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Flow under Sluice Gate

Annual Project Submitted to the Department of Building and Construction Engineering of the University of Technology in Partial Fulfillment of Requirements for the Degree of B.Sc. In Building and Construction Engineering.

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Supervisor Certification

I certify that this project entitled (Flow under Sluice Gate) was prepared under my supervision at Building and Construction Engineering Department, University of Technology as partial fulfillment of the requirements for the degree of B.Sc. in Water and Dams Engineering.

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ألإهـــــــــداء:

أهدي هذا المشروع إلى مثلي الأعلى و قدوتي في الحياة والذي ضحى بكل ما يملك من اجل راحتي و وصولي إلى كل ما تمناه لي وكان لي صديقًا، وأخًا، ومرشدًا، وأستاذًا فاضلا والدي العزيز له كل حبي واحترامي.

اهدي هذا المشروع إلى من كانت ساهرة وما زالت ساهرة لأجل راحتي ،التي طالما انتظرت لكي تراني على ما أنا عليه ،التي مهما تحدثت عنها لن استطيع أن أحصي ولو جزءًا قليلا من تضحياتها لأجلي والدتي ألحبيبه.

اهدي هذا المشروع إلى أستاذي العزيز الدكتور جعفر صادق معتوق مع احترامي وتقديري له.

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اهدي هذا المشروع إلى كل إخوتي وأخواتي وكل أصدقائي ولكل من سكن قلبي من عراقنا الحبيب.

شـــــكـــــــر و تـــقـــــديــــر:

نتقدم بوافر شكرنا وامتناننا بوجل إلى ذو الجلال والإكرام الله سبحانه وتعالى على ما منحنا من قوه وعزم لاختتام دراستنا الجامعية وتقديم هــذا المشــروع المتواضع كما نتقدم بالشكر الجزيل وفائق التقدير والاحترام إلى الأستاذ الفاضل (الدكتور جعفر صادق معتوق) لأشرافه على هذا المشروع وعلى بذله الجهــود الســخية وتقديمــه التوجيهــات الســديدة لإتمــام هــذا المشــروع.

طلاب المشروع

عهد مازن داود بطي　　　　محمد فلاح حسن

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NOMENCLATURE

Ho	upstream water depth
y_1	water depth at the vena contracta
$y_{2(T)}$	tail water depth
$y_{2(S)}$	sequent depth
L	distance between hydraulic jump and gate
G	gate opening
Cc	contraction coefficient
Fr	Froude number at the vena contracta
V	velocity of flow
g	gravity acceleration
Q	discharge of the gate
W	width of canal
Cd.c	discharge coefficient computed
Cd.m	discharge coefficient measured
Cv	coefficient of velocity of approch
Vact.	actual velocity
Vtheo.	theoretical velocity

Chapter One

INTRODUCTION

Sluice gates are widely used for controlling discharge and water depth in irrigation and drainage channels. Flows through the gate may be free or submerged depending on the tail water depth, as illustrated in Figures (1&2), and the discharge coefficients for the two cases are different. The discharge through a sluice gate is affected not only by the upstream depth for free flow but by both the upstream and downstream depths for submerged flow. Similarly, for a given discharge, the upstream depth is independent of tail water depth in free flow, but increases with the tail water depth when a gate operates at a submerged condition. To avoid upstream surcharge and achieve accurate discharge control, one must be able to determine whether a gate will be free or submerged, and the hydraulic performance in both free and submerged conditions must be well understood .The occurrence of submerged flow is affected by the contraction coefficient. The contraction coefficient varies with gate opening, upstream specific energy, and gate type [Sluice or other types.].In this study the experiments were conducted in hydraulic laboratory (University of Tech.) for collecting a suitable data used to show the relation between the discharge and gate coefficient. This relation may be considered as the calibration from which the stage-discharge formulation can be constructed without need to know or calculate the discharge or gate coefficient. It should be noted that the laboratory work only free flow condition in this project.

