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EXPERIMENTAL INVESTIGATION ON MAKHOOL DAM STILLING BASIN

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ABSTRACT - This research is an experimental investigation on the hydraulic performance of the combined hydraulic jump and plunge pool stilling basin operating under high head for Makhool Dam. Two series of tests are carried out; the first series are on the model as it is designed, while the second series are on a modified model by adding two rows of chute blocks.

(81) Experiments are performed on both models. The results indicated that for the first model the stilling basin length can be reduced and there is negative pressure at the beginning of the jump on the sloping apron with high turbulence and unstable water surface. After adding the chute blocks, the tests of the second model indicated that the stilling basin length can be reduced and all pressures are positive with reasonably stable water surface as well as lower turbulence. Therefore, chute blocks are recommended to be added.

1. INTRODUCTION

The problem of energy dissipation downstream of hydraulic structures has attracted the attention of hydraulic engineers for a long time. Various means such as hydraulic jump on horizontal or sloping floors, roller and ski-jump buckets have been used to achieve proper dissipation of the energy. Jump-type stilling basins is one of the most common types involves the provision of a depressed floor with or without appurtenant structures like chute blocks, baffle blocks, sills etc.

By definition, a stilling basin is a short length of paved channel placed at the end of spillway, downstream the gates or any other source of supercritical flow. According to the type of dam, topographical condition, upstream head and other factors, the types of stilling basins are chosen.

From intensive studies of many existing structures and laboratory investigations, various types of generalized design of stilling basin have been developed by the ***United State Bureau of Reclamation (USBR)*** . According to this classification and under the above factors, the type of stilling basin under investigation is ***USBR basin II*** and this stilling basin is commonly used for high-dam and earth-dam spillways and for large canal structures. The basin contains chute blocks at the upstream end and a dentated sill near the downstream end. No baffle piers are used because the relatively high velocities entering the jump might cause cavitations at the piers.

At Makhool Dam water entering this stilling basin via the bottom outlet which is controlled by radial gates. In addition, water released via the upper emergency spillway as a jet created by the flip bucket into the air and then into stilling basin i.e. the basin will operate as hydraulic jump stilling basin and plunge pool. This combination needs to be investigated and tested.

2- REVIEW AND THEORY

In the literature, enormous information are available about the hydraulics performance of stilling basins, this can be found in (1, 2, and 3). Information about the design of any type of stilling basins can be found in (4, 5, 6, and 7).

<u>BASIC HYDRAULICS</u>

For supercritical flow in a horizontal rectangular channel, the energy of flow is dissipated through frictional resistance offered by the channel boundary, resulting in a decrease in velocity and an increase in depth in the direction of flow.

A hydraulic jump will form in the channel if Froude number (F_1) of the flow, the flow depth (Y_1) and downstream depth (Y_2) satisfy the following equation:

$$\frac{Y_2}{Y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^{\,2}} - 1\right) \qquad (2\text{-}1)$$

where, Y_2: water depth at the end of the jump.

Y_1: water depth at the beginning of the jump.

F_1: Froude numbers at the beginning of the jump.

This equation may be represented by a curve as given in (4). This curve has been verified experimentally by many researchers and was found useful in the analysis and design of hydraulic structures.

For the analysis of the jump on sloping apron, a rectangular channel of unit width is assumed. Considering all effective forces parallel to the channel bottom, the general equation of D_2/D_1 and F_1 may be written as:

$$\frac{D_2}{D_1} = \frac{1}{2}\left(\sqrt{1+8G^2} - 1\right) \qquad \ldots(2\text{-}2)$$

where, D_2: vertical depth of water on the sloping surface at the end of the jump.

D_1: vertical depth of water on the sloping surface at the beginning of the jump.

$$G = \frac{F_1}{\sqrt{\cos\theta - \dfrac{KL\sin\theta}{D_2 - D_1}}} \qquad \ldots(2\text{-}3)$$

K: correction factor for the effect of slope.

