{b})$ for that value of α
2. $\phi_{E_3} = 100 - \phi_C$

Ex: $b_1 = 8m$, $b = 20m$, $d = 5m$ Find ϕ_{E_3}

$$\alpha = \frac{b}{d_1} = \frac{20}{5} = 4$$

$$\frac{b_1}{b} = \frac{8}{20} = 0.4$$

Subject: Hydraulic Structures / /

$$\left(1-\frac{b_1}{b}\right) = 1-0.4 = 0.6 \ \left(\text{New } \frac{b_1}{b}\right)$$

from Curve $\phi_C = 29.2\%$

$\therefore \phi_{E_3} = 100 - 29.2$

$= 70.8\%$

To Get ϕ_{D_3} for value of $\frac{b_1}{b}$ less than 0.5

1. Read ϕ_D for base ratio $\left(1-\frac{b_1}{b}\right)$

2. $\phi_{D_3} = 100 - \phi_D$ (from curve)

To Get ϕ_{D_3} for value of $\frac{b_1}{b}$ more than 0.5

1. Read ϕ_D direct from Curve for $\frac{b_1}{b}$

2. $\phi_{D_3} = \phi_D$ (from Curve)

$$\frac{b_1}{b} = 0.4 < 0.5$$

$$\therefore \left(1-\frac{b_1}{b}\right) = 1-0.4 = 0.6 \text{ with } \alpha = 4$$

$\phi_D = 45.3\%$ (from Curve)

$\therefore \phi_{D_3} = 100 - 45.3 = 54.7\%$

To Get ϕ_{C_3} read ϕ_C direct from Curves

$\phi_{C_3} = \phi_C$ (from curve)

$\frac{b_1}{b} = 0.4$ with $\alpha = 4 \Rightarrow \phi_C = 41\%$

$\therefore \phi_{C_3} = \phi_C$ (from Curve) $= 41\%$

Subject: *Hydraulic Structures* / /

Corrections of pressures :-

1. Correction of Mutual Interference of pile :-

تصحيح التداخل الحاصل من استخدام pile في المنشأ لوجوده في آن واحد

$$C_1 = 19\sqrt{\frac{D}{b_1}}\left(\frac{d+D}{b}\right)$$

b_1 = distance between two piles

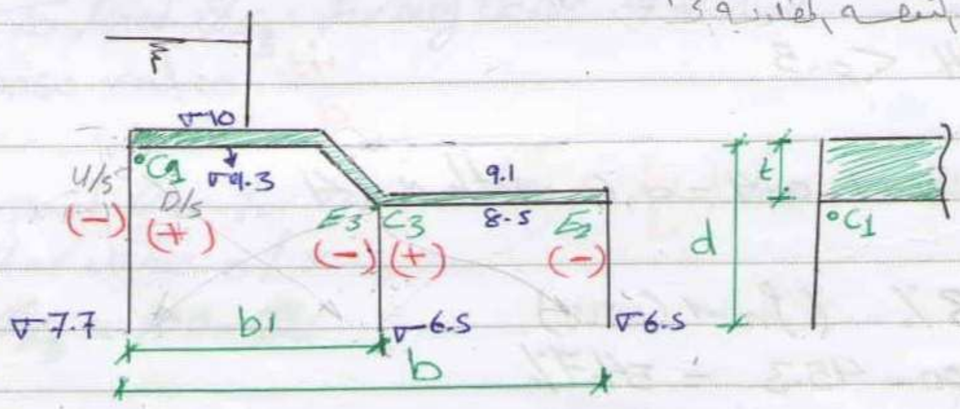
b = Length of the floor

d = depth of pile $= (d-t)$

D = depth of pile whose effect required to be determined

عمق التأثير للـ pile المقابل

العمق من منسوب النقطة المطلوبة



D = منسوب النقطة المطلوب إيجاد التصحيح لها − منسوب أوطى نقطة للـ pile المقابل

$D_{C_1} = 9.3 - 6.5$, $D_{C_2} = 8.5 - 6.5$

$D_{E_3} = 8.5 - 7.7$, $D_{E_2} = 8.5 - 6.5$

Subject: Hydraulic Structures / /

Correction (C_1) is (+ve) in the rear or back of water

تكون الاشارة موجبة اذا كانت موقع النقطة معاكس الجريان

Correction (C_1) is (-ve) in the front of the flow

عكس اعتبار pile: اي تقع في U/s سالبة وفي D/s موجبة مع الاتجاه هنالك

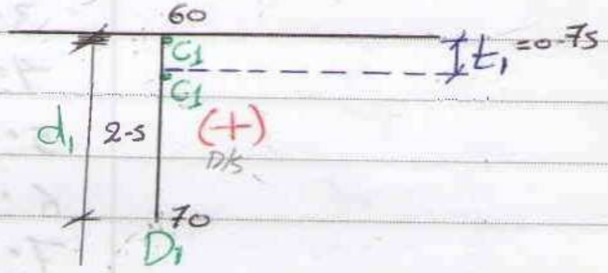
شيء تعكس الرسم نحسب الاتجاه اذا موقع U/s و D/s

2. Correction of Floor Thickness

Khosle's graphs give the percentage of pressure at the top level of the floor. While the acual junction at the bottom. المنحنيات تعطي نسبة مئوية الضغط على السطح

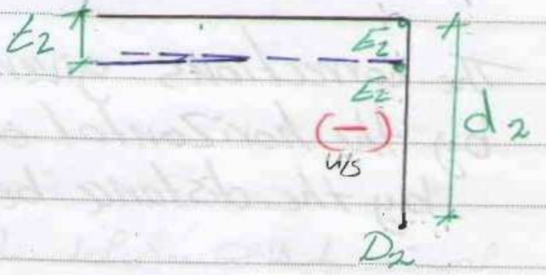
الاعلى في الارضية ولكنه الحقيقي يكون في الاسفل

$$C_{2\phi C_1} = \left(\frac{\phi_{D_1} - \phi_{C_1}}{d_1}\right)(t_1)$$



الضغط اعلى   الضغط اقل

$$C_{2\phi E_2} = \left(\frac{\phi_{E_2} - \phi_{D_2}}{d_2}\right)(t_2)$$



Subject: Hydraulic Structures   /   /

The Correction of thickness is (+ve) for key point lie on the D/S side of pile, and this Correction is (-ve) for key point on the U/S side of pile.

3. Correction of slope

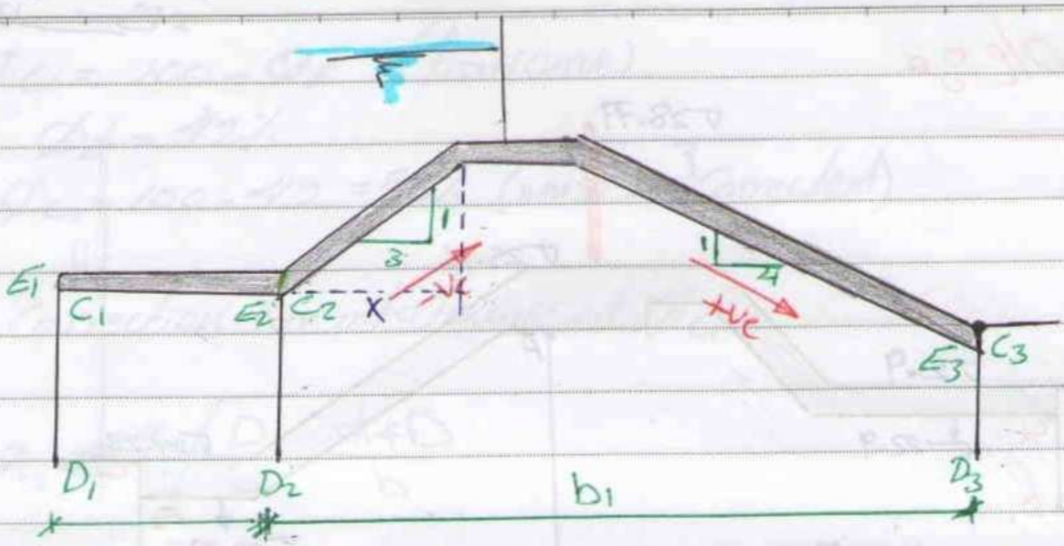
Correction is applied for sloping floor and take (+ve) for the down and (-ve) for up slopes following the direction of flow

Slop H : V	Correction
1:1	11.2
2:1	6.5
3:1	4.5
4:1	3.3
5:1	2.8
6:1	2.5
7:1	2.3
8:1	2

The corrections given in the table is to be multiplied by the horizontal distance of slope and divided by the distance between two piles

التصحيح المستخرج من الجدول نضربه مع المسافة الأفقية للميل ونقسمه على المسافة بين ال pile

Subject: Hydraulic Structures



from table

$4.5 * \frac{X}{b_1}$ → X: horizontal distance of slop; b_1: distance between two piles

