معمل هندسة الري والهيدروليكا

و التجارب المعمليه

أولاً: بيانات المعمل الأساسية

إسم المعمل: معمل هندسة الري والهيدروليكا

القسم العلمي: هندسة الري والهيدروليكا (الهندسة المدنية)

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التليفون: 1311(داخلي)

الموقع بالنسبة للكلية: مبني المعامل البحرية – الدور الأرضي والدور الأول علوي

مساحة المعمل: 316.9 م^2 الدور الأرضي - 316.9 م^2 الدور الأول علوي

ثانياً: قائمة بالأجهزة والمعدات الموجودة بالمعمل:

م	إسم الجهاز	العدد
1	ترابيزة هيدروليكية كاملة بمقاس بوردن للضغط	4
2	جهاز قياس ضغط النافورة	1
3	قناة معملية بعرض 7.5 سم	1
4	جهاز توضيح مسار الهيل	1
5	جهاز تعيين مركز الضغط	1
6	جهاز قياس التصرف خلال فتحة مستطيلة أو مثلثية	1
7	جهاز ثبات الجسم العائم	1
8	جهاز معايرة الضغط لجهاز بوردن	1
9	جهاز قياس التصرف من خلال فتحة دائرية	1
10	جهاز قياس التصرف من خلال الفنشوريمتر	1
11	جهاز قياس العمق الميكانيكى	1
12	جهاز قياس العمق الكهربائى	1
13	تربينة بلتون	1
14	تربينة فرانسيس	1
15	جهاز السريان المنتظم المضطرب	1
16	مضخة طاردة مركزية ذات مرحلتين	1
17	كوبري انفاق عائم	1
18	قناة معملية بطول 7 م	1
19	نفق دخاني كامل	1
15	جهاز سريان المياه الجوفية	1
16	بروجكتور كامل بالشاشة	1
17	جهاز قياس السرعات في الإتجهات الثلاثة	1
18	جهاز قياس التصرف	1
19	جهاز دراسة الإحتكاك داخل الأنبوبة	1
20	قناة معملية (حوض أمواج) بطول 15.6 م وعرض 1 م و إرتفاع 1.75 م ومصنوعة من الصاج سمك 2 مم	1
21	قناة معملية من خشب السويد بعرض 60 سم	1
22	جهاز قياس معامل اللزوجة	1

23	جهاز توضيح تدفق فقاعات الهيدروجين	1
24	جهاز إيجاد معامل السحب للأشكال	1
25	جهاز الدوامة المجبرة	1
26	جهاز تعيين مركز الضغط	1
27	جهاز قياس التصرف من خلال فتحة دائرية	1
28	جهاز قياس التصرف خلال الفنشوريميتر	1
29	طلمبة تربينة 100 مم (جلكس) بالمحتويات	1
30	عداد سرعة F4 كامل بالحجارة والمفاتيح	1

ثالثاً: قائمة بالتجارب التي تجرى داخل المعمل (مرحلة البكالوريوس):

م	التجربة	الغرض منها
1	**دراسة ثبات الجسم العائم** **(Stability of the floating body)**	يستخدم الجهاز فى قياس ثبات الأجسام الطافية ودورانها واتزانها.
2	جهاز قياس التصرف من خلال فتحة دائرية **(Discharge through an Orifice)**	يستخدم الجهاز لتوضيح كيفية حساب التصرف عن طريق عبور المياه خلال فتحة دائرية.
3	السريان فوق الهدارات (Flow over weirs and notches)	يستخدم الجهاز لتوضيح كيفية حساب التصرف عن طريق عبور المياه فوق هدار مثلث الشكل
4	الفواقد خلال خطوط المواسير والشبكات (Friction loss in pipes and networks)	يستخدم الجهاز لتحديد الفواقد الرئيسية خلال خطوط المواسير
5	الضغط الهيدروستاتيكي علي الاسطح المغمورة (Hydrostatic pressure on submerged surfaces)	يستخدم الجهاز لتحديد الضغط الهيدروستاتيكي علي البوابات و تحديد مركز الضغط
6	السريان خلال الفتحات (flow through orifices)	يستخدم الجهاز لتحديد معاملات السرعة والإختناق والتصرف
7	السريان خلال الفنشوريميتر (Flow through Venturi-meter)	يستخدم الجهاز لتحديد التصرف خلال الأنابيب
8	المطرقة المائية (water hammer)	قياس سرعة موجة الطرق
9	القفزات الهيدروليكية (Hydraulic jumps)	تصميم الفرشة الخرسانية خلف منشأت الحجز

رابعا: التجارب المعمليه:

EXPERIMENT (1)

1.1. General Information

- Experiment name: ***Stability of the floating body***
- Second year civil engineering
- First term

1.2. Apparatus Description

The apparatus is arranged from a rectangular sheet metal pontoon floats in water and carries stem braced with cords, Figure (1.1.a). From this a plumb-bob is suspended so that the angle of list of the pontoon may be read off a scale marked in degrees. The height of the center of gravity of the floating body may be varied by an adjustable weight which slides up and down the stem. A jockey weight is arranged to slide along a bar fixed on the pontoon parallel to its base; as this weight is moved by known intervals, the change in angle of list is noted, and the stability of the pontoon thereby measured.

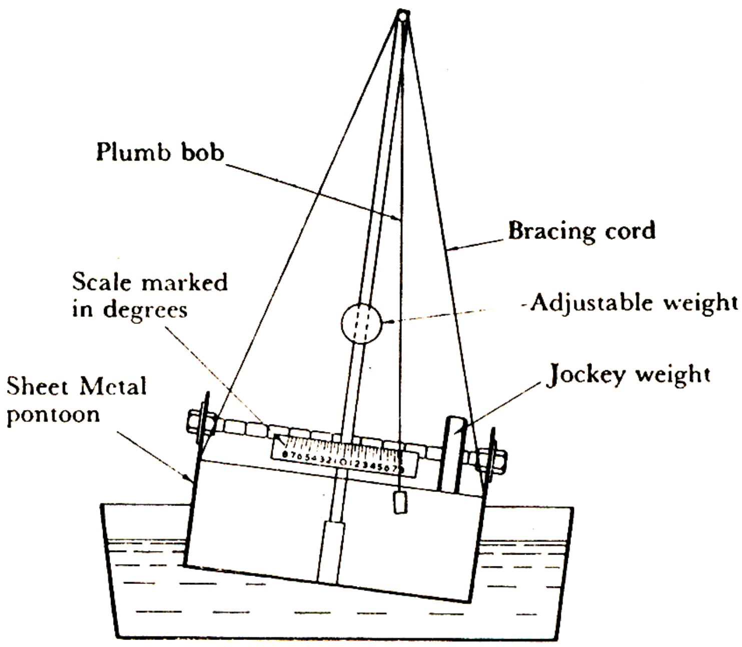


Figure (1.1.a): Arrangement of floating pontoon

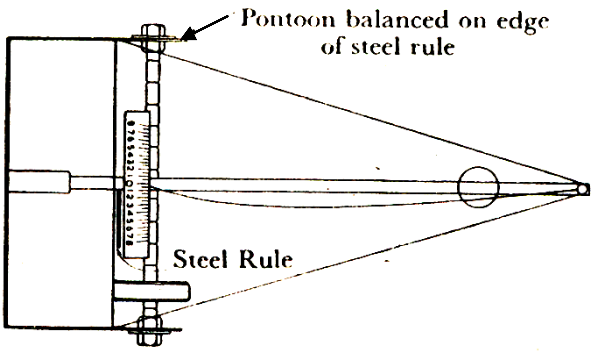


Figure (1.1.b): method for finding height of centre of gravity

1.3. Theoretical Background

Consider the rectangular pontoon floating in equilibrium on even keel, Figure (1.2.a). The weight of the floating body acts vertically downwards through its center of gravity (G) and this is balanced by an equal and opposite buoyancy force acting upwards through the center of buoyancy (B), which lies at the center of the gravity of the liquid displaced by the pontoon.

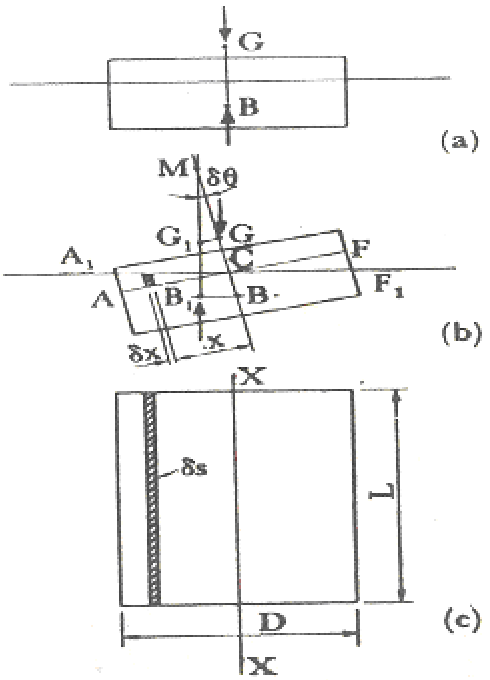


Figure (1.2): Derivation of stability of floating pontoon

To investigate the stability of the system, consider a small angular displacement ($\delta\theta$) from the equilibrium position as sown in Figure (1.2.b). The center of gravity of liquid displaced by the pontoon is shifted from (B) to (B_1). The vertical line of action of the buoyancy force is shown in the figure and intersects the extension of line (BG) in (M), called *the metacenter*.