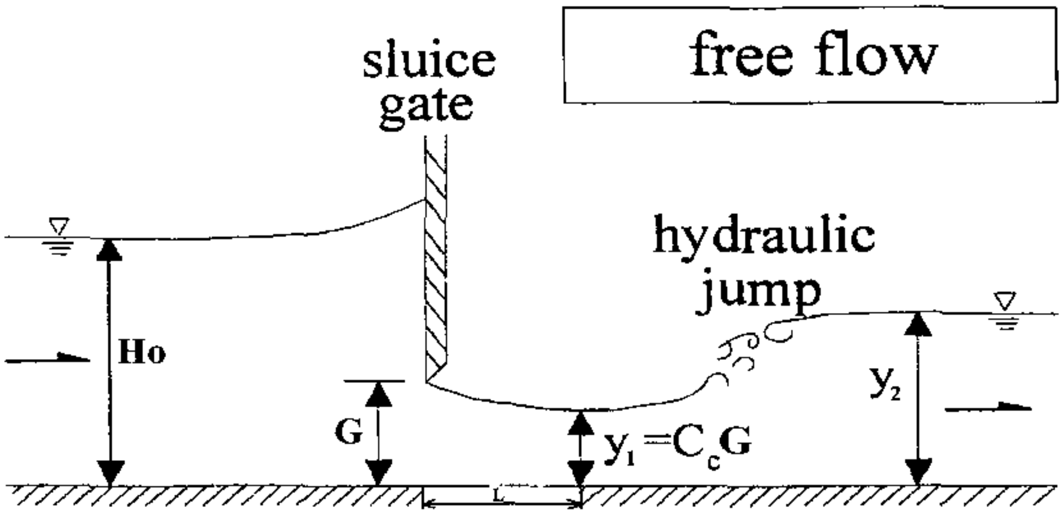


Figure. 1. Sketch of free flow

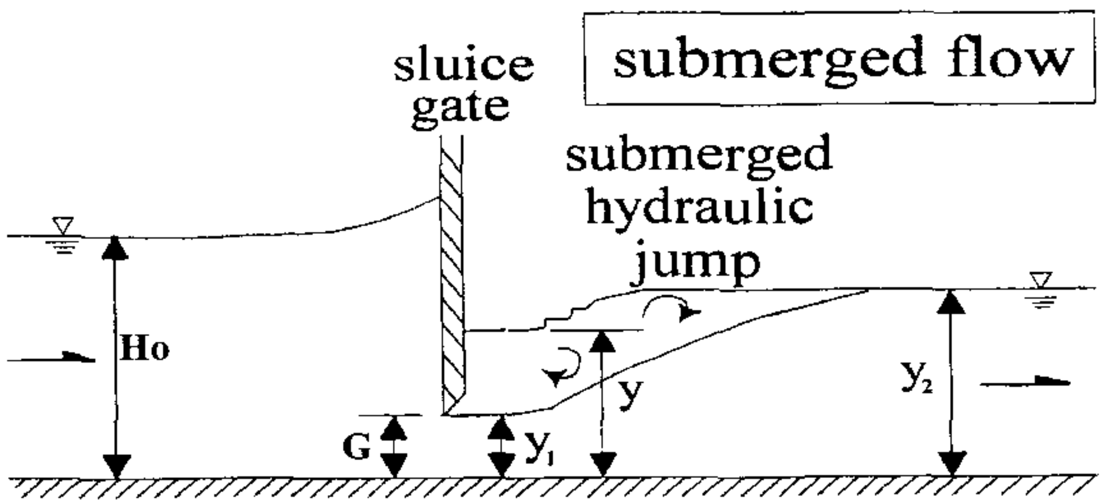


Figure. 2. Sketch of submerged flow

Chapter Two

THEORETICAL BACKGROUND

Flow contraction commonly occurs below a sluice gate. The degree of contraction may be represented by the contraction coefficient, defined as the ratio of the water depth at the vena contracta (y_1) to the gate opening (G) as shown in Figure 1.