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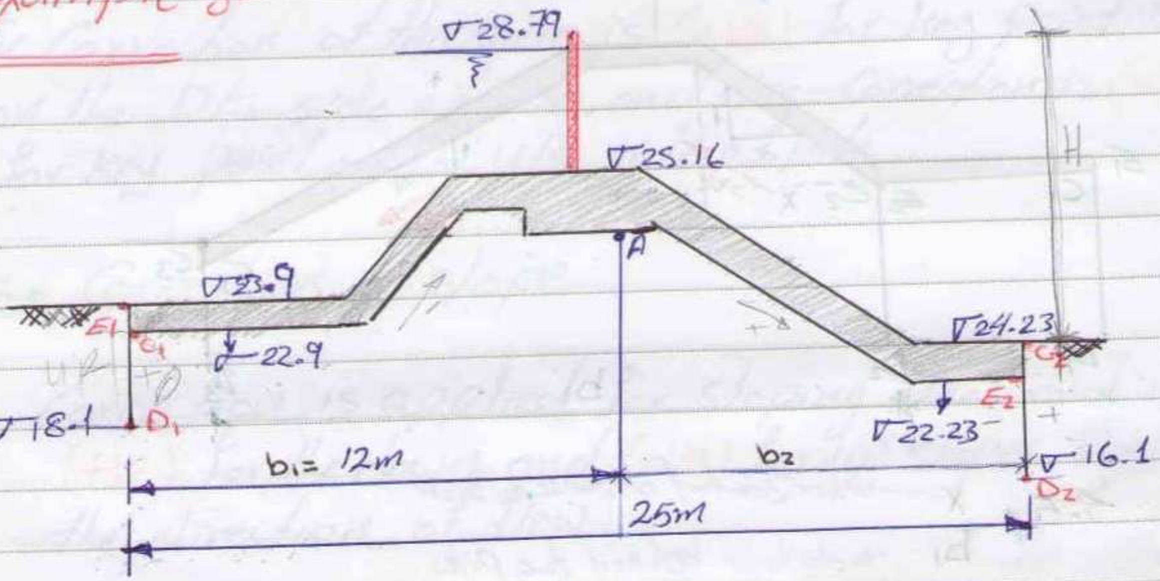
Example



Determine the percentage pressure at key points and then find the thickness of floor at point A. Using Khosla's theory

Sol//

1. U/S Pile

$$\frac{1}{\alpha} = \frac{d_1}{b}$$

$d_1 = 23.9 - 18.1 = 5.8m$

$\frac{1}{\alpha} = \frac{5.8}{25} = 0.23$

$\phi_{E_1} = 100\%$

$\phi_{D_1} = 100 - \phi_D$ (from curve)

$\phi_D = 28\%$

$\therefore \phi_{D_1} = 100 - 28 = 72\%$

Subject: Hydraulic Structures

$\phi_{C_1} = 100 - \phi_E$ (from curve)

$\phi_E = 42\%$

$\therefore \phi_{C_1} = 100 - 42 = 58\%$ (must be Corrected)

a. Correction for interference of ϕ_{C_1}

$$C_1\phi_{C_1} = 19\sqrt{\frac{D}{b_1}}\ \frac{d+D}{b}$$

$b_1 = b = 25\,m$

$d = 22.9 - 18.1 = 4.8\,m$ ← نستخدم d بالاعتماد على هذه القيمة

$D = 22.9 - 16.1 = 6.8\,m$

ونستخرجها بهذا الشكل فقط عندما نصحح
C1 التصحيح الاول وفيما
عدا ذلك نستخدم قيمة d كما استخرجناها
في بداية الحل

$$C_1\phi_{C_1} = 19\sqrt{\frac{6.8}{25}}\left(\frac{4.8+6.8}{25}\right)$$

$$= 4.61\%\ (+ve)$$

b. Correction for thickness of ϕ_{C_1}

$$C_2\phi_{C_1} = \left(\frac{\phi_{D_1} - \phi_{C_1}}{d_1}\right)(t_1)$$

$$= \frac{72 - 58}{5.8}(1) = 2.41\%\ (+ve)$$

c. ~~No~~ Correction for sloping

$\therefore$ Corrected $= \phi_{C_1} = 58 + 4.61 + 2.41$

$= \boxed{65.02\%}$

Subject: Hydraulic Structures

2. D/S pile

$$\frac{1}{\alpha} = \frac{d_2}{b}$$

$d_2 = 24.23 - 16.1 = 8.13m$

$$\frac{1}{\alpha} = \frac{8.13}{25} = 0.325$$

$\phi_{E_2} = \phi_E$ (from curve)

$\phi_E = 48\%$

$\therefore \phi_{E_2} = 48\%$ (must be corrected)

$\phi_{D_2} = \phi_D$ (from curve)

$\phi_D = 32\%$

$\therefore \phi_{D_2} = 32\%$

$\phi_{C_2} = \text{Zero}$

a. Correction for interference of ϕ_{E_2}

$$C_1 \phi_{E_2} = 19 \sqrt{\frac{D}{b_1}} \left(\frac{d+D}{b}\right)$$

$b_1 = b = 25$

$d = 22.23 - 16.1 = 6.13m$

$D = 22.23 - 18.1 = 4.13m$

Subject: *Hydraulic Structures*

$$\therefore C_{1\phi_{E_2}} = 19\sqrt{\frac{4.13}{25}\left(\frac{6.13+4.13}{25}\right)} = 3.17\%(-ve)$$

b. Correction for thickness of ϕ_{E_2}

$$C_{2\phi_{E_2}} = \left(\frac{\phi_{E_2} - \phi_{D_2}}{d_2}\right)(t_2)$$

$$C_{2\phi_{E_2}} = \left(\frac{48-32}{8.13}\right)(24.23-22.23)$$

$$= 3.94\% \ (-ve)$$

$$\therefore \text{Corrected } \phi_{E_2} = 48 - 3.17 - 3.94$$

$$= \boxed{40.89\%}$$

2//

$$\text{percentage head at point } A = \phi_{C_1} - \frac{(\phi_{C_1} - \phi_{E_2})}{b}(b_1)$$

$$\text{or} = \phi_{E_2} + \left(\frac{\phi_{C_1} - \phi_{E_2}}{b}\right)(b_2)$$

$$= 65.02 - \left(\frac{65.02 - 40.89}{25}\right)(12)$$

$$\text{or} = 40.89 + \left(\frac{65.02 - 40.89}{25}\right)(13)$$

$$= 53.43\%$$

ا- عبارة عن ϕ_{C_1} مطروح منه مقدار الفرق في الضغط بين C_1 و E_2 وذلك لكل وحدة طول ثم نضرب بالمسافة بين C_1 و A

ب- الضغط في جهة الثانية A : عبارة عن ϕ_{E_2} نجمع معها الفرق في الضغط بين C_1 و E_2 لكل وحدة طول ثم نضربها بالمسافة بين E_2 و A

$$h_A = 0.5343\,(H)$$
$$= 0.5343\,(28.79 - 24.23)$$
$$= 2.439\ m$$

$$t = \frac{h_A}{G-1}\left(\frac{4}{3}\right)$$

$$t_A = \left(\frac{2.439}{2.4-1}\right)\left(\frac{4}{3}\right)$$

$$t_A = 2.32\,m$$

Exit Gradient (G.e)

$$G.e = \frac{H}{d} * \frac{1}{\pi\sqrt{\lambda}}$$

H = U/S water level – D/S water level (closed gate)
d = depth of D/S pile

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$$

$$\alpha = \frac{b}{d}$$

$$F.S = \frac{1}{G.e}$$

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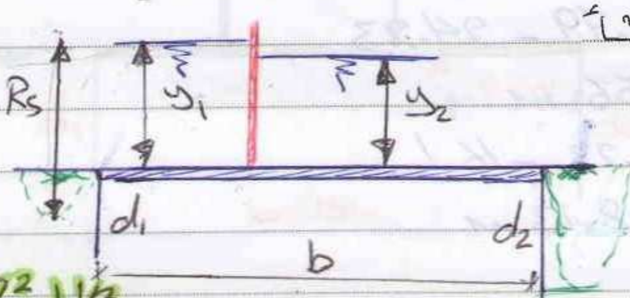
No.	Soil Type	G.C
1	Shingle	$\frac{1}{4}-\frac{1}{5}$
2	Coarse sand	$\frac{1}{5}-\frac{1}{6}$
3	Fine sand	$\frac{1}{6}-\frac{1}{7}$

Depth of pile

نعتمد على حساب التعرية التي تحدث
في بداية ونهاية المنشأ
فبذلك يتم وضع pile تحت
على العمق الذي سوف
عندما يحفر تحتها
تسرب المياه



$$R_s = 1.35\left(\frac{q^2}{f}\right)^{1/3}$$

$$q = \frac{Q}{S_w}$$

f :- silt factor (0.65 – 1) $\Rightarrow f = 1.76\sqrt{D}$

R_s :- distance from water surface to the lower point of excavation

D :- Diameter of particales

at U/S use $(1-1.25)R_s$

at D/S use $(1.25-1.5)R_s$

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$$d_1 = (1 - 1.25)R_s - y_1$$
$$d_2 = (1.25 - 1.5)R_s - y_2$$

Example :- for the previous example is the structure safe against piping use khosla's theory. $Ge = \frac{1}{6}$

Solution :-

$$G.e = \frac{H}{d} * \frac{1}{\pi\sqrt{\lambda}}$$

$H = 28.79 - 24.23$

$H = 4.56\ m$

$d = d_2 = 24.23 - 16.1$

$= 8.13\ m$

$b = 25\ m$

$$\alpha = \frac{b}{d_2} = \frac{25}{8.13} = 3.075$$

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$$

$$\Rightarrow \frac{1+\sqrt{1+(3.075)^2}}{2} = 2.116$$

$$G.e = \frac{4.56}{8.13} * \frac{1}{\pi\sqrt{2.116}} = 0.122 = \frac{1}{8.149} < \frac{1}{6}$$