The equal and opposite forces through (G) and (B_1) exert a couple on the pontoon, the provided that (M) lines above G as shown in Figure (1.2.b). Those couple acts in the sense of restoring the pontoon to even keel (i.e. the pontoon is stable). If, however, the meta-center (M) lies below the center of gravity (G), the sense of the couple is to increase the angular displacement and pontoon is unstable. The special case of neutral stability occurs when (M) and (G) coincide. Figure (1.2.b) shows clearly how the meta-center height (GM) may be established experimentally using the jockey weight to displace the center of gravity sideways from (G). Suppose the jockey weight (m) is moved a distance equal to (δx_1) from its central position, if the weight of the whole floating assembly is W, then the corresponding movement of the center of the gravity of the whole pontoon, in a direction parallel to the base of the pontoon, is $\frac{m}{w}\delta x_1$.

If this movement produces a new equilibrium position at an angle of list ($\delta\theta$), then in Figure (1.2.b), (G_1) is the new position of the center of the gravity of the whole pontoon:

$$GG_1 = \frac{m}{W}\delta x_1 \tag{1.1}$$

from the geometry of the figure:

$$GG_1 = GM.\delta\theta \tag{1.2}$$

eliminating (GG_1) between these two equations we derive the following equation:

$$GM = \frac{m}{W}\frac{\delta x_1}{\delta \theta} \qquad (1.3)$$

or, in the limit form:

$$GM = \frac{m}{W}\left(\frac{dx_1}{d\theta}\right) \qquad (1.4)$$

The metacentric height may thus be determined by measuring $\left(\frac{dx_1}{d\theta}\right)$ by knowing the values of both (m) and (W).

1.4. Experimental Procedure

Firstly the weight of the various components of the floating assembly are noted and the length and width of the pontoon carefully measured by steel rule. The stem is then fitted into its housing in the pontoon and is rigidly braced by drawing the cords tight.

The height of the center of the gravity of the pontoon above the base is then established by turning it on its side and supporting it at the stem on the edge of a steel rule, to obtain the point at which it balances with the base of the pontoon vertical as indicated in Figure (1.1.b). To obtain a convenient point of balance it may be necessary to move the adjustable weight along the stem to a suitable position. While the pontoon is turned on its side, the plumb-bob line should be looped round the scale to keep the plumb-bob approximately in its normal relative position. The point of balance is marked and the height of this point and the adjustable weight above the base is measured by steel rule. It is convenient to refer dimensions of the sheet should be added to measurements made upwards from the inner with the adjustable weight in one known position; its height may be calculated for any other position of the adjustable weight.

The pontoon is now allowed to float in water. It is convenient, but by no means necessary, to move the adjustable weight sideways so that the angle of tilt is zero when the jockey weight is in its central position. Angles are then recorded for various positions of the jockey weight to both sides of the center, the maximum displacement being determined by maximum angle which may be recorded on the scale marked off in degrees. The procedure may be repeated with the adjustable weight set at a number of different heights.

1.5. Results and Calculations

Total weight of floating assembly, W = 5.39 lb

Jockek weight, m = 0.50 lb

Adjustable weight = 1.00 lb

Breadth of pontoon, D = 8.02 in

Length of pontoon, L = 14.10 in

Second moment of area, I = $LD^3/12$ = 606 in^4

Volume of water displaced V = 5.39/62.4 = 149.3 in^3

$$\therefore BM = \frac{I}{V} = 4.06\ in$$

Depth of pontoon immersion = V/LD = 1.32 in

Depth of center of buoyancy, CB= 1.32/2 = 0.66 in

Height of meta-center above water surface, CM=BM – CD = 4.06-0.66 = 3.40 in

All above results are shown in Figure (1.3).

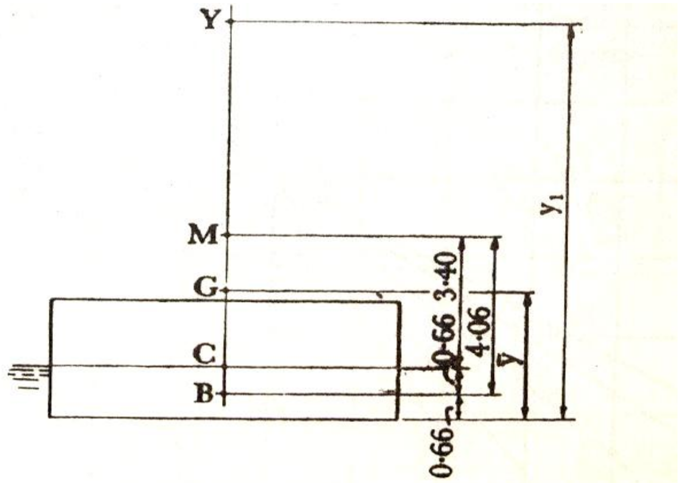


Figure (1.3): Diagram showing calculated dimensions

When the pontoon was turned on its side and balanced at the stem on the edge of a steel rule, the following result was obtained.

- Height of adjusted weight above base = 10.27 in
- Height of G above base = 3.22 in

Now the height y of (G) above the base will vary with the height (y_1) of the adjustable weight above the base according to the equation

$$\bar{y} = \frac{y_1}{5.39} + A$$

where A is constant.

Since the ratio of the adjustable weight to the weight of the whole pontoon is 1 : 5.39. By substituting in the above equation the value of A is calculated as follows:

$$3.22 = \frac{10.27}{5.39} + A$$

$$\therefore A = 1.31\ in$$

So that

$$\bar{y} = \frac{y_1}{5.39} + 1.31\ in$$

Referring to Figure (1.3), the height of (G) above the water surface is:

$CG = \bar{y} - 1.32 \qquad CG = \frac{y_1}{5.39} - 0.01\ in$

Measurements of angles of tilt produced by moving the jockey weight, with the adjustable weight set at various heights, are given in Table (1.1) and are presented graphically in Figure (1.4). The calculation of meta-centric height from the results is set out in Table (1.2). For example, when y_1 = 5.62 in, the value of $\left(\frac{dx_1}{d\theta}\right)$ read from the graph is found to be 0.443 in per degree, or 0.443*57.3 in per radian.

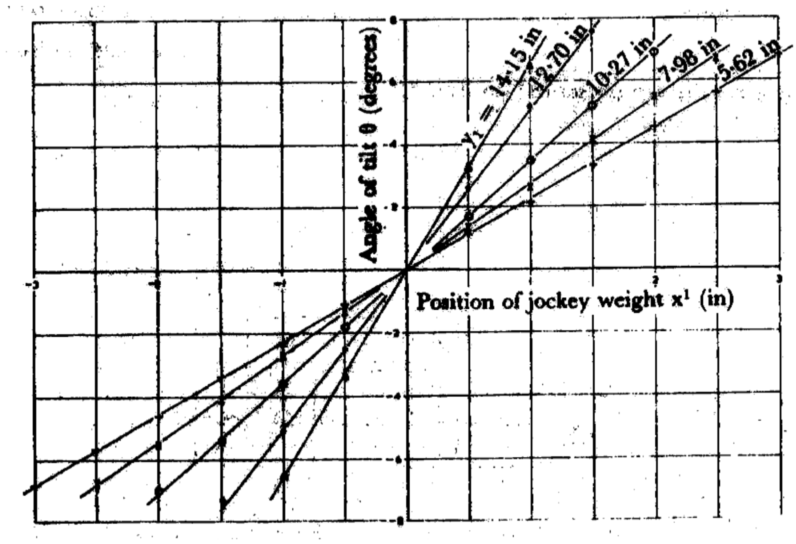


Figure (1.4): Variation of angle of tilt with position of jockey weight

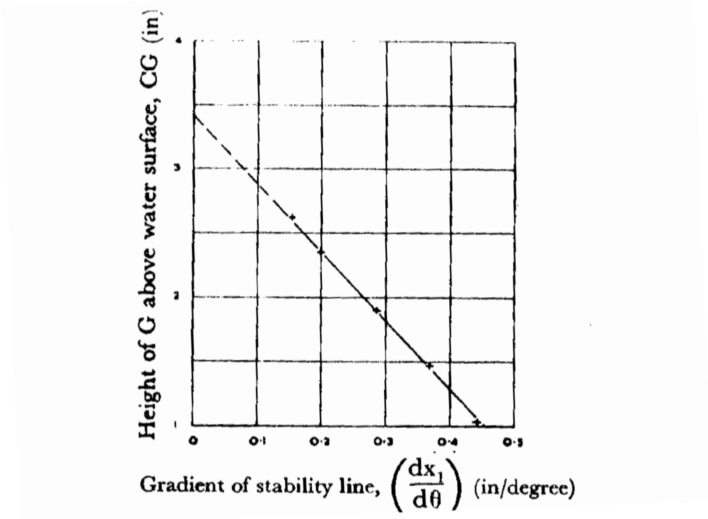


Figure (3.5): Variation of stability with height of centre of gravity

Table (3.1): Values of angles of tilt, θ (degree)

Ht. of adjustable Weight, Weight, y_1 (in)	***Position of jockey weight, x_1 (in)***												
	-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3
5.62	-6.8	-5.7	-4.6	-3.4	-2.3	-1.1	0.0	1.1	2.1	3.3	4.5	5.6	6.8
7.98	-	-6.7	-5.5	-4.1	-2.7	-1.3	0.0	1.3	2.6	4.1	5.5	6.7	-
10.27	-	-	-7.0	-5.4	-3.6	-1.8	0.0	1.7	3.5	5.2	6.9	-	-
12.70	-	-	-	-7.3	-5.1	-2.5	0.0	2.6	5.2	7.6	-	-	-
14.15	-	-	-	-	-6.5	-3.4	0.0	3.3	6.5	-	-	-	-

Table (3.2): Derivation of metacentric height from experimental results and comparison with calculations.