$$Cc = \frac{y_1}{G} \quad (1)$$

Under a free flow condition, a hydraulic jump will occur in downstream from the sluice gate in a horizontal channel. The downstream depth of the hydraulic jump (y_2) (sequent depth) may be calculated by taking the water depth at vena contracta(y_1)as an(initial depth).For a rectangular horizontal channel, the downstream depth for free flows (y_2)(sequent depth) can be expressed as:-

$$y_2 = \frac{y_1}{2}\left(\sqrt{1+8Fr_1^{\,2}}-1\right) \quad (2)$$

And froud number expressed as :-

$$Fr = \frac{V}{\sqrt{gy_1}} \quad (3)$$

By using Orifice equation for free flow, the general equation for discharge through sluice gate can be expressed as :-

$$Q = C_d C_v W G \sqrt{2gHo} \tag{4}$$

The discharge coefficient for free flow can be derived from the continuity and energy equations for the upstream section and the vena contracta, and can be expressed as :

$$Q = Cd.Cv.W.G\sqrt{2g(Ho+y_1)} \quad \text{............ (A)}$$

$$Q = Cd.W.G\sqrt{2gHo(1+\frac{y_1}{Ho})} \quad \text{............... (B)}$$

$$Q = Cd.W.G\sqrt{2gHo}\sqrt{1+\frac{y_1}{Ho}} \quad \text{............... (C)}$$

But $Cc = \frac{y_1}{G} \rightarrow y_1 = Cc.G$

$$Q = Cd.W.G\sqrt{2gHo}\sqrt{1+Cc\frac{G}{Ho}} \quad \text{........... (D)}$$

By continuity eq.

$$(y_1.W)\sqrt{2gHo} = Cd.WG\sqrt{2gHo}\sqrt{1+Cc\frac{G}{Ho}} \quad \text{.......... (E)}$$

$$\frac{y_1}{G} = Cd\sqrt{1+Cc\frac{G}{Ho}} \quad \text{...................... (F)}$$

$$Cc = Cd\sqrt{1+Cc\frac{G}{Ho}} \quad \text{........................ (G)}$$

C

$$Cd.c = \frac{Cc}{\sqrt{1+\frac{CcG}{Ho}}} \tag{5}$$

And the discharge coefficient (measured) can be expressed from the flowing eq.

$$Cd.m = \frac{Q.m}{WG\sqrt{2gHo}} \qquad (6)$$

Or from this eq.