$\therefore$ the structure is safe against piping

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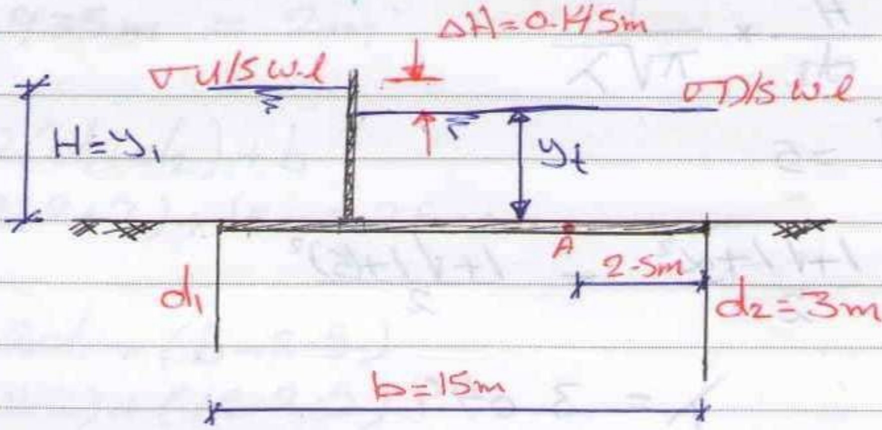
Ex: A regulator was constructed to pass a discharge of canal with allowable head loss (ΔH) equal to (0.145 m). The following data are available:

- Depth of D/S pile (d_2) = 3m
- Length of horizontal floor (b) = 15m
- Width of regulator gate (S_w) = 6m
- $G.e = \frac{1}{7}$; $f = 0.712$, $C = 0.92$
- $G_{conc.} = 2.4$ ton/m³ ; neglect hv



a- Find the approximate design discharge (Q) of this regulator

b. Find thickness of floor at point (A) using Bligh's theory

c. Is this structure is safe against piping by using Bligh's theory use $i = \frac{1}{12}$

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Solution:

$$Q = C * S_w * y_t \sqrt{2gH_1}$$

$H_1 = \Delta H = 0.145m$

$S_w = 6m$

$C = 0.92$

$y_t = ?$

$$G.e = \frac{H}{d_2} * \frac{1}{\pi\sqrt{\lambda}}$$

$$\alpha = \frac{15}{3} = 5$$

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2} = \frac{1+\sqrt{1+(5)^2}}{2}$$

$$\lambda = 3.049$$

$$\frac{1}{7} = \frac{H}{3} * \frac{1}{\pi\sqrt{3.049}} \Rightarrow H = 2.351m = y_1$$

$$\therefore y_t = H - \Delta H$$

$$\Rightarrow 2.351 - 0.145 = 2.206m$$

$$Q = 0.92 * 6 * 2.206 \sqrt{19.62(0.145)}$$

$$Q = 20.5\ m^3/sec$$

Subject: Hydraulic Structures

b.

* $d_1 = 1.25 R_S - y_1$
* $R_S = 1.35\left(\frac{q^2}{f}\right)^{1/3}$

$q = \frac{20.5}{6} = 3.416 \ m^3/sec/m$

$R_S = 1.35\left(\frac{(3.416)^2}{0.712}\right)^{1/3} = 3.429 m$

$d_1 = 1.25(3.429) - 2.351$
$= 1.935 m \approx 2m$

$l.w. = 2(d_1 + d_2) + b$
$= 2(2+3) + 15 = 25 m$

$l.w._A = 2d_1 + (b - 2.5)$
$= 2(2) + (15 - 2.5)$
$= 16.5 m$

$\therefore h_A = H\left(1 - \frac{l.w_A}{l.w.}\right)$

$= 2.351\left(1 - \frac{16.5}{25}\right) \Rightarrow h_A = 0.799 m$

$t_A = \frac{4}{3} * \frac{h_A}{G-1} = \frac{4}{3} * \frac{0.799}{1.4}$

$= 0.76 m$

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C.

$l.w. = 25$

$H = 2.351\,m$

$i = \frac{H}{l.w.} = \frac{2.351}{25} = \frac{1}{10.6} > \frac{1}{12}$

$\therefore$ the structure is not safe against piping.

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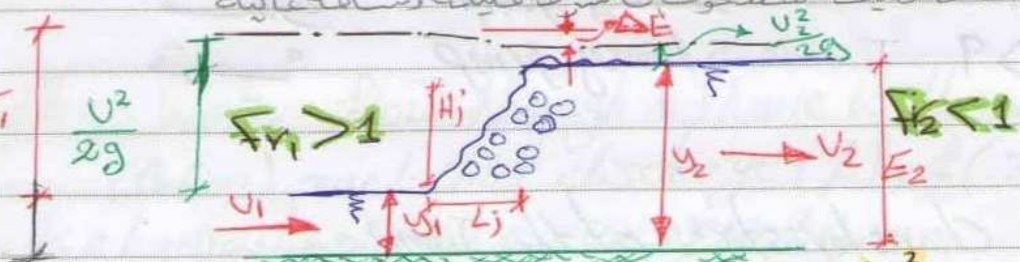
Energy Dissipation تشتيت الطاقة

1. Hydraulic Jump

It is one of the best energy dissipators. The Froud Number (Fr) is used an index to the properties of this jump. واحده من افضل مشتتات الطاقة وتحتوي على (Fr) للتعبير عن القفزه

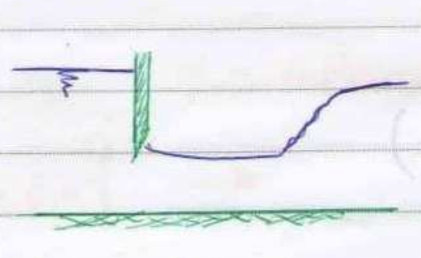
سرعه عاليه ومساحه قليله ستتحول الى سرعه قليله ومساحه عاليه

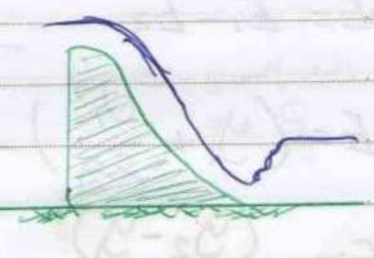


$$E_1 = y_1 + \frac{U_1^2}{2g}$$
الطاقة قبل القفزه

$$E_2 = y_2 + \frac{U_2^2}{2g}$$
الطاقة بعد القفزه

$$Fr = \frac{V}{\sqrt{gy}}$$





The equation of the hydraulic jump is: $Fr > 1$ لا يمكن تصميم المعادله الا ل

$$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8Fr_1^2} - 1\right]$$

$$Fr_1 = \frac{U_1}{\sqrt{gy_1}} , \quad Fr_2 = \frac{U_2}{\sqrt{gy_2}}$$

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Types of Hydraulic Jump:

The jump can be classified according to (Fr) as:

1. $Fr = 1 - 1.7$ undular jump متموجه
2. $Fr = 1.7 - 2.5$ weak jump ضعيفه
3. $Fr = 2.5 - 4.5$ Oscillating Jump متذبذبه
4. $Fr = 4.5 - 9$ steady jump مستقره
5. $Fr > 9$ strong jump قويه

Basic charateristics of the Jump:

1. Energy Loss (ΔE)

$$\Delta E = E_1 - E_2$$

$$\Delta E = \left(y_1 + \frac{U_1^2}{2g}\right) - \left(y_2 + \frac{U_2^2}{2g}\right)$$

$$\Delta E = \frac{(y_2 - y_1)^3}{4 y_1 y_2}$$

2. Efficiency of the jump كفاءه القفزه

$$\frac{E_2}{E_1} = \frac{(8Fr_1^2 + 1)^{3/2} - 4Fr_1^2 + 1}{8Fr_1^2 (2 + Fr_1^2)}$$

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3. Height of the jump (H_j)   هذه المعادلات في القنوات المستطيلة فقط

$$H_j = y_2 - y_1$$

4. Length of the Jump (L_j)

$$L_j = 6.9(y_2 - y_1)$$

Example: Water flow through a flume (قناة) with a depth of (0.6m) and unit discharge (q) of ($3.7\ m^3/sec/m$)

1. Is a hydraulic jump occur or not?
2. Determine the depth of flow at the D/S of the jump and find the energy dissipation in this jump (ΔE).