Ht. of Adjustable Weight y_1 (in)	*Height of G above water surface, CG (in)*	$\left(\frac{dx_1}{d\theta}\right)$ *(in/degree)*	*Metacentric height GM. (in)*	*Height of M above water surface, CM. (in)*
5.62	1.03	0.443	2.35	3.38
7.98	1.47	0.368	1.96	3.43
10.27	1.90	0.286	1.52	3.42
12.70	2.35	0.198	1.05	3.40
14.15	2.62	0.154	0.82	3.44

$$GM = \frac{m}{W}\left(\frac{dx_1}{d\theta}\right) = 2.35\ in$$

$$CG = \frac{y_1}{5.39} - 0.01 = 1.03\ in$$

$$CM = GM + CG = 2.35 + 1.03 = 3.38\ in$$

1.6. General Questions

1- What suggestions have you for improving the apparatus?

2- How would the stability of the pontoon be affected if it were floated on a liquid with a density greater than that of water?

EXPERIMENT (2)

2.1. General Information

- Experiment name: ***Discharge through an orifice***
- Second year civil engineering
- First term

2.2. Apparatus Description

The following figure shows the arrangement of the tank which is fed from the bench supply valve through a sprinkler pipe distributes the water over perforated screen. The water passes down the tank through a second screen which serves to stabilize the flow, and leaves through a sharp edged orifice which is fitted into the base of the tank in such a way that there is no unevenness along the inner surface.

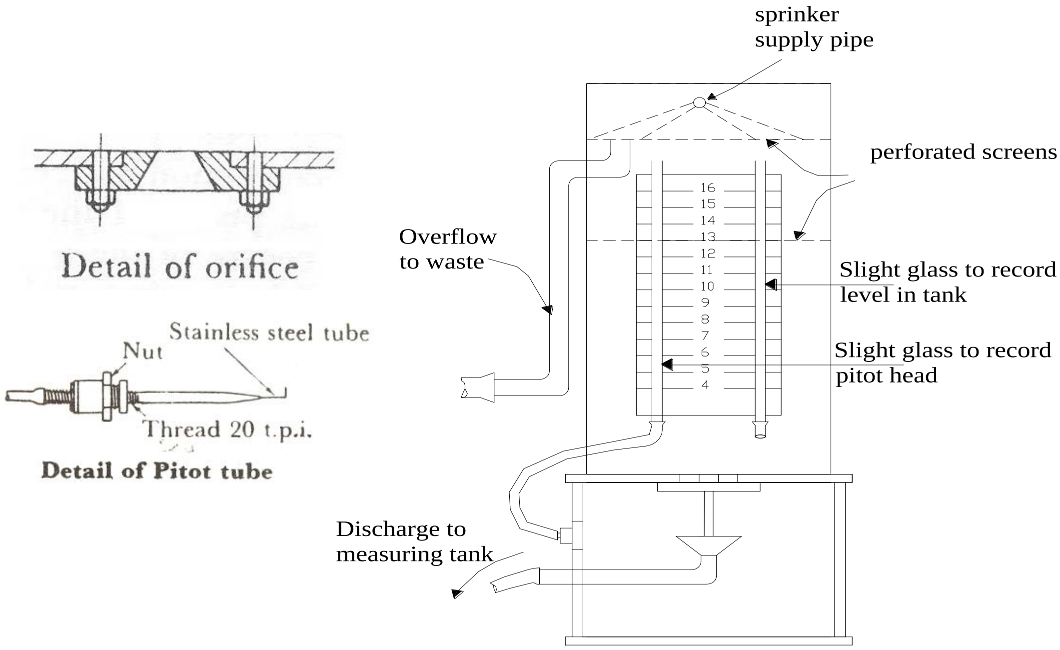


Figure (2.1): Arrangements of orifice apparatus

2.3. Experimental Procedure

The experiment may be divided into two parts, firstly, the measurement of C_d, C_u, and C_c at a single constant value of H_o, and, secondly, measurement of discharge at a number of different values of H_o. In the first part of the experiment, water is admitted to the tank to allow it to fill to the height of the over flow pipe and the inflow is regulated so that a small steady discharge is obtained from the over flow. To measure C_u, the pitot tube is inserted into the emerging jet close to the underside of the tank, the values of H_c, and H_o are noted. To measure C_c it is necessary to find the diameter of the jet at the vena-contracta. In the second part of the experiment, the inflow to the tank is reduced to lower the level in the tank in stages, the discharge from the orifice being measured at each stage.

2.4. Results and Calculations

- Diameter of orifice = 0.497 in
- Cross-sectional area, a_o = 0.194 in^2
- Head of orifice, H_o = 14.86 in
- Time required to collect 30 lb of water = 65.6 sec
- Discharge , Q = 0.00733 cusecs
- Pitot tube reading, H_c = 14.84 in
- Diameter of jet = 0.391 in.

$$C_d = \frac{Q}{\sqrt{2gH_o a_o}}$$

$$C_d = \frac{0.00733}{\sqrt{64.4 \times 1.23 \times 0.001347}}$$

C_d = 0.61

Coefficient of velocity, $C_u = \sqrt{\frac{H_c}{H_o}}$

C_u = 0.999

Coefficient of contraction $C_d = \frac{a_c}{a_o}$

C_c = 0.619

Table (2.1): Measurements of H_0 and Q

Qty. lb	**t** sec	**H_o** in	ft	**Q** cuses	**$H_o^{0.5}$** $ft^{0.5}$
30	65.6	14.9	1.23	.00733	1.11
30	68.8	13.5	1.12	.00699	1.05
30	71.4	12.2	1.01	.00673	1.0
30	77.2	10.6	0.88	.00623	0.93
30	82.6	9.14	0.76	.00582	0.87
30	90.0	7.52	0.62	.00534	0.79
30	101.6	6.01	0.5	.00473	0.70
30	112	4.8	0.4	.00429	0.63

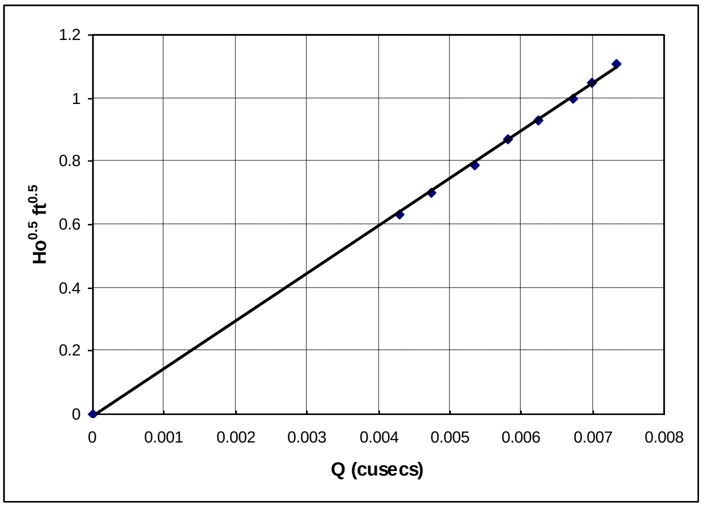


Figure (2.2): Variation of $H_0^{0.5}$ with Q for discharge through an orifice

EXPERIMENT (3)

3.1. General Information

- Experiment name: ***Flow over weirs and notches***
- Second year civil engineering
- First term

3.2. Apparatus Description

The following figure shows the arrangement in which water from the bench supply valve is led through a flexible hose to three short perforated pipes which serve to distribute the water fairly evenly in the enlarged end of the tank. A contraction section leads the water to a short channel, in the end of which a plate may be plotted, notched rectangular or V-shape. The construction is such that the internal surfaces of the tank and plate are flush and edges of the notch are sharp.