L: length of the jump.

Since $D_1=Y_1\cos\theta$ and $D_2=Y_2\cos\theta$, equation (2-2) may also be written as:

$$\frac{Y_2}{Y_1} = \frac{1}{2}\left(\sqrt{1+8G^2} - 1\right) \qquad \ldots(2\text{-}4)$$

3- EXPERIMENTAL WORK

The experimental work is carried out at the hydraulic laboratory of the college of Engineering Al-Mustansiria University. Two stilling basin are used. The first stilling basin is without chute blocks as shown in fig. (3) and fig. (4), while the second is with chute blocks added later as shown in fig. (5) and fig. (6).

Altogether (81) experiments are performed by using these two physical models. (33) experiments are performed on the first model, and (44) experiments are performed on the second model and (4) experiments are performed by using emergency spillway.

THE FLUME

The laboratory flume is (20.0m)-working length, (0.9m) width and (0.6m) depth with armored plate-glass sidewalls. On the top of the sidewalls, there are rails along which instrument carriages could be moved. The flume base is made of steel plate. Water is supplied to the flume through (0.3m) delivery pipe discharging into a steel inlet tank (2.0m length, 1.6m width and 0.9m depth). At the downstream end of the flume, an exit tank (1.7m length, 0.9m width and 0.8m depth), also made of steel, is provided from which the flow passes via the sump to the suction pipe of the pump. The setup is shown in Figs. (1, and 2).

Both inlet and outlet tanks are rigidly attached to the upstream and downstream ends of the flume, and the whole system is mounted on the steel frame supported on two cylindrical bearings at its center. For electrically controlled screw jacks with system of gears, each pair on one end of the flume is provided to enable rotation of the flume about a central bearing, thus allowing the flume slope to be adjusted as required.

A large sump tank is constructed along the side of the flume under the laboratory floor. Water is stored in this tank and pumped to the flume via an axial flow vertical pump (100 L/s) maximum capacity, with (22 kW) and (1460-rpm) motor. The flow is controlled by a manually operated valve, installed on the circulation system pipe. The pump can be kept at a stable operation by means of a by-pass pipe controlled by a butterfly valve.

THE HYDRAULIC MODEL

To study the hydraulic performance of the combined stilling basin of Makhool Dam spillway, a sectional hydraulic model with scale 1:50 of the spillway is constructed from Perspex sheets, to provide the visibility and which is necessary for visual observation of the flow to show the flow through the models. The dimensions of the model are scaled down prototype dimensions to a scale of 1:50 selected to suite the flume and to keep the similarity condition. This model represents one bay of the prototype.

To accommodate the model in the flume, the height of the inlet part to the model is raised to 120 cm, by adding an additional steel tank connected to the flume inlet part.

The steel tank is constructed at distance (1.5m) from the existing inlet steel tank of the flume. The length of the additional tank is (240cm), of width (60cm) and height (120cm). This tank is divided into two parts by Perspex sheet with 624 openings each (0.2cm) in diameter. The length of the first part is (1m) and second part is (1.4m). Water is supplied to this tank via two flexible hoses, due to the limitation of the standard dimensions of the Perspex sheets.

INSTRUMENTATION AND MEASUREMENTS

The following measuring instruments are used throughout the experimental work.

Discharge Measurement

Discharge is measured by a rectangular uncontrolled sharp crested weir, manufactured according to (B.S.I) British standard institution part 4. The weir is manufactured from Perspex plate of (10mm) thickness installed at downstream end. The head upstream the weir is measured by using a hock type gauge with a vernire scale reading (0.1mm), as shown in Fig. (2). To eliminate the errors in gauge reading due to flow turbulence and surface waves, a well gauge is installed at (1.5m) distance from the weir connected to the flume bed. At the downstream of the weir, two flexible tubes are installed, one at end side of the weir to ensure proper aeration of the flow lower nap .