B البعد العمودي = عرض القناة

$q = \frac{Q}{B}$

تعريف لكل وحدة طول

1.

$$Fr_1 = \frac{U_1}{\sqrt{g y_1}}$$

$$U_1 = \frac{Q}{A_1} = \frac{q \times B}{y_1 B} = \frac{3.7}{0.6} \Rightarrow U = 6.17\ m/sec$$

$$Fr_1 = \frac{6.17}{\sqrt{9.81 * 0.6}} = 2.54 > 1$$

∴ The jump will occur. Oscillating jump

2.

$$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8Fr_1^2} - 1\right]$$

$$\frac{y_2}{0.6} = \frac{1}{2}\left[\sqrt{1+8(2.54)^2} - 1\right]$$

$$\Rightarrow y_2 = 1.88\ m$$

$$\Delta E = \frac{(1.88-0.6)^3}{4(0.6)(1.88)} = 0.46\ m$$

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الثلاثاء

EX:- The formula of discharge which pass over the Crest of Spillway (shown in the figure) is:-

$$Q = C L H^{3/2}$$

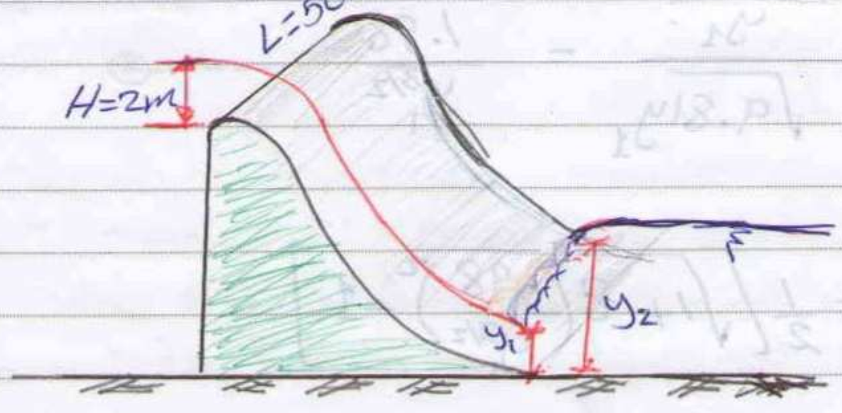
where:-

L = the water way of the spillway (50m)
H = the water depth over the crest = 2m
C = Coefficient of discharge = 2.2

At the end of this spillway; a hydraulic jump occured. The hight of this jump (h_j) is (5m)

1. Find the depth of water before and after the jump (y_1 and y_2)

2. what is the name of this jump and How much is the energy loss in this jump?



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$$Q = C H^{3/2} L$$

$$Q = 2.2(2)^{3/2}(50)$$

$$Q = 311.12 \ m^3/sec$$

$$h_j = y_2 - y_1 = 5m \Rightarrow y_2 = 5 + y_1 \quad — \circledast$$

$$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8Fr_1^2} - 1\right]$$

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}}$$

$$V_1 = \frac{Q}{A_1} = \frac{311.12}{50 y_1}$$

$$V_1 = \frac{6.22}{y_1}$$

$$Fr_1 = \frac{\frac{6.22}{y_1}}{\sqrt{9.81 y_1}} = \frac{1.98}{y_1^{3/2}} \quad ---- \circledast$$

$$\frac{5+y_1}{y_1} = \frac{1}{2}\left[\sqrt{1+8\left(\frac{1.98}{y_1^{3/2}}\right)^2} - 1\right]$$

Notebook

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$$5+y_1 = \frac{y_1}{2}\left[\sqrt{1+8\left(\frac{1.98}{y_1^{3/2}}\right)^2}-1\right]$$

$$y_1 = \left[\frac{y_1}{2}\left[\sqrt{1+8\left(\frac{1.98}{y_1^{3/2}}\right)^2}-1\right]\right]-5$$

لإيجاد قيمة y_1 نستخدم طريقة Try & Error

نفرض قيمة y_1 للطرف الأيمن ويجب أن تكون مساوية أي y_1 في الطرف الأيسر الناتج سالب هنا يدل على أن الجواب أن نأخذ ما بينهما

$\Rightarrow 0.2 \Rightarrow 1.16$

$\rightarrow 0.3 \Rightarrow -0.035$

$\Rightarrow 0.25 \Rightarrow 0.6$

$\Rightarrow 0.28 \rightarrow 0.15$

$\Rightarrow 0.268 \rightarrow 0.276$

$\approx y_1 = 0.268$

$y_2 = 5+0.268 = 5.268\,m$

$$\Delta E = \frac{(y_2-y_1)^3}{4y_1y_2} = \frac{(5)^3}{4(0.268)(5.268)} = 22.134\,m$$

$$Fr_1 = \frac{\frac{6.22}{0.268}}{\sqrt{9.81 * 0.268}} = 14.3 > 9 \quad \text{Stronge Jump.}$$

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2. Standard Stilling Basins

A stilling basin is a short length of a paved channel placed at the end of any supercritical flow. The aim of the designes is to make a hydraulic jump form within the basin, so that the flow is converted to subcritical before it reaches the exposed and unpaved river bed at D/S

قناة مبطنة قصيرة الطول توضع في نهاية أي جريان فوق الحرج الغاية هو صنع قفزة
هايدروليكية فيتحول الجريان إلى قبل الحرج وهذا قبل أن يصل
أرضية النهر المكشوفة غير المبطنة

Types of stilling Basins :-

1. U.S.B.R. stilling basin No. II :-

It is used when the incoming velocity exceed 15 m/sec and for high spillway or high head and large structures

يستخدم عندما تكون V القادم للحوض أكثر من 15
وتستخدم للارتفاعات الكبيرة

$Fr > 4.5$

This basin contains chute blocks at the U/S end and dentated sill near the D/S end. No baffle piers are used because the relatively high velocities entering the jump might cause cavitation on piers.

يحتوي على chute block لا تستخدم في الوسط لأنها قد تسبب تفريغ
نتيجة السرعة العالية مما يؤدي الى تآكل الكتل

Subject: Hydraulic Structures / /

2. U.S.B.R. Stilling Basin No. III :-

This Basin may be used when the incoming velocity do not exceed ·15m/sec and for $Fr > 4.5$, but for small structures.
It is same as No. II but with addional blocks (baffle piers) and continous sill.
كتل صدمة

نستخدم سرعة أقل من 15 و $Fr > 4.5$، ويستخدم للمنشآت الصغيرة وللاختلاف
بينه وبين NO.II انه في الحوض يحتوي block
sill عتبة مستمرة.

3. U.S.B.R. Stilling Basin No IV :-

This is recomended for use with jumps of $Fr = 2.5$ to 4.5
which is usually occur on canal structures and diversion dams.
This basin is applicable to rectangular cross section only.
دائماً تحدث في منشآت القنوات والسدود التحويلية.

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4. S.A.F Stilling Basin

It is used for small structures and for $F_r = 1.7 - 17$

The stilling basin side walls may be parallel (as in rectangular stilling basin) or they may diverge as an extension of the transition side walls (as in trapezoidal Basin)
الجوانب

Design parameters for S.A.F Basins.

F_{r1}	$1.7 - 5.5$	$5.5 - 11$	$11 - 17$
L_B/y_2	$4.5/F_{r1}^{0.76}$	$4.5/F_r^{0.76}$	$4.5/F_{r1}^{0.75}$
TW/y_2	$1.1 - F_{r1}^2/120$	0.85	$1 - F_{r1}^2/800$

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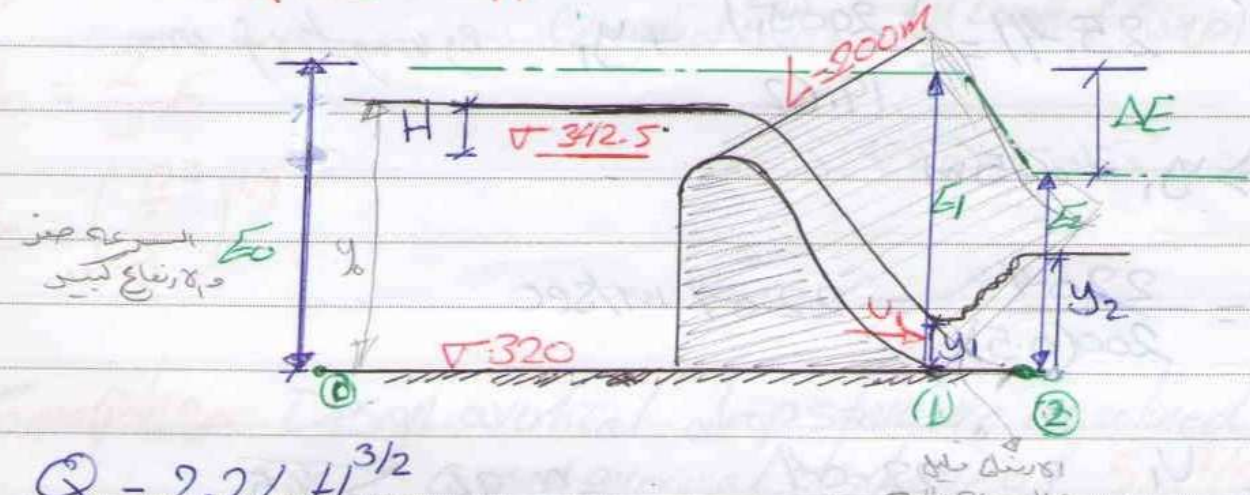
Ex: Design a stilling basin for an over flow spillway with the following given data:

- Design Discharge (Q) = 2204 m³/sec
- Length of the spillway (L) = 200 m
- Crest level of spillway = 342.5 m