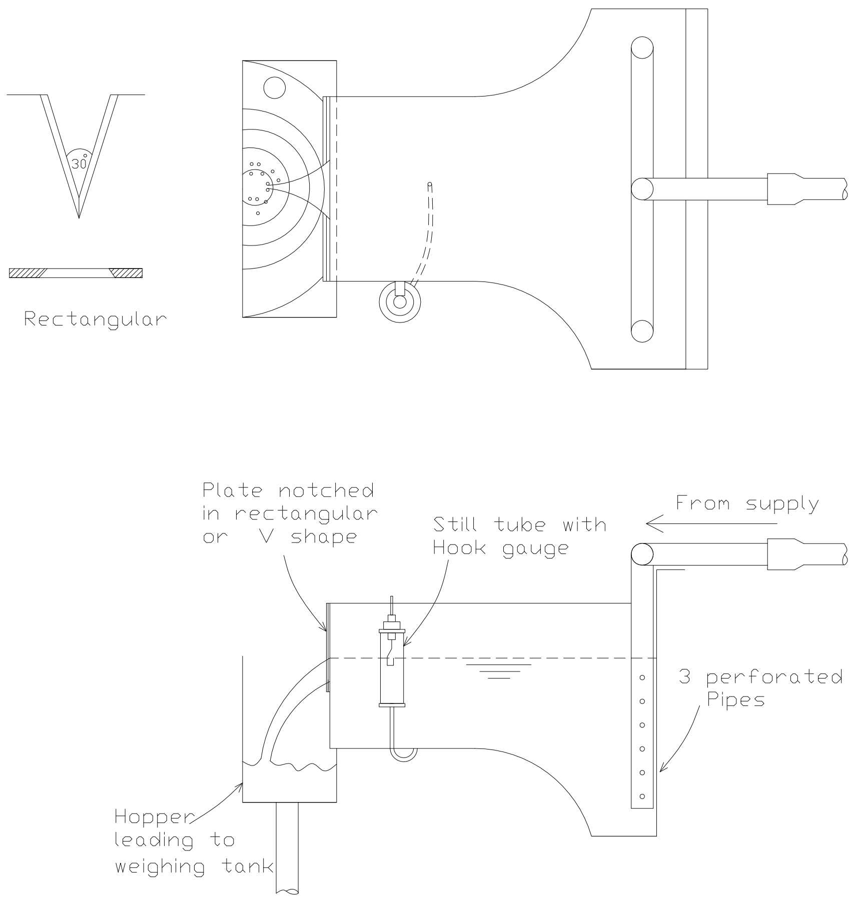


Figure (3.1): Arrangement of apparatus for measuring flow over weirs

3.3. Experimental procedure

The main purpose of this experiment is to estimate the coefficient of the venturi-meter C_d. The apparatus is first leveled and the zero of the hook gauge is established (i.e. the hook gauge reading corresponding to the level of the crest of the notch). To do this, water is admitted from the bench supply to the apparatus until the level is approximately correct, and then carefully baled out or in, using a small beaker, until the crest of the wear lies just in the surface. The reflection of the V in the surface serves to indicate weather the level is correct or not. When the correct level has been obtained, the hook gauge is set in the water surface in the still tube and the zero reading taken.

The equation of the rectangular notch is given by:

$$Q_{th} = \frac{2}{3} B\sqrt{2g}.H^{3/2} \quad (3.1)$$

The equation of the triangular V- notch is given by:

$$(3.2)\ Q_{th} = \frac{8}{15}\sqrt{2g}.\tan\theta.H^{5/2}$$

where: $\theta = 30^o$

$$(3.3)\ Q_{act} = \frac{1000w}{t} cm^3/\sec$$

$$(3.4)\ c_d = \frac{Q_{act}}{Q_{th}}$$

The relationship between *log (Q)* and *log (H)* is driven as follows:

$$Log (Q) = 2.5 Log(H) + 0.1392 \quad (3.5)$$

from which:

$$Q = 0.7 H^{2.5} \quad (3.6)$$

3.4. Experimental Steps

The followings explain the steps of the experiment:

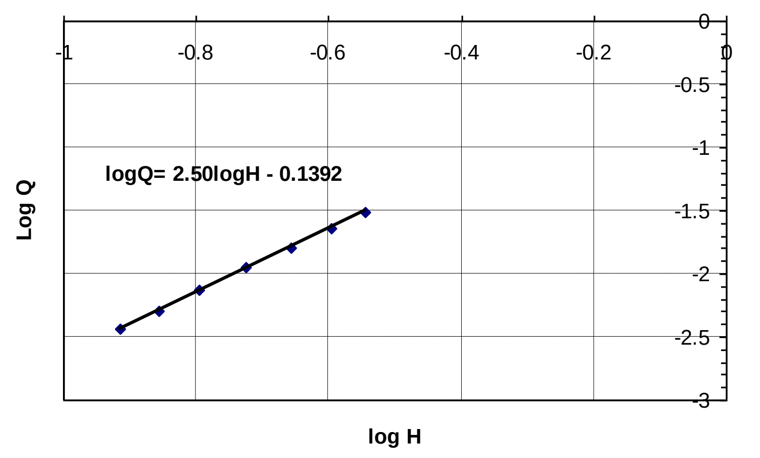
- Run the apparatus and measure the value of H_o
- Waiting until the water surface to be in a specified level then measure the value of H_1 and calculate the value of H.
- Calculate the value of Q_{th}.
- Determine the required time until balance occurs.
- Calculate the value of Q_{act}.
- Calculate C_d.
- Repeat the previous steps with changing the value of H_1.

3.5. Results

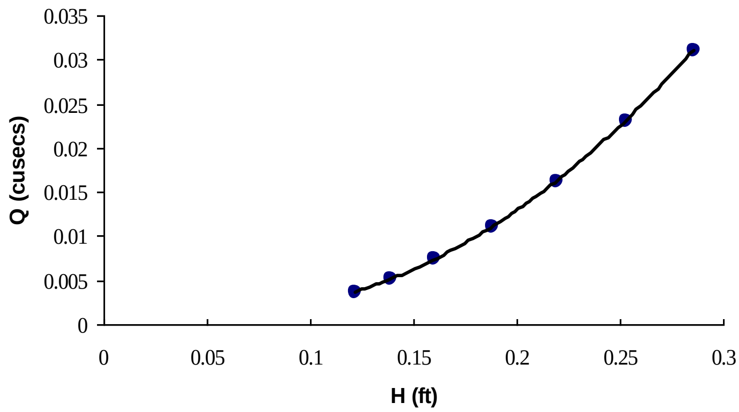
H ft	**Q**	**T** sec	**Q** cusecs	*log***Q**	*log***H**
0.2857	90	46.4	0.03108	-1.508	-.544
0.2529	90	62.6	0.02304	-1.638	-.597
0.2197	60	59.4	0.01619	-1.791	-.658
0.1881	60	86.6	0.01110	-1.955	-.726
0.1604	30	64.8	0.00742	-2.130	-.795
0.1393	30	93.6	0.00514	-2.289	-.856
0.1217	30	132.6	0.00363	-2.440	-.915

3.6. Discussion

From the notch equation the value of C_d can be calculated $C_d = 0.6$



Variation of logQ with log H



Variation of H with Q

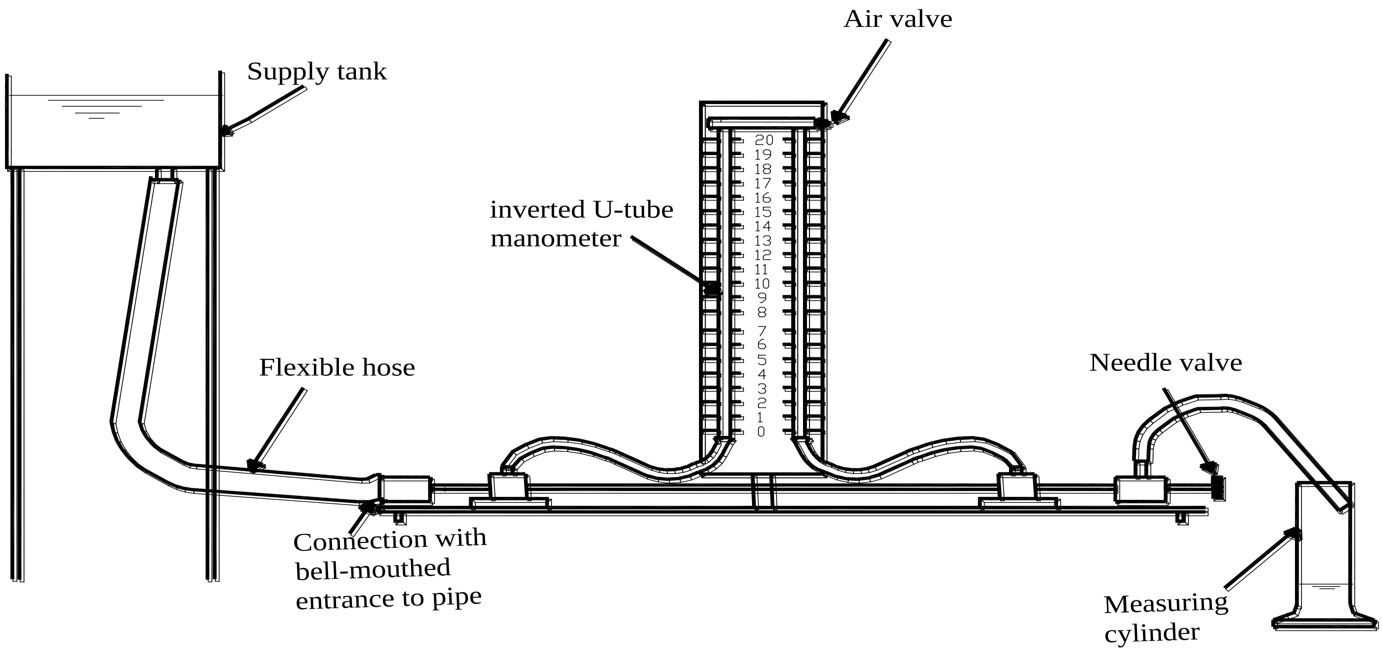
EXPERIMENT (4)

4.1. General Information

- Experiment name: ***Friction Loss Along a Pipe and a Networks***
- Second year civil engineering
- First term

4.2. Apparatus Description

The following figure shows the arrangement in which water from a supply tank is led through a flexible hose to the bell-mouthed entrance to a straight tube along which the frictional loss is measured. Pizometer tappings are made at an upstream section which lies approximately 50 tube diameters away from the pipe entrance and at a downstream section which lies approximately 20 tube diameters away from the pipe exit. The rate of flow along the pipe is controlled by a needle valve at the pipe exit.