Rehbock formula is used for the calculation of the discharge;

$$Q(m^3/s) = C_e \frac{2}{3}\sqrt{2g}\,BH_e^{3/2}$$

in which:

$Ce=0.602+0.083\ H_w/P$

$He=H_w+0.0012$

(H_w, He, P, B) in meter

Water Level Measurement

An accurate long point gauge with a venire-scale reading to 0.1 mm is used for measuring water levels. This gauge is supported by an aluminum bass with Perspex pointer on a carrier mounted on two rails fixed on the top of the flume sides and could be moved in three directions. The pointer of the base moves against a metric scale fixed on the front of the carrier to show the position of the point gauge across the width of the flume and two streak pointers are screwed within the rail from the outer side of the flume to read the position of the point gauge along the flume. Due to water fluctuation in water surface, a well gauge is used at the downstream of the model connected to the side wall of the model and another is used upstream the gate.

Water Temperature Measurement

Water temperature is recorded by a thermometer. Two or three readings are recorded for each test run and the effective temperature is taken as the mean of these reads. The range of water temperature during the whole work of this study varies from 27 C^0 to 29 C^0 .

Pressure Measurements

A total of (104) copper pieces each of 3cm length is inserted at the center of the floor of all model bases, first section, stilling basin, end sill, upper and lower face of spillway, 5cm a part. Flexible tubes are connected to these pieces and used to measure the pressure at those points.

THE EXPERIMENTAL PROGRAM

The experimental work is carried out in the hydraulic laboratory of Al-Mustansiria University. Two stilling basins are used in this work. The first stilling basin is without chute blocks, while the second is with chute blocks.

Altogether (81) experiments are performed by using these two physical models. (33) experiments are performed by using the first model, (44) experiments are performed by using the second model and (4) experiments are performed by using emergency spillway. The variables measured (i.e. $H_w, T.W., G_0, L_0, L, Y_1, Y_2, B_3,$ water temperature.), (105) piezometers are measured (62) times and (122) piezometers measured (4) times in case of combination of stilling basin-cover wide range of the models which amount to (7724) data points.

4- SIMILITUDE

To ensure complete similarity, it is essential that both, the model and the prototype are geometrically similar.

Geometric similarity: When the shape of the model is similar to the prototype, geometric similarity is said to exist. This means that the ratio between all corresponding lengths including roughness between model and prototype is equal. This ratio (L_r) is called the scale ratio.

Now, Length ratio (L_r) = L_m/L_p

Area ratio $=A_m/A_p= (L_m/L_p)^2 =(L_r)^2$ …(4-1)

Volume ratio$=V_m/V_p =(L_m/L_p)^3 =(L_r)^3$ …(4-2)

For this model (L_r) is taken to be (0.02)

5- DATA ANALYSIS AND RESULTS

The results concerning the jump length (L), tail water depth (T.W.), jump initial depth (Y_1) and jump sequent depth (Y_2) the ratios, which are plotted with (F_1) are shown in figures (7), (8) and (9).

Length of the jump (L)

To demonstrate the difference between the results obtained from the two models shown from Figs. (7) and (8), it is clear that for the same range of L/T.W. Froude number decreases from (9.02) to (3.95) and the same is applied for the ratio of L/Y_2 with F_1 which highlights the effects of the chute blocks added to the 2-nd model.

Location of the Jump (L0)

From the experimental data shown in tables (5-1) to (5-23), it is clear that this distance decreases with the increase in the gate opening for the same discharge and increases with the increase in the discharge for the same gate opening for the two models but, for the same discharge and the same gate opening this distance in the second model is smaller than that in the first model.

The Downstream Tail water

From the experimental data, in second model F1 decreases from 9.02 to 3.95 which indicates clearly the effects of the added chute blocks as shown in Fig.(9).