$$Cd.m = Cv * Cc \qquad (7)$$

And Cv :Coefficient of velocity of approch can be expressed as:-

$$Cv = \frac{V_{act.}}{V_{theo.}} \qquad (8)$$

And **V**act. expressed as:-

$$V_{act.} = \frac{Q_{act.}}{A_{(vena)}} \qquad (9)$$

And **V**theo. Expressed as:-

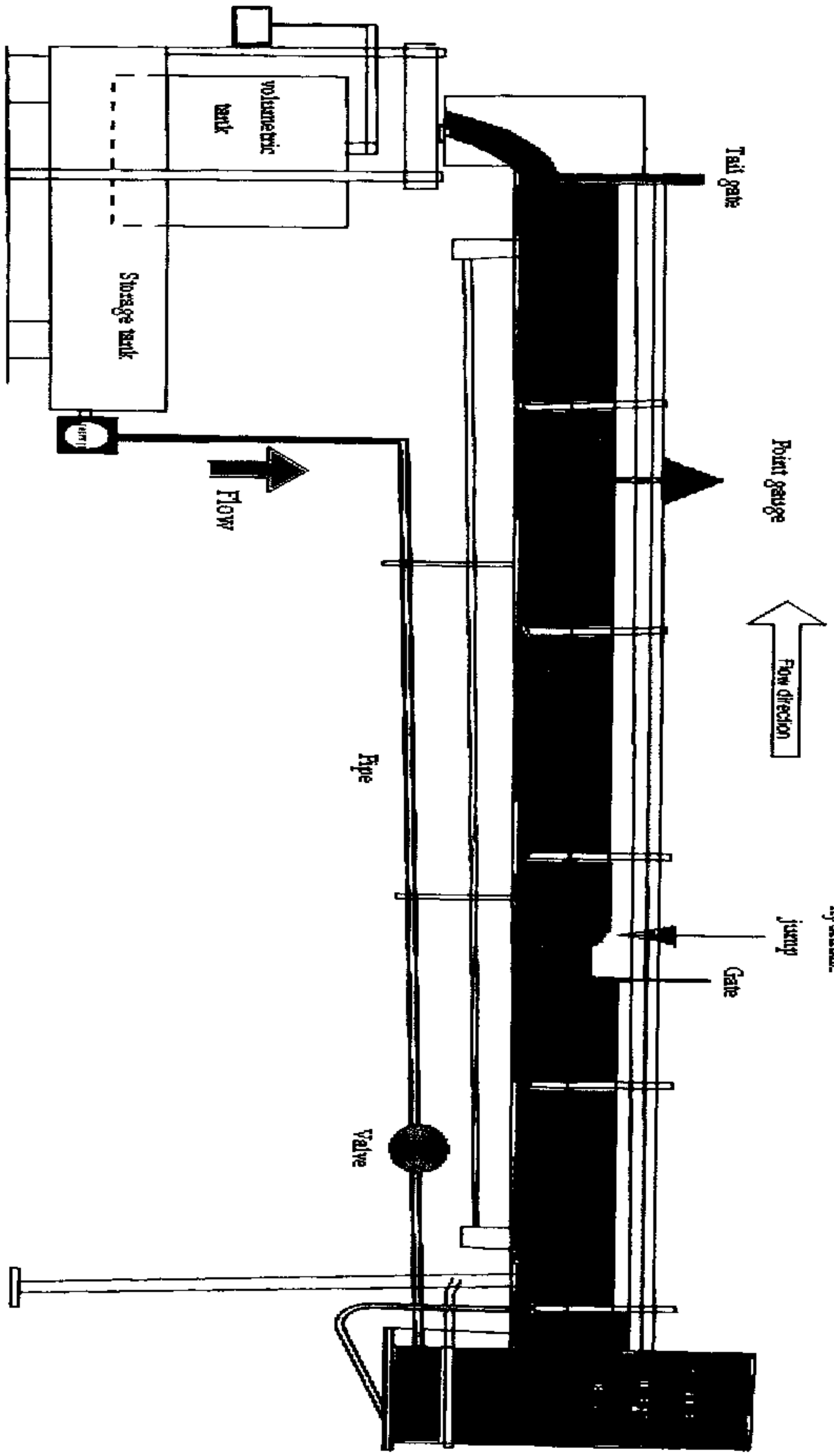
$$V_{theo.} = \sqrt{2gHo} \qquad (10)$$

Chapter Three

HYDRAULIC EXPERIMENTS

FLUME DIMENSION.

Hydraulic experiments were conducted in the laboratory of the Department of Hydraulics in university of Technology. The model (canal) consisted of a (5m) long,(7.6cm)wide,(15cm) deep glass. During the experiments, water was pumped from a storage tank to a Temporary storage tank through a connecting pipe. Valves were installed along the pipe for regulating discharge. Discharge was measured using a volumetric tank with time reading. An adjustable tail gate was used to set the desired tail water depth. The vertical sluice gate was installed in the canal. The upstream and downstream water depths were measured using point gauges with (0.1mm) accuracy. The channel bed was kept horizontal during the experiments.



volumetric tank
Storage tank
Flow
Pipe
Valve
Tail gate
Point gauge
Flow direction
hydraulic jump
Gate

Figure.3

EXPERIMENTAL PROCEDURE:

1. Open gate with initial height and turn on the pump and open the valve to allow maximum initial flow.

2. Control of tail water gate to select the location of hydraulic jump. The location of hydraulic jump at distance (twice gate opening) from gate location.

3. Measure the flow.(using volumetric tank and stop watch)

4. Change the gate opening at different four heights for the same flow.

5. Record the depth of water at locations (Ho, y_1, y_2) for each gate opining. (see fig. 1)

6. Repeat steps (4 and 5) for four different flow rates.

Chapter Four

CALCULATIONS AND RESULTS

This Table results from hydraulic experimental.