Arrangement of apparatus for measuring friction loss along apipe

4.3. Theoretical Background

Studying the Hydraulic Losses in Energy for the following:

1-Rounded Bend

2-Sharp Bend 90°

3-Pipe Lines (PVC)

4-Gate valve and ball valve

5-Sudden expansion

6-Sudden Contraction

7-Four rounded Bends

8-For sharp Bends

At different values for flow rates (Q)

- The apparatus is set on the bench and leveled so that the manometers stand vertically and inverted u-tube manometer is connected to the pizometer. The supply tank is filled by a hose from the bench valve which may then be shut off. The needle valve is then closed whereupon the levels in the two limbs of the inverted u- tube should settle to the same value. The first reading of head loss and flow may now be taken. The needle valve is opened fully to obtain a differential head of at least 12 in and the collection of a suitable quantity of water in the measuring cylinder is timed. To obtain a rang of results in the turbulent region it is necessary to work with much greater differential heads than can be measured by the inverted u-tube manometer. It is desirable to take one or two readings at the lower end of the rang which overlap the rang already covered by the water manometer. Since a reading of 1 in on the mercury u-tube corresponding 12.6 in on the water manometer this requires one or two readings in the region of 1 in. the diameter of the tube and the length between pizometer tapping should be noted.

- Length of pipe between pizometer tappings, l…………………………...20.7in
- Diameter of pipe, D…………….0.116 in
- Cross sectional area of pipe, A…………………………..$1.057x10^2$ in^2
- So that……….. $u = \frac{Q}{30.48^3} \times \frac{1}{7.34 \times 10^{-5}}$

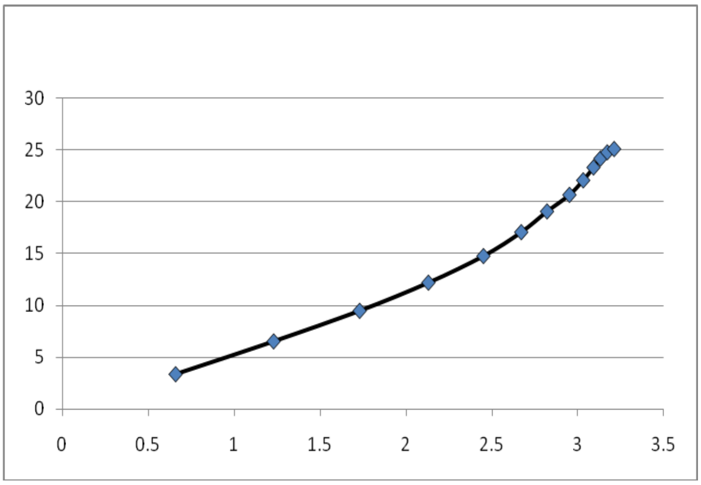
4.4. Steps of the Experiment

1- Operate the pump at different flow rate
2- Remove the air from the system
3- Take the manometers reading in table as shown
4- Repeat the table readings at different flow rates

4.5. Results

Q ty cc	t sec	U Ft/sec	h_1 In	h_2 in	i	Ө °c	log I (-ve)	logu
400	56.6	3.4	16.6	2.83	.66	18.7	.1	.5
400	60.6	3.17	15.7	3.82	.57		.2	.5
400	65.2	2.95	14.9	4.78	.48	18.7	.3	.4
400	71	2.71	13.95	5.82	.39		.4	.4
300	56.2	2.57	13.23	6.57	.32		.5	.4
300	62.4	2.31	12.72	7.11	.27	18.7	.5	.3
300	72.8	1.98	12.3	7.68	.22		.6	.3
300	82.8	1.63	11.9	8.12	.18		.7	.2
300	101	1.43	11.66	8.39	.15	18.7	.8	.1
200	81	1.19	11.44	8.75	.13		.9	.1
200	117	.82	11.07	9.22	.08		1	.2
150	120	.6	10.84	9.47	.06	18.7	1	.5
100	148	.32	10.58	9.84	.03		1	.5

4.6. Discussion



Variation of hydraulic gradient i with velocity u along pipe

EXPERIMENT (5)

5.1. General Information

- Experiment name: ***Hydrostatic Pressures on Submerged Surfaces***
- Second year civil engineering
- First term

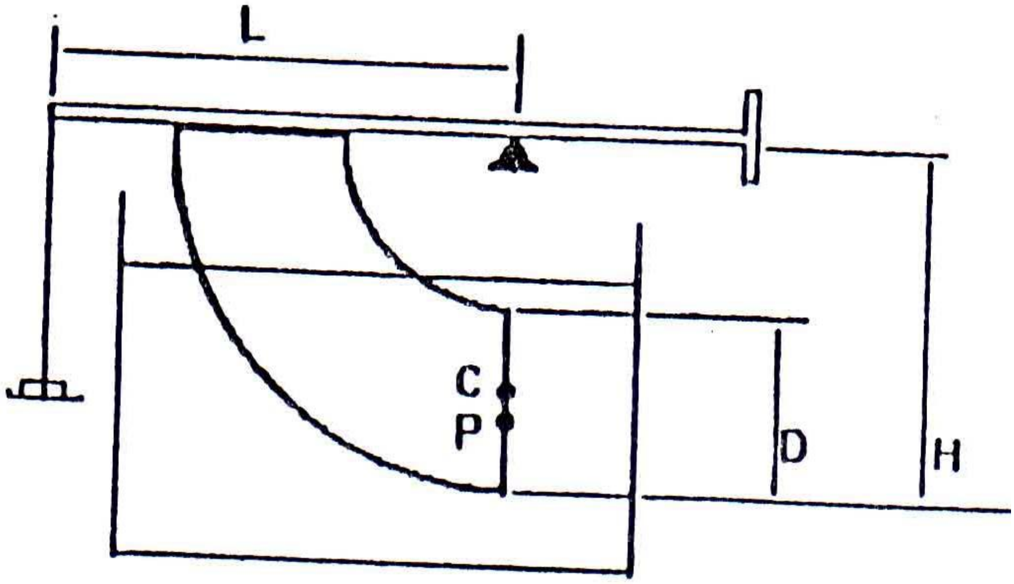
5.2. Theoretical Background

We consider a submerged surface in a stationary fluid. When a fluid is stationary, it has only normal stress,which is called pressure, but it has no shear stress. Hence, any submerged surface in astationary fluid would experience hydrostatic force. Another characteristic of stationary fluid is that its free surface is always perpendicular to the direction of gravitational acceleration. What we need to determine here are the magnitude and location of the hydrostatic forces acting on the submerged surface of the torroid .The hydrostatic pressure p below thehorizontal free surface is given by**:** $\mathbf{p = \gamma y + p_{atm}}$

where $\boldsymbol{\gamma}$ is the specific weight of the fluid, $\mathbf{y}$ is the vertical distance below the free surface, and $\mathbf{p_{atm}}$ is the atmospheric pressure which can be taken to be zero. The fluid pressure acts normal to the surface of an object and is positive in the direction into the surface. Integration of the pressure over a submerged surface yields the total hydrostatic pressure force acting on that surface. Similarly the resultant moment about a suitable specified point can be obtained by integrating the moments from the pressure over the body surface. Through total moment of momentum balance, the rotating part of the equipment is balanced with the load **W** on the scale.

5.3. Steps of the Experiment

1- Use the small weight and Put it in the balance.
2- Fill the system with water .
3- Read the value d against w at Horizontal level for the arm.
4- Repeat the Experiment by using Different weights .