Bed level of the spillway = 320 m

Equation of discharge over the spillway is:

$$Q = 2.2\, L H^{3/2}$$



$$Q = 2.2\, L H^{3/2}$$

$$2204 = 2.2\,(200)\, H^{3/2} \Rightarrow H = 2.91\ m$$

$$E_0 = E_1$$

$$\cancel{\frac{U_0^2}{2g}} + y_0 = \frac{U_1^2}{2g} + y_1$$

$$y_0 = \frac{U_1^2}{2g} + y_1$$

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$$(342.5-320)+H = \frac{U_1^2}{2g}+y_1$$

$$25.41 = \frac{U_1^2}{2g}+y_1$$

$$V = \frac{Q}{A_1} = \frac{2204}{L\times y_1} = \frac{2204}{200y_1}$$

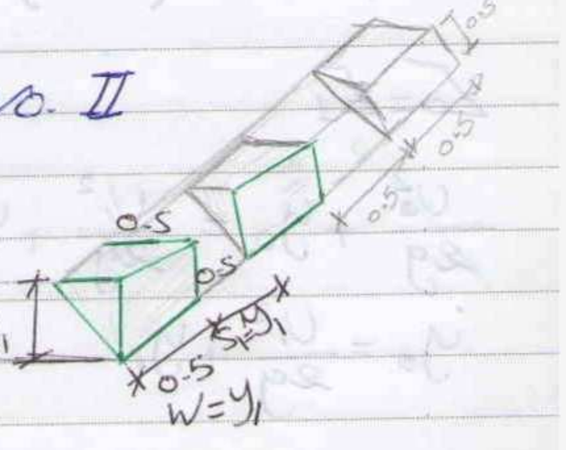
$$\Rightarrow 25.41 = \frac{\left(\frac{2204}{200y_1}\right)^2}{19.62}+y_1$$ By using try & error

$$\Rightarrow y_1 = 0.5m$$

$$U_1 = \frac{2204}{200(0.5)} = 22.04 \ m/sec$$

$$Fr_1 = \frac{U_1}{\sqrt{2gy_1}} = \frac{22.04}{\sqrt{9.81\times0.5}} = 9.96 > 4.5$$

∴ Use U.S.B.R stilling Basin No. II



$$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1+8Fr^2}-1\right]$$

$$\frac{y_2}{0.5} = \frac{1}{2}\left[\sqrt{1+8(9.96)^2}-1\right]$$

$$\Rightarrow y_2 = 6.79m$$

$$L = 4.3y_2$$

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الثلاثاء

3. Vertical Drop:

$$\text{Drop number } D = \left(\frac{y_c}{Z_D}\right)^3$$

$$L_D = 4.3 * Z_D \, D^{0.27}$$

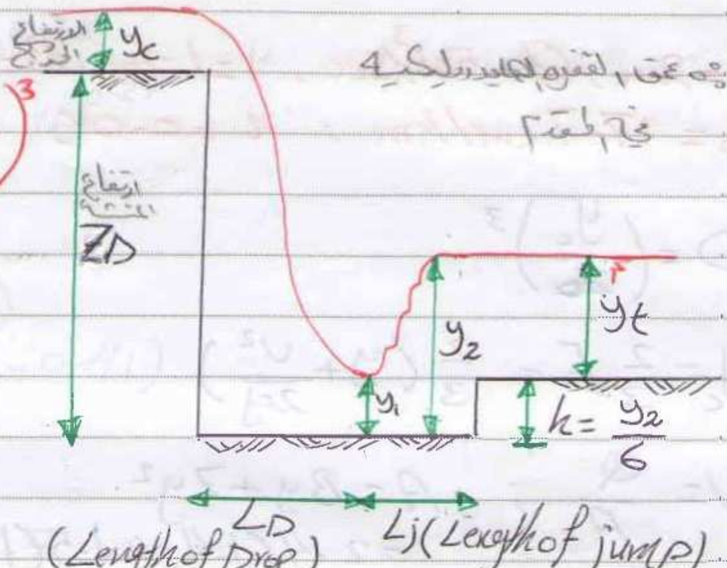
$$y_1 = 0.54 \, Z_D \, D^{0.425}$$

$$y_2 = 1.66 \, Z_D \, D^{0.27}$$

$$L_j = 6.9\,(y_2 - y_1)$$

$$y_c = \frac{2}{3} E$$

$$y_c = \left(\frac{q^2}{g}\right)^{1/3}$$



y_1 يؤخذ عمق الفقرة الهايدروليكية في المقدمة

من مشتقات الطاقة

Example: Design a vertical drop structure in a lined canal carrying a normal discharge of $5 \, m^3/sec$ to lower the water from U/S to D/S by 2m. The canal section in the reaches U/S and D/S of the structure are the same and as given below:

- Depth of flow $(y) = 1.4 m$
- Bed width $(B) = 2.4 m$
- Longitutional slop $(S) = 17.7$ cm/km
- Side slop $(Z) = 1.5:1$
- Manning's $(n) = 0.015$
- $Z_D = 2m$

Notebook FUTURE

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$Z_D = 2m$, $Q = 5m^3/sec$, $y = 1.4m$, $B = 2.4m$, $Z = 1.5:1$
$S = 17.7\ cm/km$, $n = 0.015$

$$D = \left(\frac{y_c}{Z_D}\right)^3$$

$$y_c = \frac{2}{3}E = \frac{2}{3}\left(y + \frac{V^2}{2g}\right)$$

$$V = \frac{Q}{A} \quad ; \quad A = By + Zy^2$$
$$= 2.4(1.4) + 1.5(1.4)^2$$

$$V = \frac{5}{6.3} = 0.794\ m/sec$$

$$y_c = \frac{2}{3}\left(1.4 + \frac{(0.794)^2}{2*9.81}\right) = 0.96m$$

$$D = \left(\frac{0.96}{2}\right)^3 = 0.11$$

$$L_D = 4.3 * Z_D * D^{0.27}$$
$$= 4.3(2)(0.11)^{0.27}$$
$$= 4.73m$$

$$y_1 = 0.54 * Z_D * D^{0.425}$$
$$= 0.54 * 2 * (0.11)^{0.425}$$
$$= 0.41m$$

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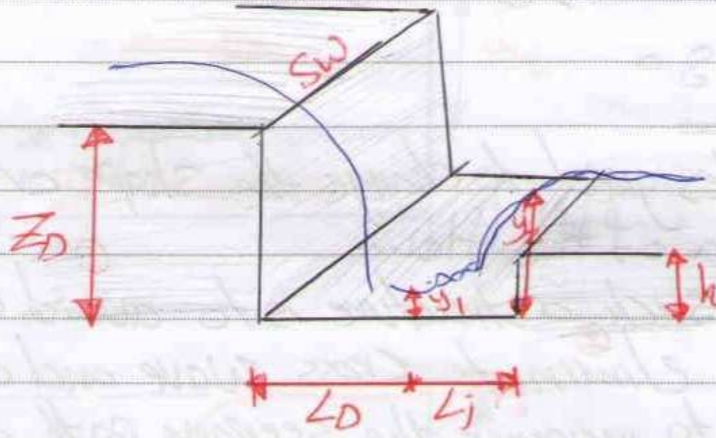
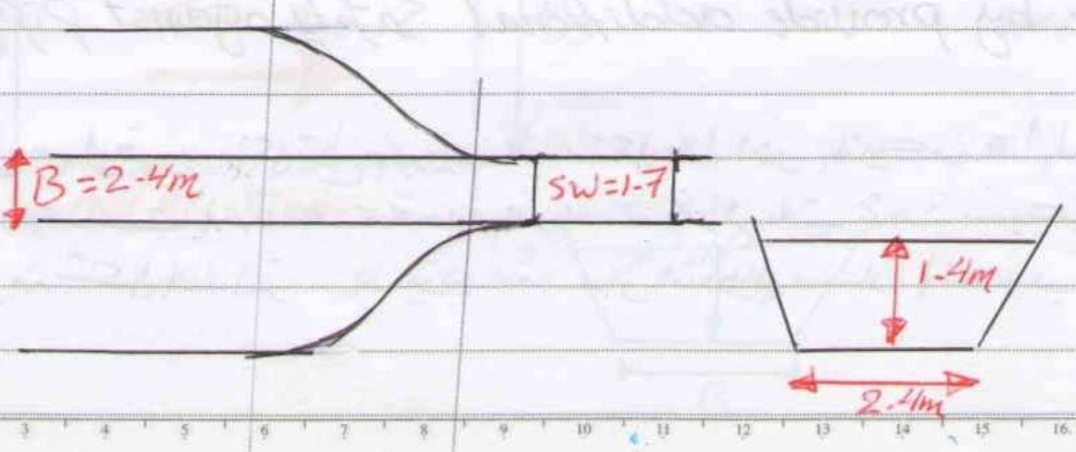
$$y_2 = 1.66 * Z_0 * D^{0.27}$$
$$= 1.66 * 2 * (0.11)^{0.27}$$
$$= 1.826m$$

$$L_j = 6.9(y_2 - y_1)$$
$$= 6.9(1.826 - 0.41)$$
$$= 9.7m$$

$$L_D + L_j = 4.73 + 9.7$$
$$= 14.43m$$

$$h = \frac{y_2}{6} = \frac{1.826}{6} = 0.306m$$





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$$Q = q * S_w$$

$$S_w = \frac{Q}{q}$$

$$y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

$$0.96 = \left(\frac{q^2}{9.81}\right)^{1/3}$$

$$\Rightarrow q = 2.937 \; m^3/sec/m$$

$$S_w = \frac{5}{2.937} = 1.7 m$$

Transitions :-

Is astructure designed to change the shape or cross-section of area of the flow.
The function of such astructure is to (1) avoid excessive energy loss, (2) to eliminate cross wave and other turbulance, and (3) to increase the seepage path and there by provide additional safety against piping.