LABORATORY DATA						
	NO.	Q(m3/s)	G(m)	Ho(m)	Y1(m)	Y2(m)(Tail Water)
Run 1	1	0.001233	0.015	0.121	0.011	0.057
	2	0.001233	0.0175	0.1	0.012	0.053
	3	0.001233	0.02	0.078	0.014	0.046
	4	0.001233	0.0225	0.0655	0.016	0.0455
	5	0.001233	0.025	0.0533	0.018	0.0375
Run2	1	0.00109	0.015	0.1103	0.011	0.055
	2	0.00109	0.0175	0.09	0.0122	0.0486
	3	0.00109	0.02	0.0699	0.014	0.0462
	4	0.00109	0.0225	0.057	0.0159	0.0411
	5	0.00109	0.025	0.0495	0.017	0.0379
Run3	1	0.00106	0.015	0.0982	0.0111	0.0515
	2	0.00106	0.0175	0.0751	0.0121	0.0475
	3	0.00106	0.02	0.0625	0.0145	0.0428
	4	0.00106	0.0225	0.0515	0.016	0.0387
	5	0.00106	0.025	0.0434	0.021	0.0358
Run4	1	0.000824	0.01	0.1064	0.007	0.0472
	2	0.000824	0.0125	0.0737	0.009	0.04
	3	0.000824	0.015	0.0568	0.0112	0.0368
	4	0.000824	0.0175	0.045	0.0125	0.0336
	5	0.000824	0.02	0.0369	0.017	0.0298
Run5	1	0.000477	0.005	0.116	0.0043	0.0356
	2	0.000477	0.0075	0.0576	0.007	0.031
	3	0.000477	0.01	0.037	0.0083	0.0256
	4	0.000477	0.0125	0.0278	0.011	0.0219
	5	0.000477	0.015	0.0265	0.014	0.0173

Table.1

This Table results from equations in chapter two.