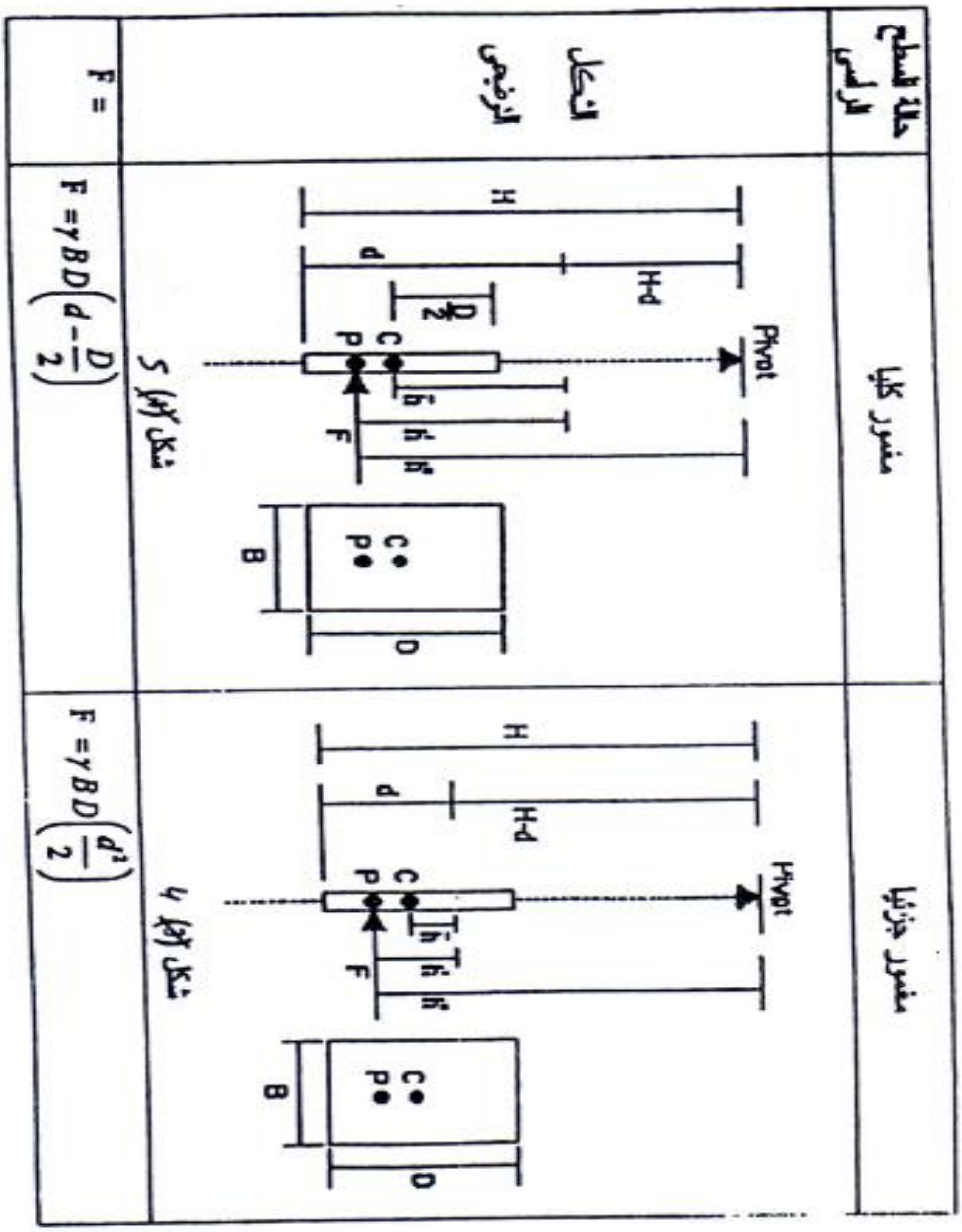
The hydrostatic pressure of liquids is the "gravitational pressure" "Phyd .It Rises due to the intrinsic Weight as the depth t increases, and is calculated from: $P_{hyd} = \rho.g.h$

where:

ρ: Density of water

g: Acceleration due to gravity ($g = 9.81\ m/s^2$)

h: Distance from liquid surface to calculate forces acting on masonry dams or ships 'hulls, for example, from the hydrostatic pressure, two steps are required:



Surface condition	Fully Submerged	Partially Submerged
Experimental $h"_{exp} =$	$h"_{exp} = \dfrac{WL}{BD\left(d - \dfrac{D}{2}\right)}$	$h"_{exp} = \dfrac{WL}{F}$
$h"_{th} =$ **Theoritical**	$h"_{th} = \dfrac{\dfrac{D^2}{12} + \left(d - \dfrac{D}{2}\right)^2}{\left(d - \dfrac{D}{2}\right)} + H - d$	$h"_{th} = H - \dfrac{d}{3}$

5.4. Results

1- Draw the Relation between the Hydrostatic force (F) and the submergence depth (d)

2- Draw the Relation between ($h_{exp.}$) and ($h_{theo.}$)

Depth of immersion, d cm	Weight W (Kg)	Readings No
		1
		2
		3
		4
		5
		6
		7
		8

(h" t h) cm	(h "exp) cm	Force F Kg	Depth of immersion, d	Weight W (Kg)	Readings No
					1
					2
					3
					4
					5
					6
					7
					8

5.5. General Questions

1) Why is the weight of the vessel and the beam not included in the expression for the center of gravity?

2) How would the location of the center of pressure change if a different fluid were used in the tank?

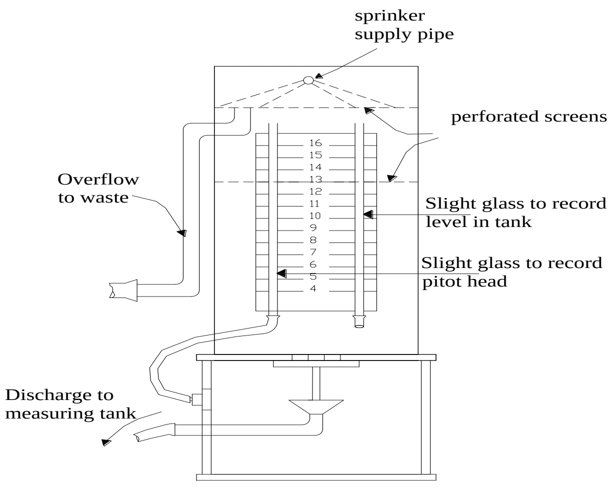
EXPERIMENT (6)

6.1. General Information

- Experiment name: ***Discharge Through an Orifice***
- Second year civil engineering
- First term

6.2. Theoretical Background

The following figure shows the arrangement of the tank which is fed from the bench supply valve through a sprinkler pipe distributes the water over perforated screen. The water passes down the tank through a second screen which serves to stabilize the flow, and leaves through a sharp edged orifice which is fitted into the base of the tank in such a way that there is no unevenness along the inner surface.



Arrangements of orifice apparatus

6.3. Steps of the Experiment

The experiment may be divided into two parts, firstly, the measurement of C_d, C_u, and C_c at a single constant value of H_o, and, secondly, measurement of discharge at a number of different values of H_o. In the first part of the experiment, water is admitted to the tank to allow it to fill to the height of the over flow pipe and the inflow is regulated so that a small steady discharge is obtained from the over flow. To measure C_u, the pitot tube is inserted into the emerging jet close to the underside of the tank, the values of H_c, and H_o are noted. To measure C_c it is necessary to find the diameter of the jet at the vena-contracta. In the second part of the experiment, the inflow to the tank is reduced to lower the level in the tank in stages, the discharge from the orifice being measured at each stage.

6.4. Results

Diameter of orifice = 0.497 in

Cross-sectional area, a_o = 0.194 in^2

Head of orifice, H_o = 14.86 in

Time required to collect 30 *Ib* of water = 65.6 sec

Discharge , Q = 0.00733 cusecs

Pitot tube reading, H_c = 14.84 in

Diameter of jet = 0.391 in.

$$C_d = \frac{Q}{\sqrt{2gH_o a_o}}$$

$$C_d = \frac{0.00733}{\sqrt{64.4 \times 1.23 \times 0.001347}}$$

C_d =0.61

Coefficient of velocity, $C_u = \sqrt{\frac{H_c}{H_o}}$

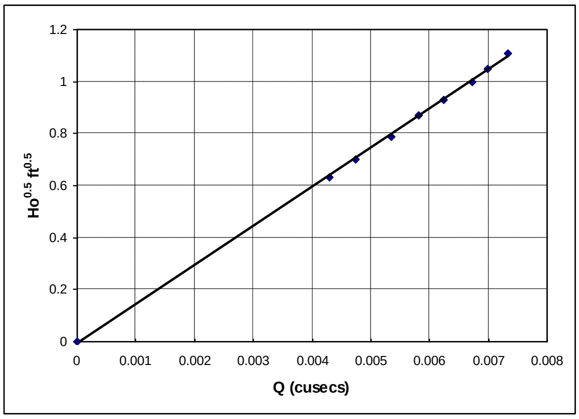
$C_u = 0.999$, say 1

Coefficient of contraction

$$C_d = \frac{a_c}{a_o}$$

$C_c = 0.619$

Qty.	**t**	**H_o**		**Q**	**$H_o^{0.5}$**
		in	ft		
Ib	sec			cuses	$ft^{0.5}$
30	65.6	14.9	1.23	.00733	1.11
30	68.8	13.5	1.12	.00699	1.05
30	71.4	12.2	1.01	.00673	1.0
30	77.2	10.6	0.88	.00623	0.93
30	82.6	9.14	0.76	.00582	0.87
30	90.0	7.52	0.62	.00534	0.79
30	101.6	6.01	0.5	.00473	0.70
30	112	4.8	0.4	.00429	0.63



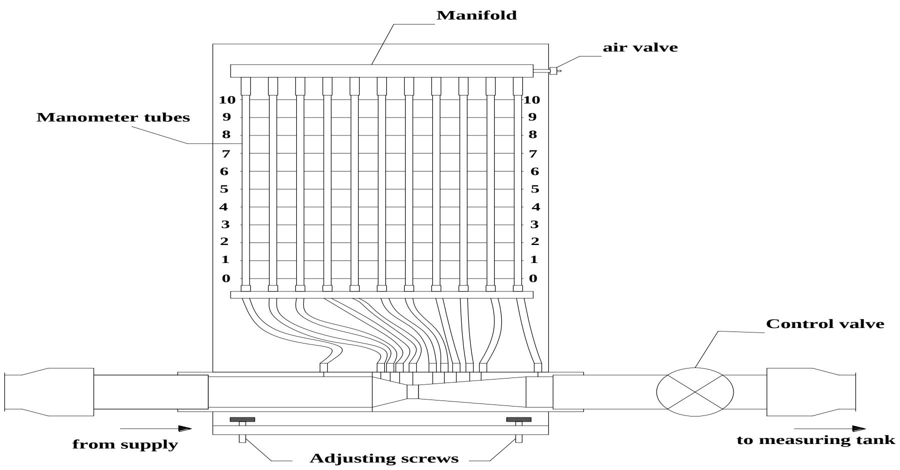
EXPERIMENT (7)

7.1. General Information

- Experiment name***: Flow through a Venturi-meter***
- Second year civil engineering
- First term

7.2. Theoretical Background

The following figure shows the arrangement of the venturi meter, which is manufactured in clear plastic material. Water is admitted from the bench supply valve and passes through a flexible hose into the meter. Beyond the control valve, which is just downstream the meter, a further flexible hose leads to the measuring tank. At a number of points along the length of the convergent-divergent passage of the venturi piezometer tubes are drilled into the wall and connections are made from each of these to vertical manometer tubes.