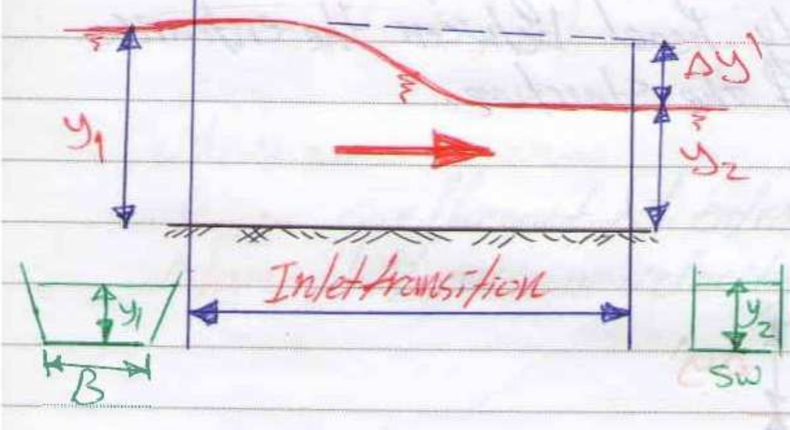
منشأ يصمم ليغير شكل مقطع الجريان من شكل الى اخر، الغاية من هذا المنشأ
١. لتقليل ضائعات الطاقة ٢. التخلص من الدوامات والامواج التي تحدث نتيجة الانتقال
المباشر من شكل الى اخر ٣. يزيد من مسار القناة او مسار التسرب

The common types of transitions are :-

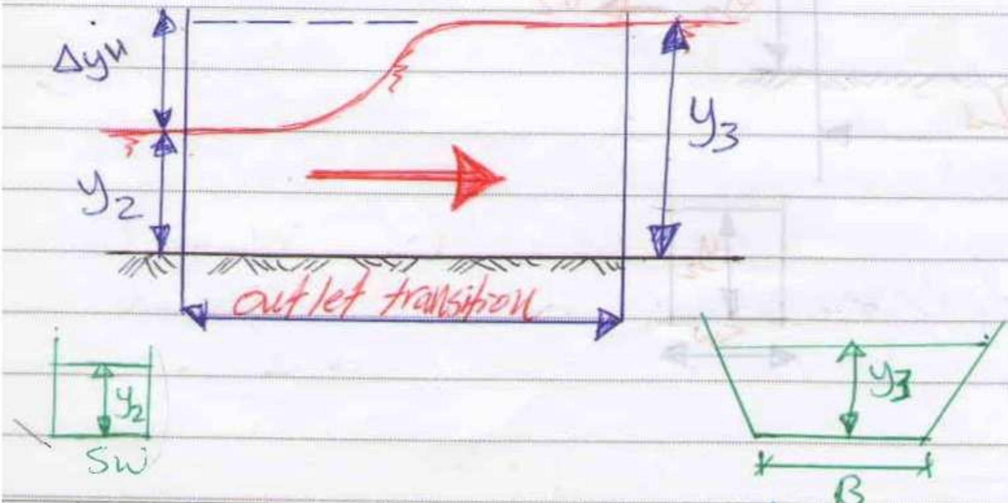
1- Inlet and outlet transition between canal and flume.
2. Inlet and outlet transition between canal and tunnel. نفق
3. Inlet and out let transition between canal and inverted siphon.

It should be noted that appreciable change in depth of flow generally occurs in all types of transition

يجب ان نعرف التغير الحقيقي للعمق



هبوط



صعود

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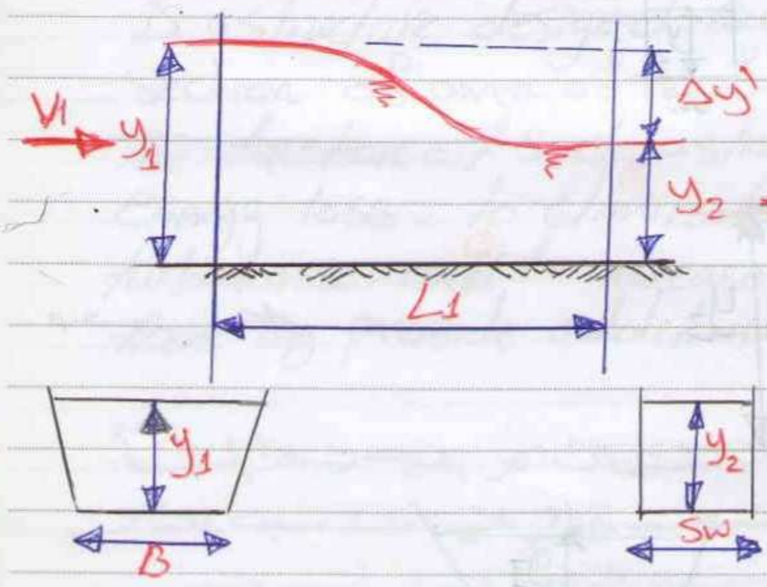
Losses :-

The energy loss in a transition consists of :-

1. The friction loss which may be estimated by means of any uniform flow formula, such as Manning formula.
This loss usually have very little effect on the transition flow profile and may be ignored in perliminary design.

2. The conversion which is generally expressed in terms of change in velocity head between the entrance and exit section of the structure.

for Inlet structure



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The entrance velocity (V_1) is less than the exit velocity (V_2), the water surface must allways drop at least of full difference between the velocity head plus a small conversion loss known as the inlet loss.
the drop ($\Delta y'$) in water surface for inlet structure may therefore be expressed as :

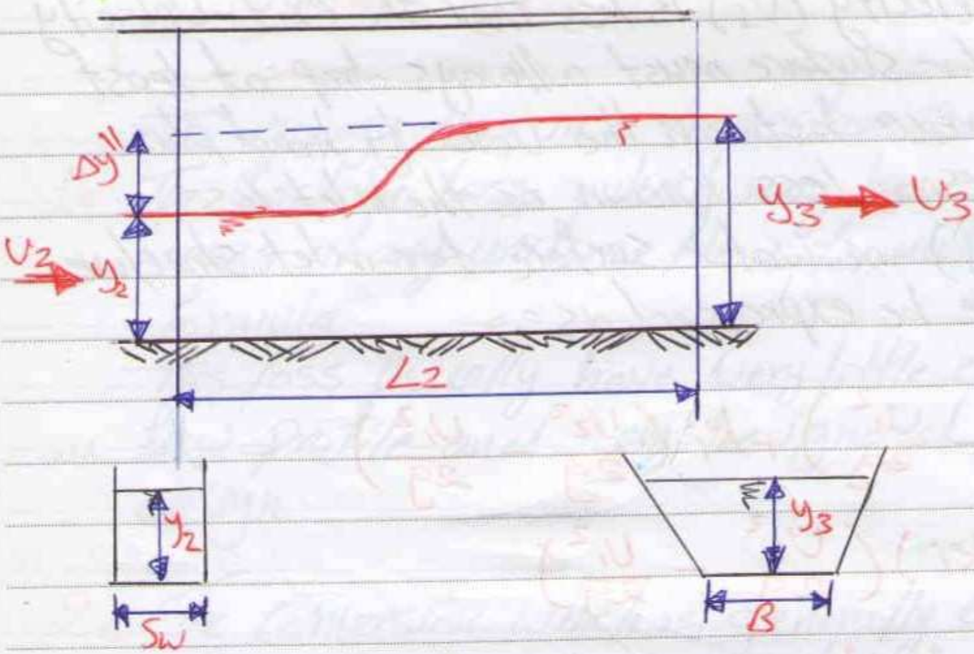
$$\Delta y' = \left(\frac{U_2^2}{2g} - \frac{U_1^2}{2g}\right) + K_i\left(\frac{U_2^2}{2g} - \frac{U_1^2}{2g}\right)$$ معادلة مهمة

$$= (1+K_i)\left(\frac{U_2^2}{2g} - \frac{U_1^2}{2g}\right)$$

$$= (1+K_i)\,\Delta hv$$

where :
K_i : coefficient of entrance loss
Δhv : difference in velocity head

For outlet structure :



The velocity is reduced, at least in part in order to lift the water surface, The rise in water surface known as the recovery of velocity head is usually accompanied by a conversion loss known as the outlet loss; The rise ($\Delta y''$) in water surface for outlet structure may be expressed as :

$$\Delta y'' = (1-k_o)\left(\frac{V_2^2}{2g} - \frac{V_3^2}{2g}\right)$$

معادلة مهمة

$$= (1-k_o)\,\Delta h_v$$

where

k_o = coefficient of exit loss

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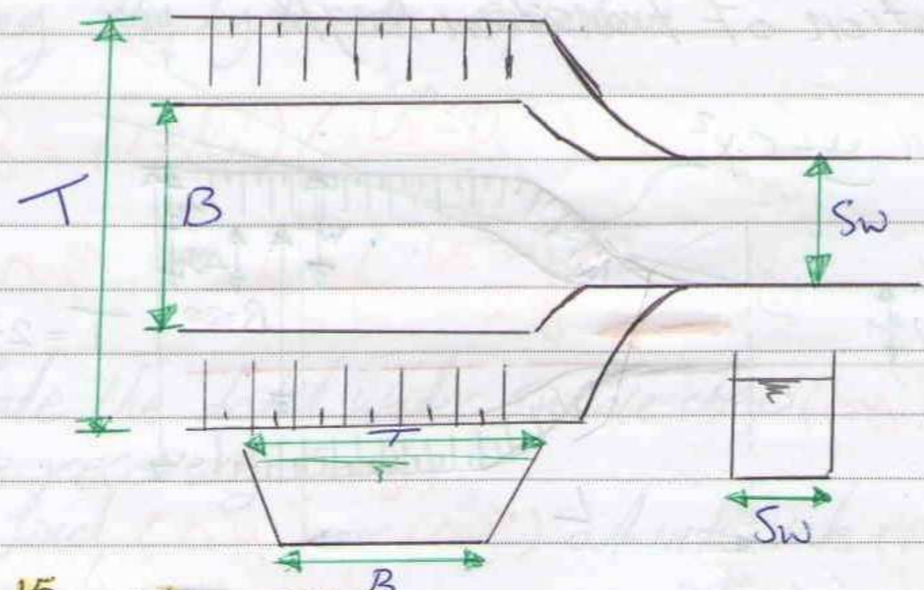
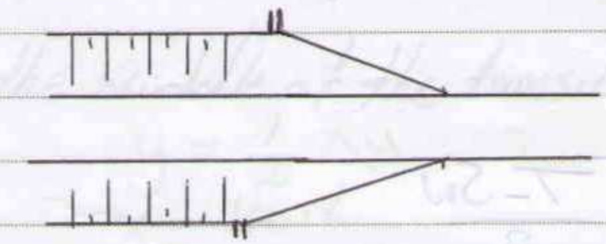
Types of Transitions:

1. Cylinder Quadrant



$K_i = 0.15$; $K_o = 0.25$

2. Wedge type transition



$K_i = 0.14$; $K_o = 0.24$

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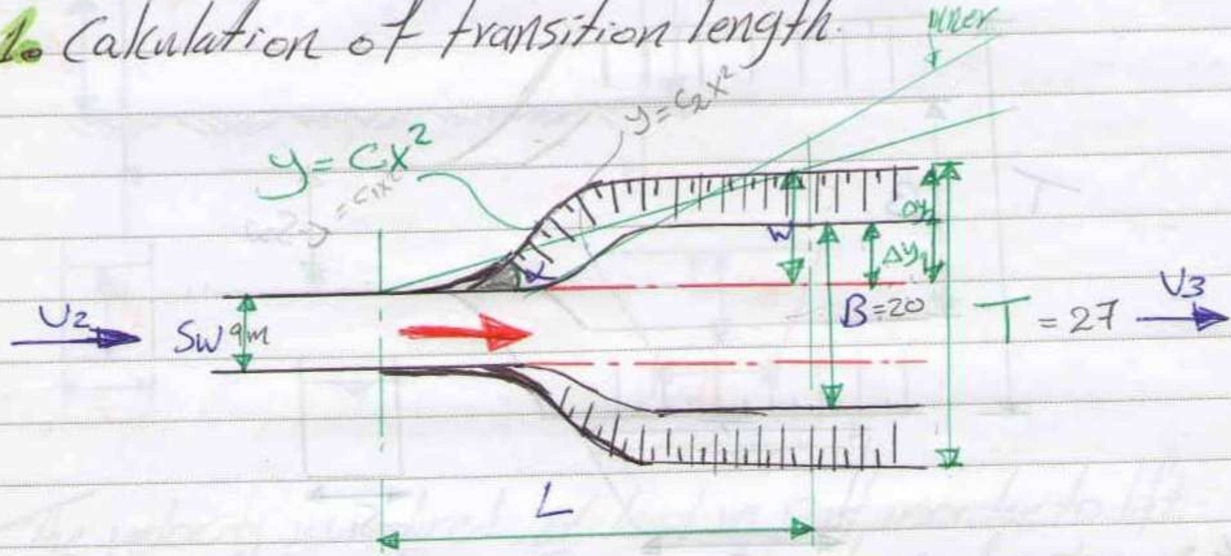
Warped Transition

Calculation of Warped transition

1. Calculation of transition length



$$\tan\alpha = \frac{W}{L}$$

$$W = \frac{T}{2} - \frac{Sw}{2} = \frac{T - Sw}{2}$$

$$\therefore L = \frac{W}{\tan\alpha} \Rightarrow L = \frac{\frac{T-Sw}{2}}{\tan\alpha}$$

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2. Divide the horizontal distance (L) along the transition into equal whole Number increments (ΔX)

أقسم L للحصول على نقطة وسطية للحصول على مسافة زوجية (لرسم زوجي L) ولمسافات متساوية

3. Using the hydraulic equation

$$\Delta y' = (1+k_i)\left(\frac{V_2^2 - V_1^2}{2g}\right)$$ انتقال داخل

or

$$\Delta y'' = (1-k_o)\left(\frac{V_2^2 - V_3^2}{2g}\right)$$ انتقال خارج

Calculate the total water surface drop ($\Delta y'$) or the surface recovery ($\Delta y''$)

Then find ($\Delta y'$) or ($\Delta y''$) at intervals (ΔX) from the equation $y = CX^2$

ايجاد القيمة الكلية $\Delta y'$ ، $\Delta y''$

ايجاد قيمة $\Delta y'$ ، $\Delta y''$ لكل قطع ΔX

4. The parabola is plotted as $y = CX^2$

at the middle of the transition

$$y = \frac{1}{2}\Delta y$$
$$X = 1/2\ L$$

$$\therefore \frac{1}{2}\Delta y = C\left(\frac{L}{2}\right)^2 \Rightarrow \text{find } C$$

اوجدنا قيمة العلم 3

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5. $\Delta h_v = \dfrac{\Delta y''}{1-k_o}$ or $\Delta h_v = \dfrac{\Delta y'}{1+k_i}$

Δy تطلع من كل مقطع
كالسلم

6. Find V in each section

$$V = \sqrt{2g\,\Delta h_v}$$

$$\Delta h_v = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

7. find A in each Section

$$A = \frac{Q}{V}$$

and then estimat. $\left(\dfrac{B+T}{2}\right)$

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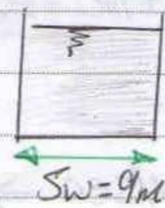
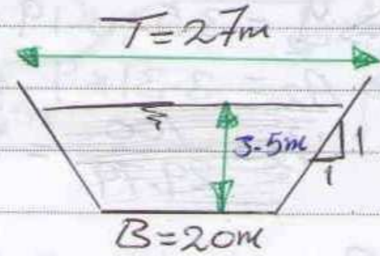
Ex: Calculate and plot the required warped transition which used to connect a trapezoidal canal with flume of regualator

- Bed width of the canal = 20m
- depth of water in the canal = 3.5m
- side slope of the canal = 1:1
- Bed width of the flume = 9m
- The design discharge $Q = 100 m^3/sec$
- $K_o = 0.2$; $\alpha = 12.5°$
- Assume the elevation of water in the canal = 10m

Solution:





$Q = 100 m^3/sec$

$V_3 = \frac{Q}{A_3}$

$T = 20 + 2(3.5) = 27m$

$A_3 = By + Zy^2$
$= 20(3.5) + 1(3.5)^2 = 82.25 m^2$

$V_3 = \frac{Q}{A_3} = \frac{100}{82.25} = 1.216 \ m/sec$

$L = \frac{W}{\tan\alpha}$

$W = \frac{T - Sw}{2} = \frac{27-9}{2} = 9m$

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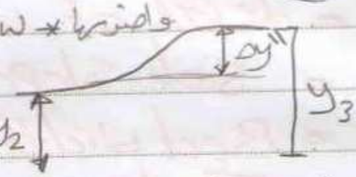
$$L = \frac{9}{\tan 12.5^\circ} = 40.6\,m \approx 40\,m$$

لحل هذه المعادلة نفرض قيمة V_2
وتكون أكبر من V_3.
ونستخرج $\Delta y''$ واطرحها من 3.5
واضربها * Sw.

$$\Delta y'' = (1 - K_0)\left(\frac{V_2^2 - V_3^2}{2g}\right)$$

$$\Delta y'' = (1 - 0.2)\left(\frac{V_2^2 - (1.216)^2}{19.62}\right)$$



ثم استمرها على التجريب لحين ان
تتساوى

$\Rightarrow$ Assume $V_2 = 2.5\ m/sec$

$\Rightarrow \Delta y'' = 0.19$

$\Rightarrow y_2 = 3.5 - 0.19 = 3.31$

$\Rightarrow A_2 = 3.31 * 9 = 29.79\,m^2$

$\Rightarrow V_2 = \frac{100}{29.79} = 3.35$

افرض $\Delta y \Leftarrow V \Leftarrow A_2 \Leftarrow \div 9 \Leftarrow y$
$3.5 -$ $\Leftarrow \Delta y$ يجب ان تتساوى واذا
لم تتساوى استخدم الكبيره

Assume $V_2 = 3.35\ m/sec \Rightarrow \Delta y'' = 0.397$

$\Rightarrow y_2 = 3.5 - 0.397 = 3.102 \rightarrow A_2 = 27.92$

$\Rightarrow V_2 = 3.58\ m/sec$

Assume $V_2 = 3.58\ m/sec \Rightarrow$

$V_2 = 3.65 \Rightarrow V_2 = 3.7$

عندما تقترب الرقم نقف
استدلى

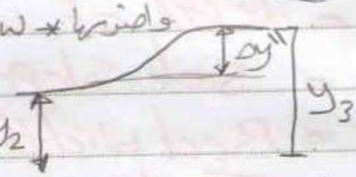
$V_2 = 3.7\ m/sec$, $\Delta y'' = 0.499$

$$L = \frac{9}{\tan 12.5^\circ} = 40.6\,m \approx 40\,m$$

لحل هذه المعادلة افرض قيمة V_2
وتكون اكبر من V_3.
نستخرج $\Delta y''$ واطرحها من 3.5
واضربها $* S_w$

$$\Delta y'' = (1-K_o)\left(\frac{V_2^2 - V_3^2}{2g}\right)$$

$$\Delta y'' = (1-0.2)\left(\frac{V_2^2 - (1.216)^2}{19.62}\right)$$



ثم استمر على التجربة الى ان تتساوى

$\Rightarrow$ Assume $V_2 = 2.5$ m/sec

$\Rightarrow \Delta y'' = 0.19$

$\Rightarrow y_2 = 3.5 - 0.19 = 3.31$

$\Rightarrow A_2 = 3.31 * 9 = 29.79\,m^2$

$\Rightarrow V_2 = \frac{100}{29.79} = 3.35$

افرض $\Delta y \Leftarrow V \Leftarrow A_2 \Leftarrow \div 9 \Leftarrow y$
$3.5 - \Leftarrow \Delta y$ حتى تتساوى واذا
لم تتساوى استخدم الجديد