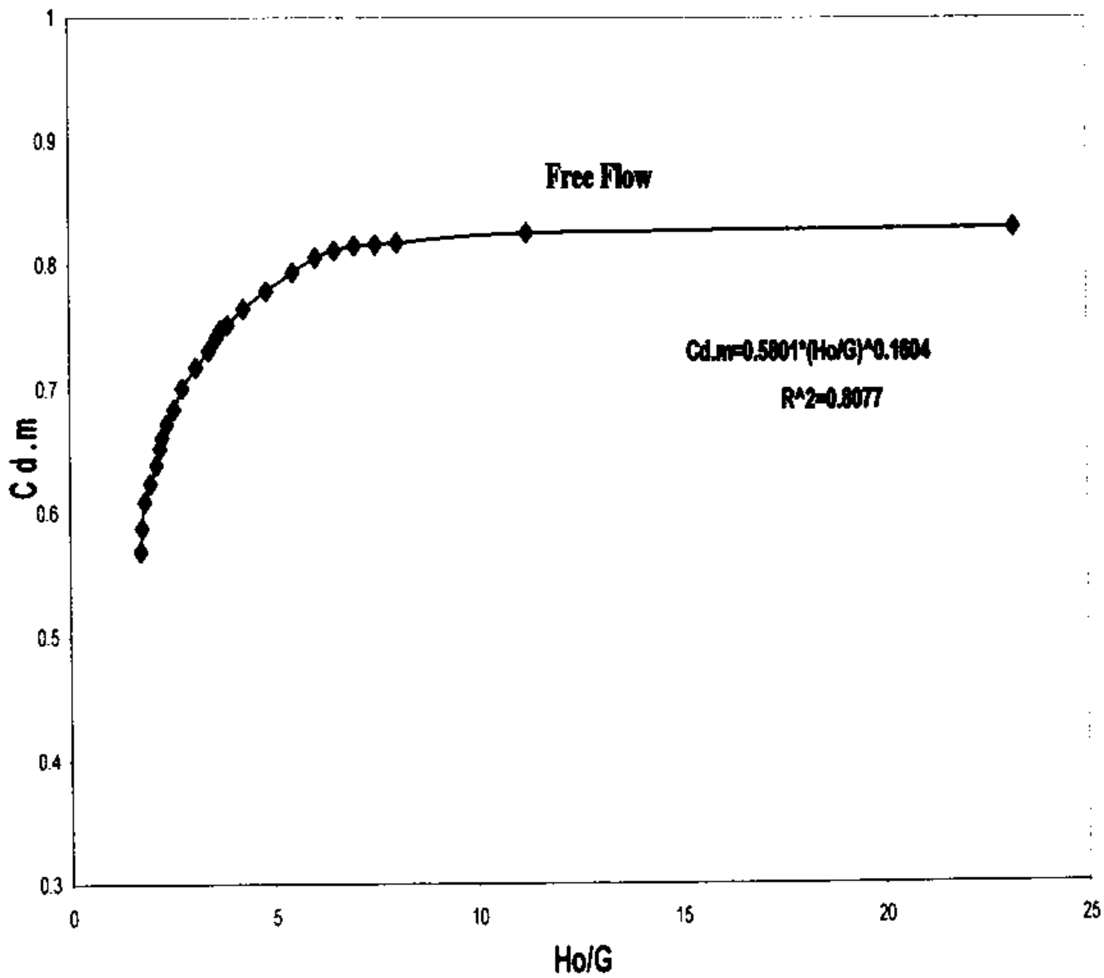
Table.2

	NO.	W(m)	Y2.c(sequent depth)(m)	Cd.c	Cd.m	Ho/G
Run 1	1	0.076	0.064	0.588167	0.70196594	8.066667
	2	0.076	0.0611	0.579836	0.6618536	5.714286
	3	0.076	0.055	0.567249	0.65572643	3.9
	4	0.076	0.05	0.55465	0.63605814	2.911111
	5	0.076	0.046	0.537885	0.6345946	2.132
Run2	1	0.076	0.056	0.586171	0.64995665	7.353333
	2	0.076	0.052	0.576754	0.61674282	5.142857
	3	0.076	0.048	0.562855	0.61234309	3.495
	4	0.076	0.0439	0.547622	0.60275866	2.533333
	5	0.076	0.0418	0.53335	0.58213109	1.98
Run3	1	0.076	0.054	0.583424	0.66987808	6.546667
	2	0.076	0.051	0.570781	0.65657562	4.291429
	3	0.076	0.045	0.557968	0.62975666	3.125
	4	0.076	0.0424	0.542034	0.61667542	2.288889
	5	0.076	0.0341	0.524736	0.60458574	1.736
Run4	1	0.076	0.055	0.593232	0.75040083	10.64
	2	0.076	0.047	0.5807	0.72130736	5.896
	3	0.076	0.0409	0.566104	0.68469742	3.786667
	4	0.076	0.0379	0.548411	0.65935577	2.571429
	5	0.076	0.0299	0.528813	0.63711956	1.845
Run5	1	0.076	0.041	0.602135	0.83206315	23.2
	2	0.076	0.0305	0.587129	0.78719582	7.68
	3	0.076	0.0272	0.565187	0.73663852	3.7
	4	0.076	0.022	0.540378	0.6798653	2.224
	5	0.076	0.0179	0.525924	0.58028466	1.766667