Arrangement of Venturi Meter Apparatus

7.3. Steps of the Experiment

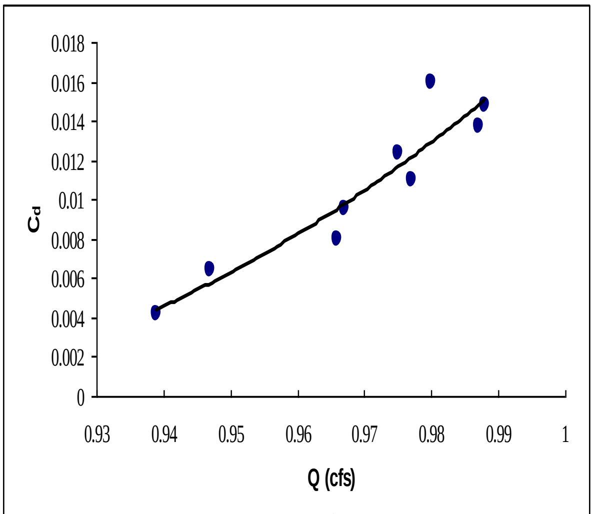
The coefficient of the meter is to be estimated. It is necessary to obtain the variation of (h_1-h_2) with discharge, Q. Preliminary, the manometer scale should be leveled. When the water level have risen to a convenient height, the bench valve is also gradually closed, so that the meter is left containing static water under moderate pressure. Measurements of a series of values of (h_1-h_2) and Q can be made. If difficulty is experienced in reaching a steady condition, air may be released from the manifold through the small valve at the end. The significant value of (h_1-h_2) is at the throat of the venture.

7.4. Results

The coefficient of the discharge, C_d, can be calculated from the equation:

$$Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2g(h_1 - h_2)}$$

a_1 is the inlet area, and a_2 is the area at the throat.



Variation of C with Q

Q cfs	**(h_1-h_2)$^{0.5}$** $ft^{0.5}$	**C_d**
0.01592	0.876	0.980
0.01478	0.806	0.988
0.01368	0.747	0.987
0.01236	0.683	0.975
0.01098	0.606	0.977
0.00954	0.532	0.967
0.00801	0.447	0.966
0.00641	0.365	0.947
0.00420	0.241	0.939

EXPERIMENT (8)

8.1. General Information

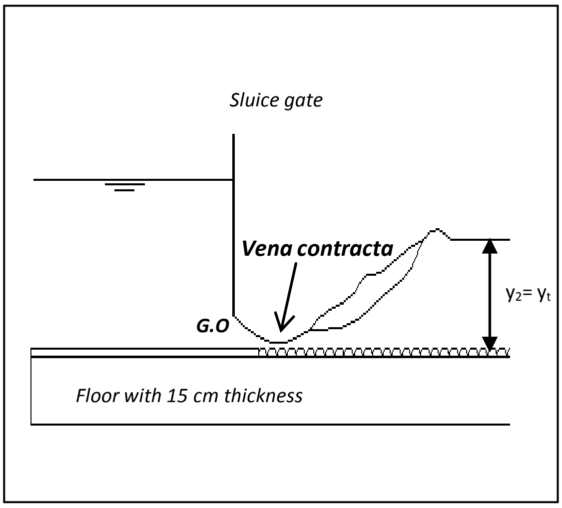
- Experiment name: ***Hydraulic jumbs***
- third year civil engineering
- First term

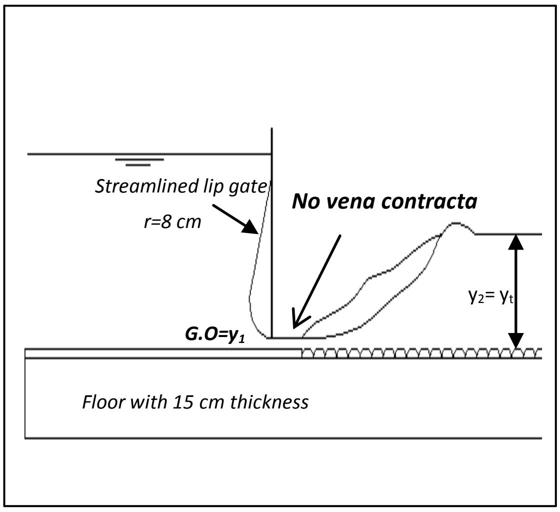
8.2. Required Apparatus for the Experiment

* Laboratory channel

* Gauge for measuring discharge

* Sluice gate.

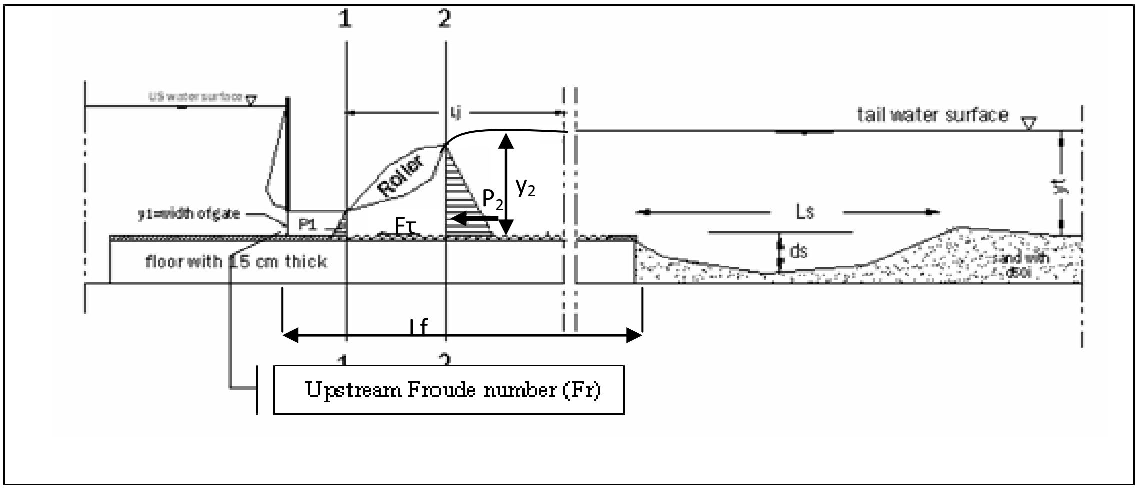




* Device for measuring velocity

8.3. Theoretical Background

The shear force acting on corrugated bed surface can be calculated by using momentum equation. The initial water depth and sequent depth of hydraulic jump can be obtained from experimental work then applying momentum equation between section (1) and section (2), figure (1).



Equation:

- the liquid is incompressible;
- the flow is steady;

- the pressure distribution is hydrostatic before and after the jump;
- the initial kinetic energy correction factor α, is unity; and
- the initial momentum coefficient β, is unity.

This equation of momentum could be written as:

$P_1 - F_\tau - P_2 = \rho\, Q\, (V_2 - V_1)$ ………………………………………. (8.1)

where:

$$P_1 = \frac{1}{2}\gamma y_1^{\,2} \;\&\; P_2 = \frac{1}{2}\gamma y_2^{\,2} \;\&\; \rho = \frac{\gamma}{g} \;\&\; V_1 = \frac{q}{y_1} \;\&\; V_2 = \frac{q}{y_2} \;\&\; q = \frac{Q}{b}$$

in which:

P_1	:	hydrostatic pressure at section (1);
P_2	:	hydrostatic pressure at section (2);
F_τ	:	shear force acting on bed surface;
g	:	acceleration due to gravity;
ρ	:	density of water;
Q	:	flow passes under gate opening;
q	:	flow per unit width;
b	:	channel width;
y_1	:	initial water depth;
y_2	:	sequent depth of hydraulic jump;
γ	:	specific weight of water;
V_1	:	velocity of water at section (1); and
V_2	:	velocity of water at section (2).

Substituting P_1, P_2, ρ, V_1, V_2 and q in equation (1), then

$$\frac{1}{2}\gamma y_1^{\,2} - \frac{1}{2}\gamma y_2^{\,2} - F_\tau = \frac{\gamma}{g} q^2 \left(\frac{1}{y_2} - \frac{1}{y_1}\right) \qquad \text{…………………………………. (8.2)}$$

From equation (2), the value of shear force acting on bed surface could be calculated by measuring initial and sequent depths of hydraulic jump and the discharge, equation (1) becomes;

$$F_\tau = \frac{1}{2}\gamma y_1{}^2 - \frac{1}{2}\gamma y_2{}^2 - \left[\frac{\gamma}{g} q^2 \left(\frac{1}{y_2} - \frac{1}{y_1}\right)\right] \quad \text{......................................} (8.3)$$

8.4. Steps of the Experiment

* Calibration of discharge gauge

The flow meter is based on an internal moving device, which activates a mechanism attached to three indicator wheels and three dials:

- **First dial ....** each cycle of the moving pointer means passing a volume equal to 10 liters of water through the flow meter.
- **Second dial ....** each cycle of the moving pointer means passing a volume equal to 100 liters of water through the flow meter.
- **Third Dial ....** each cycle of the moving pointer means passing a volume equal to 1000 liters of water through the flow meter.