Assume $V_2 = 3.35$ m/sec $\Rightarrow \Delta y'' = 0.397$

$\Rightarrow y_2 = 3.5 - 0.397 = 3.102 \rightarrow A_2 = 27.92$

$\Rightarrow V_2 = 3.58$ m/sec

Assume $V_2 = 3.58$ m/sec $\Rightarrow$

$V_2 = 3.65 \Rightarrow V_2 = 3.7$

عندما تقترب الرقم نتوقف
استدلالي

$V_2 = 3.7$ m/sec , $\Delta y'' = 0.499$

Subject: Hydraulic Structures

Equation of outer curve of transition

$y = C_3 x^2$

$x = \frac{L}{2} = \frac{40}{2} = 20\ m$

$\Delta y_2 = \frac{T - Sw}{2} = \frac{27-9}{2} = 9m$

$\frac{\Delta y}{2} = C_3 \left(\frac{L}{2}\right)^2$

$4.5 = C(20)^2$

$\Rightarrow C_3 = 0.01125$

∴ The equation of the outer curve is

$y = 0.01125 x^2$

Subject: Hydraulic Structures

20/12/1

① Water surface	②	③ Inner curve	④	⑤ outer inner	⑥	⑦ = ④ + ⑥	⑧	⑨	⑩	⑪
$y=0.000624X^2$		$y=0.006875X^2$		$y=0.01125X^2$		$\frac{1}{2}(B+T)$	$h_{v3}=\frac{V_2^2}{2g}-\frac{\Delta y''}{1+\kappa_0}$	$h_{v3}=\frac{V_3^2}{2g}$	⑩ $=\frac{Q}{⑨}$	⑪ $=\frac{⑩}{⑦}$
X	$\Delta y''$	Δy_1	$\frac{B}{2}=\frac{SW}{2}+\Delta y_1$ $=4.5+\Delta y_1$	Δy_2	$\frac{T}{2}=\frac{SW}{2}+\Delta y_2$ $=4.5+\Delta y_2$			$V_3=\sqrt{2gh_{v3}}$	$A_3=\frac{Q}{V_3}$ ($Q=100$)	$y=\frac{A}{\frac{1}{2}(B+T)}$
0	0	0	4.5	0	4.5	9	0.6977	3.7	27.01	3
5	0.0156	0.172	4.672	0.28	4.78	9.452	0.6782	3.648	27.41	2.75
10	0.0624	0.687	5.187	1.12	5.62	10.817	0.6197	3.491	28.65	2.65
15	0.1403	1.547	6.047	2.53	7.03	13.08	0.5223	3.205	31.2	2.38
20	0.2495	2.75	7.25	4.5	9.25	16.25	0.3858	2.757	36.27	2.23
25	0.449−0.140 0.3087	5.5−1.547 3.953	8.453	9−2.53 6.47	10.97	19.42	0.3118	2.215	45.14	2.32
30	0.449−0.0624 0.3866	5.5−0.687 4.813	9.313	9−1.12 7.88	12.38	21.69	0.23445	1.734	57.67	2.65
35	0.4334	5.328	9.828	8.72	13.22	23.05	0.38595	1.364	73.32	3.18
40	0.449	5.5	10	9	13.5	23.5	0.13645	1.216	82.24	3.499

القيمة ما بعد المنتصف تحسب بهذا الشكل

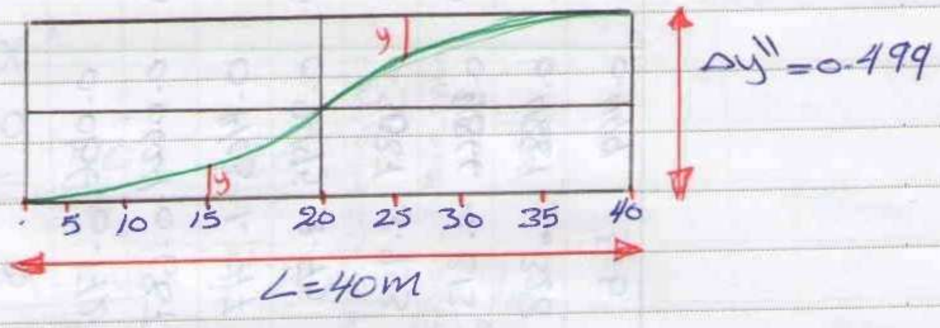
$A=\frac{B+T}{2}(y)$

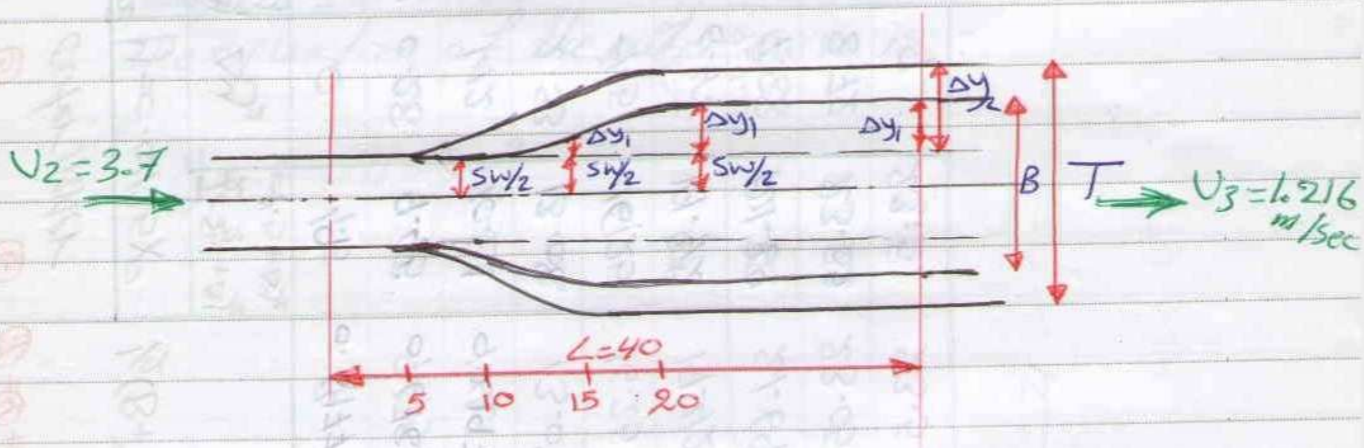
Subject: Hydraulic Structures

$\Delta y'' = 0.499$

$\Delta y_1 = 5.5m$

$\Delta y_2 = 9m$

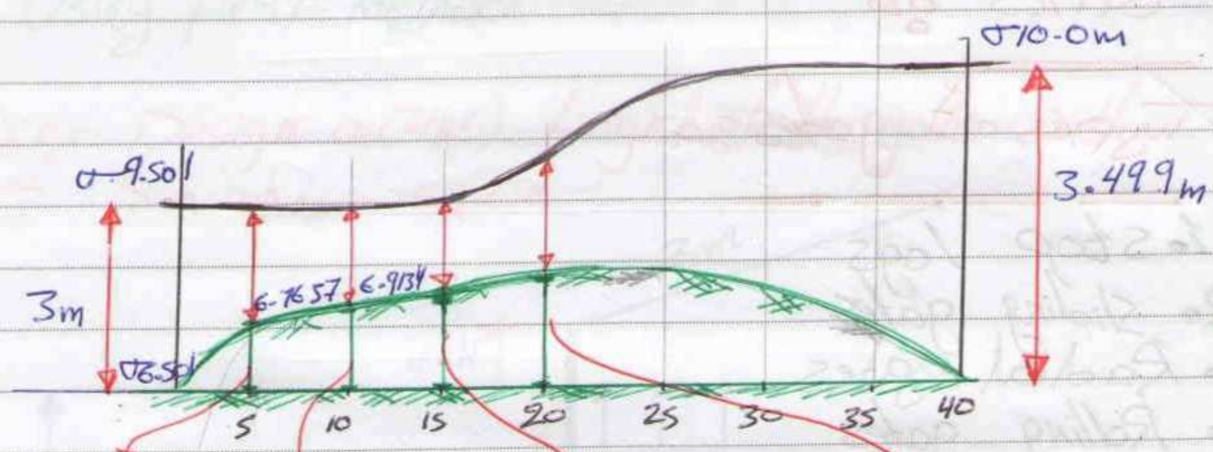




$$\Delta y'' = (1 - K_o)\left(\frac{U_2^2}{2g} - \frac{U_3^2}{2g}\right)$$

$$\frac{\Delta y''}{1 - K_o} = \frac{U_2^2}{2g} - h_{v_3}$$

$$h_{v_3} = \frac{V_2^2}{2g} - \frac{\Delta y''}{1 - K_o}$$



$3+\Delta y$

$3.0156-2.75$

$=0.2656$

$+6.501$

$=6.7657$

$3.0624-2.65$

$=0.4124$

$3.1403-2.38$

$=0.7603$

$3.2495-2.23$

$=1.0195$