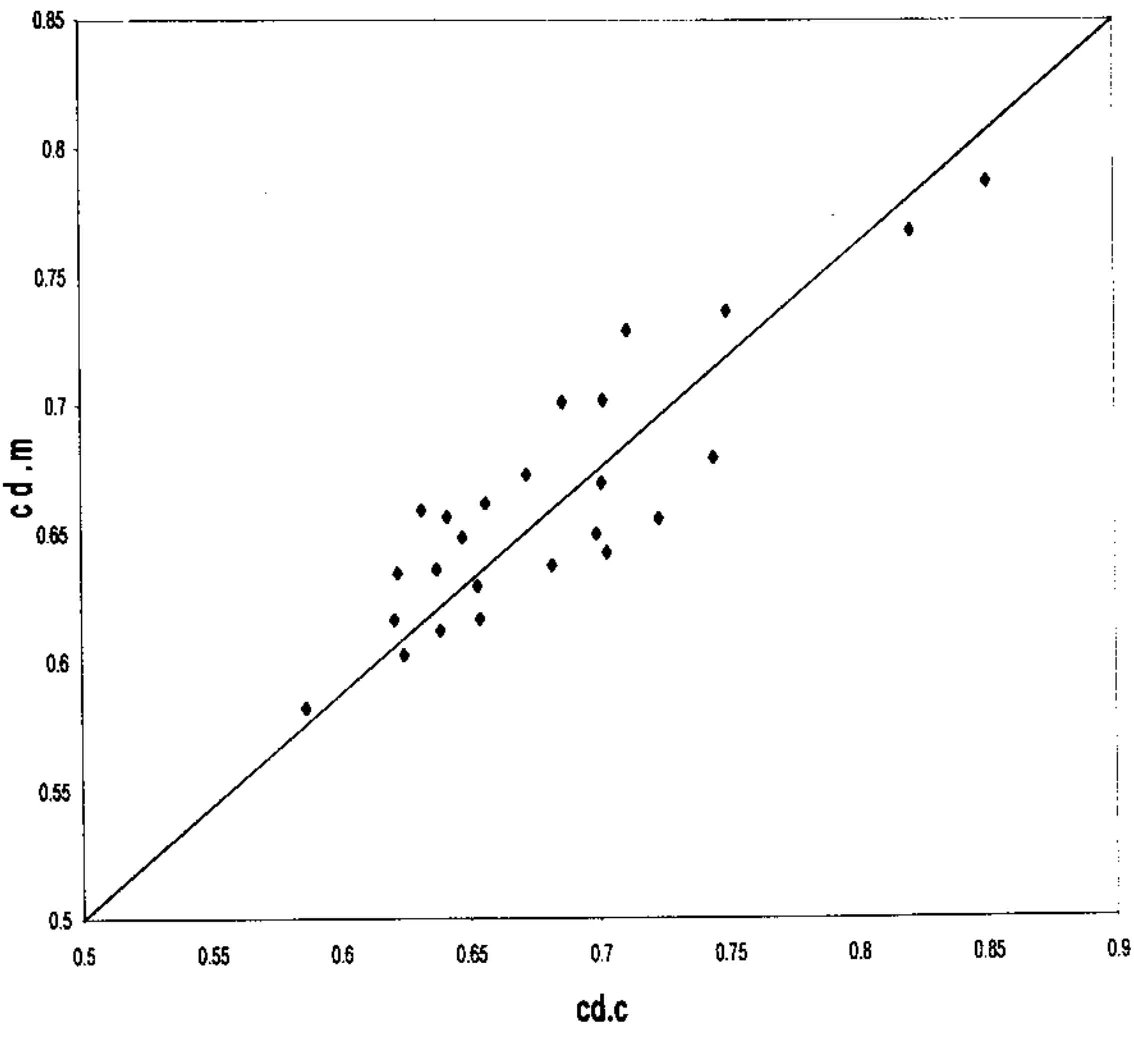
This Table results from equations in chapter two.