The measuring devices of discharge were calibrated. Table (1) gives measurements and results for the calibration processes. Figure (3) provides the actual discharge in lit. /sec. versus the flow meter discharge.

Table (1): Measurements of discharge for flow meter calibration

The head tank method			*The Flow Meter*			
Volume (Liters)	*Time (Second)*	*Discharge (Lit. /sec)*	*Volume (Liters)*	*Time (Second)*	*Discharge (Lit. /sec.)*	*%D**
600	102	5.8823	607.1	106	5.727	+2.71
600	98	6.122	607.1	101	6.01	+1.86
600	66	9.09	607.1	68	8.93	+1.79
600	49.8	12.04	607.1	51.7	11.742	+2.53
600	47	12.76	607.1	48.8	12.44	+2.57
600	44.2	13.57	607.1	46.2	13.14	+3.27
600	41	14.63	607.1	43	14.118	+3.62
600	39.5	15.1	607.1	41.3	14.699	+2.72

- *: percentage difference between the head tank method and the flow meter reading*

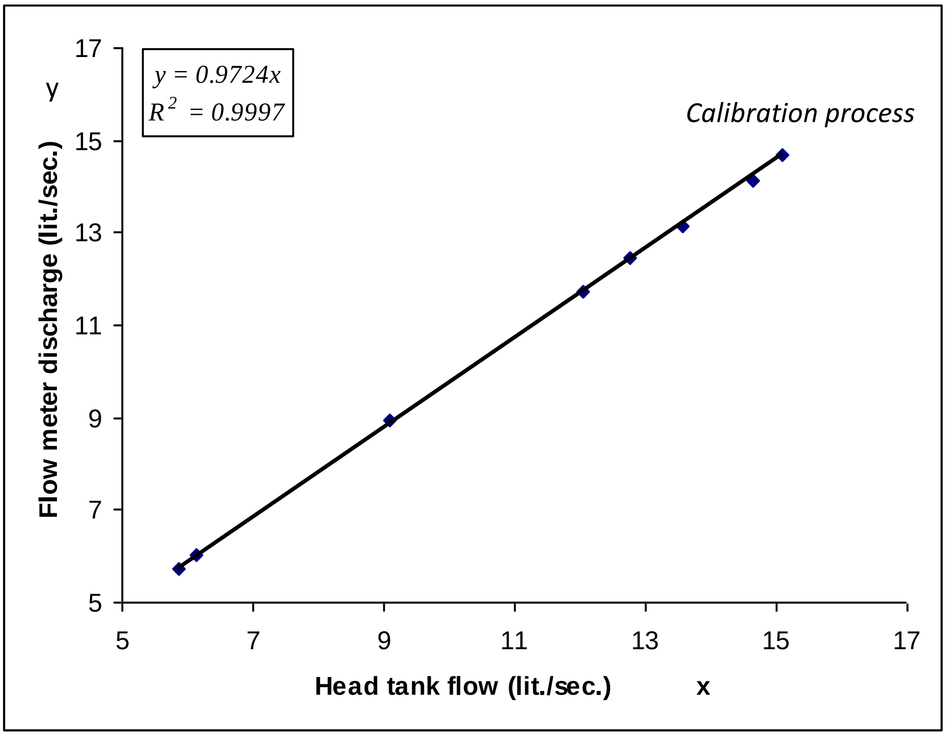


Figure (8.3): Calibration curve for the volumetric flow meter

The experiments were carried out using different models and with the three different beds to determine the following parameters:

- initial water depth on hydraulic jump (y_1) or the gate opening height (G.O);
- sequent depth of the jump (y_2);
- tail water depth (y_t);
- length of hydraulic jump (L_j);
- required time for settling the scour operation (T);
- maximum scour depth (d_s);
- maximum length of scour hole (L_s); and
- depths of the scour at selected points at the downstream sections.

Fifteen runs were carried out for every shape of corrugations with a discharge ranged from 5.0 to 15.0 lit. /sec. These runs were repeated with the three sand samples, at d_{50} = 0.62 mm (coarse), d_{50} = 0.365 mm (medium) and d_{50} =0.167 mm (fine). The total number of the experimental runs was 285 runs.

a) Experimental Set up

1- The level of sand surface is kept at the same level of the crests of the corrugated bed.
2- The level of floor upstream gate is prepared to be at the same level of the crests of corrugations, plate (1).
3- The corrugations in the floor bed start downstream a streamlined lip gate by 15 cm.
4- A streamlined lip gate is prepared to tackle the effect of *vena contracta*.
5- The regulated valve in the supply line is opened to give the required discharge.

Plate (1): Crests of corrugations are at the same level of the upstream bed *b)* ***Experimental Procedure***

1- A steady flow of water is established through all experiments.
2- The tail gate is adjusted to ensure the formation of hydraulic jump.
3- The discharge is measured using flow meter and stop watch.
4- The gate opening is considered to be the initial depth of jump and the point gauge used to measure the sequent depth of jump (y_2), the length of jump is measured by ordinary scale.
5- The time used for making the scour hole at balance state is measured using stop watch.
6- The maximum depth of scour and the corresponding length are measured.
7- The point gauge is used to measure the depth of scour at any point for drawing the scour contour lines.
8- After completion of the experiment, another model of corrugated bed is placed in the flume over the timber floor and the experiment is repeated.

8.5. Results

Plates (1) and (2) show an oscillating jump (Fr=4.26) and steady jump (Fr=5.6) over triangular corrugated bed.

Plate (1): An oscillating jump (Fr=4.26) over triangular corrugated bed

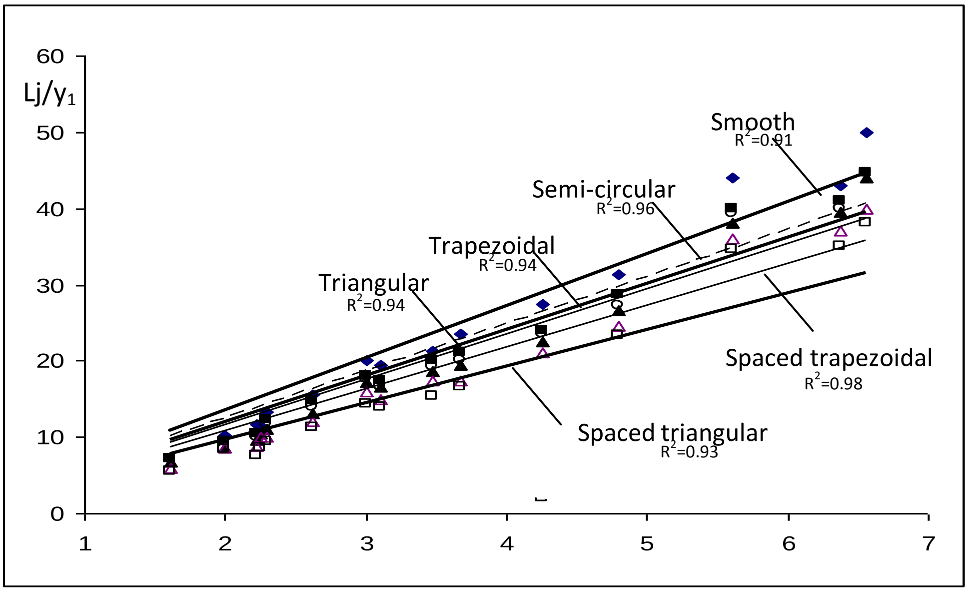
Plate (2): Steady jump (Fr=5.6) over triangular corrugated bed

8.6. Analysis

It is noticed that the length of jump over semi-circular, trapezoidal, triangular, spaced trapezoidal and spaced triangular corrugated beds at 15 lit. /sec., is less than the corresponding length over smooth bed by about 13.42%, 13.71%, 14.28%, 20% and 25.7% respectively, and it is less than the corresponding length over smooth bed at 8 lit. /sec., for these beds by about 5.0%, 9.75%, 10%, 14.75% and 18.75% respectively.

It is observed that the value of jump length by using a discharge of 15 lit. /sec., is greater than the corresponding value for all used discharges together (from 8 lit. /sec. to 15 lit. /sec.), by about 1.2% for spaced triangular bed and by about 4.42% for semi-circular bed. At a discharge of 8 lit. /sec. the jump length is less than the corresponding length, for semi-circular and spaced triangular bed by 4% and 5.72% respectively. This means that it is important to use more than one discharge for fitting the experimental data.

The length of jump (L_j) could be found in terms of, the initial depth (y_1), the sequent depth (y_2) or the difference between two conjugate depths (y_2-y_1). The plot of Fr versus L_j/y_1, is probably the best as the resulting curve can be best defined by the experimental data. For practical purposes, however, the plot of Fr versus L_j/y_2, is desirable because the resulting curves show a flat portion for the range of well established jump (Chow, 1959).


Lj/y1
Smooth
R2=0.91
Semi-circular
R2=0.96
Trapezoidal
R2=0.94
Triangular
R2=0.94
Spaced trapezoidal
R2=0.98
Spaced triangular
R2=0.93
60
50
40
30
20
10
0
1
2
3
4
5
6
7