Table.3

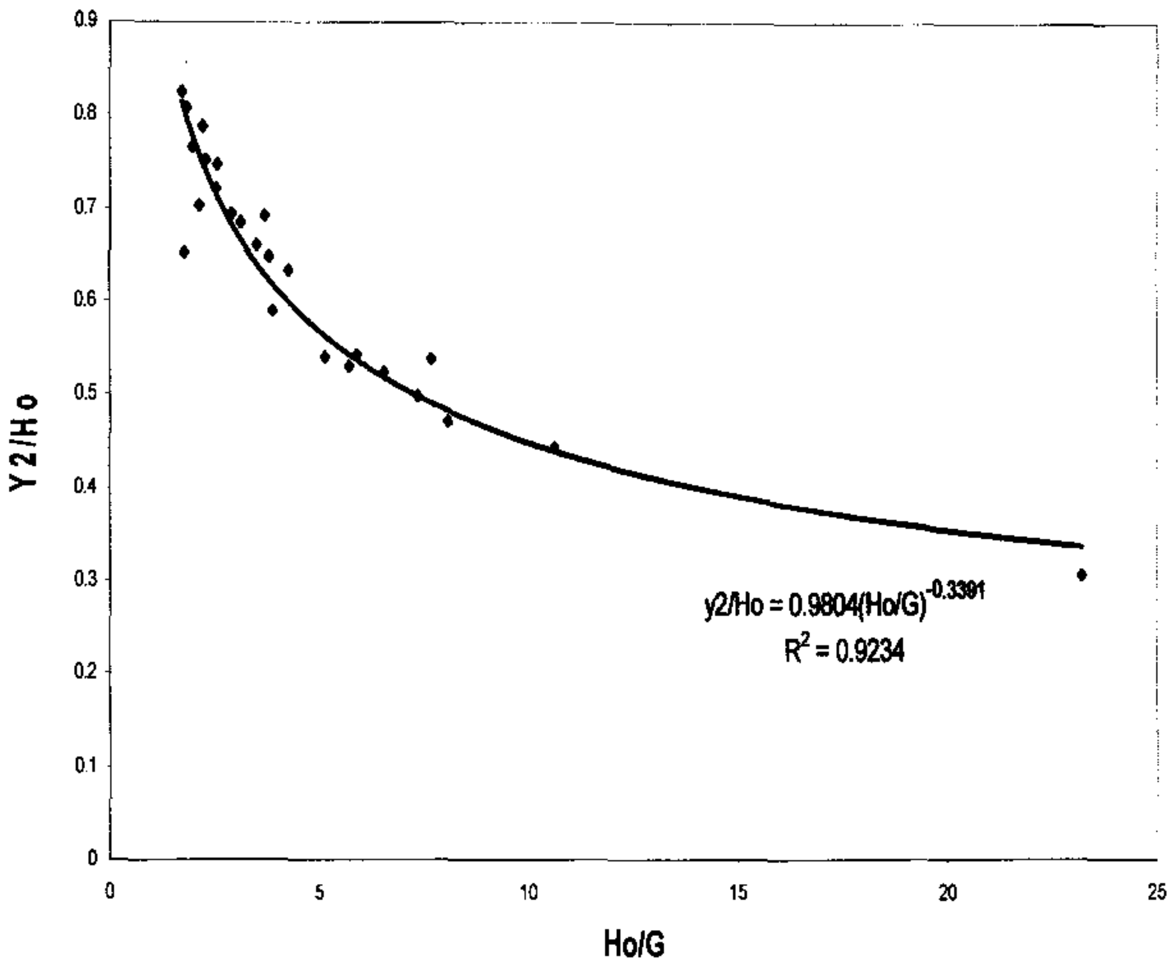
	NO.	Cc	Vtheo.	Vact.	cv
Run 1	1	0.733333	1.5407	1.474	0.957
	2	0.685714	1.4	1.351	0.965
	3	0.7	1.237	1.158	0.936
	4	0.711111	1.133	1.013	0.894
	5	0.72	1.022	0.901	0.881
Run2	1	0.733333	1.471	1.303	0.886
	2	0.697143	1.328	1.175	0.884
	3	0.7	1.171	1.024	0.874
	4	0.706667	1.057	0.902	0.852
	5	0.68	0.985	0.843	0.856
Run3	1	0.74	1.388	1.256	0.905
	2	0.691429	1.213	1.152	0.949
	3	0.725	1.107	0.961	0.868
	4	0.711111	1.005	0.871	0.867
	5	0.84	0.922	0.664	0.719
Run4	1	0.7	1.548	1.548	1
	2	0.72	1.202	1.202	1
	3	0.746667	1.055	0.968	0.917
	4	0.714286	0.939	0.867	0.923
	5	0.85	0.85	0.637	0.749
Run5	1	0.86	1.508	1.459	0.967
	2	0.933333	1.063	0.896	0.843
	3	0.83	0.852	0.756	0.887
	4	0.88	0.738	0.57	0.772
	5	0.933333	0.721	0.448	0.621



(Figure.4) relation between the Cd measured and (Ho/G).



(Figure.5) compare between Cd.m and Cd.c by express the intercepting point between them.



(Figure.6) relation between the rate of (Ho/G) and the rate of ($y_{2(T)}$/Ho) and express the equation and the correlation coefficient between them.

Chapter Five

Discussion

. In fig.(4) we find the increasing rate of (Ho/G) will increase the value of (Cd.m) until approaching the rate of (Ho/G) to (10) the value of (Cd.m) will be constant and the figure express the equation and higher correlation coefficient between them .

. In fig.(5) we find the distribution of points upper the line and lower the line . The lower points are presented over estimate and the upper points are present under estimate.

. Fig.(6) Refer to the relation between the $y_{2(T)}$ and gate opening which is extrusive relation . So as to the value of $y_{2(T)}$ will decrease when the gate opening is decrease and the correlation coefficient is higher between them.

References

[1]- From net (www.google.com/#q=flow+under+sluice+gate&hl=en&start=10&sa=n&fp=c78e48b898b2787e). {15/12/2009}.

[2]- Chow, V.T., 1959, "Open Channels Hydraulics," McGraw-Hill Book Co. Inc., New York, N.Y.