6-CONCLUSIONS AND RECOMMENDATIONS

1. From the experimental data for the two models, the hydraulic jump length and the location of the jump for all discharges are so shorter than the designed apron length.
2. For the second model, the chute blocks location, dimension and its arrangement give better results.
3. At the large discharges, water flows over the sidewalls due to water surface waving and turbulence and the same thing for the second model, but more amount of water floats over sidewalls so that it rises for the two models.
4. From the analysis of F_1 and L/TW plot for the for the two models, the second model exhibits lower range of F_1 for approximately the same range of L/TW ratio.
5. From the plots of TW/Y_1 and F_1 for the two models, the second model exhibits lower values for F_1 and TW/Y_1 the first model.
6. The stilling basin length can be reduced.

The following is recommended are suggested for further research:

It would be interesting to continue the present study by carrying out detailed measurements for the pressure fluctuations (variation of pressure with time) using more sophisticated computerized setup including pressure transducers since the piezometers give the range values only.

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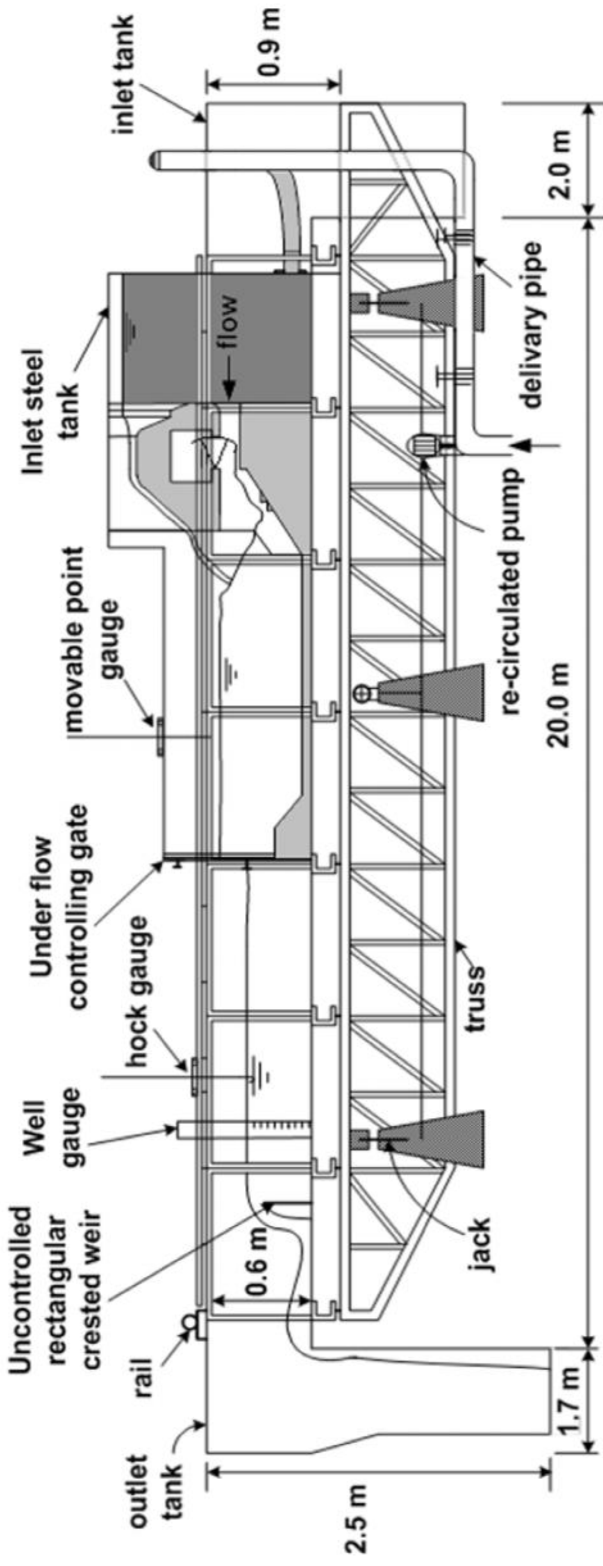

Fig. (1):- Side view of the flume

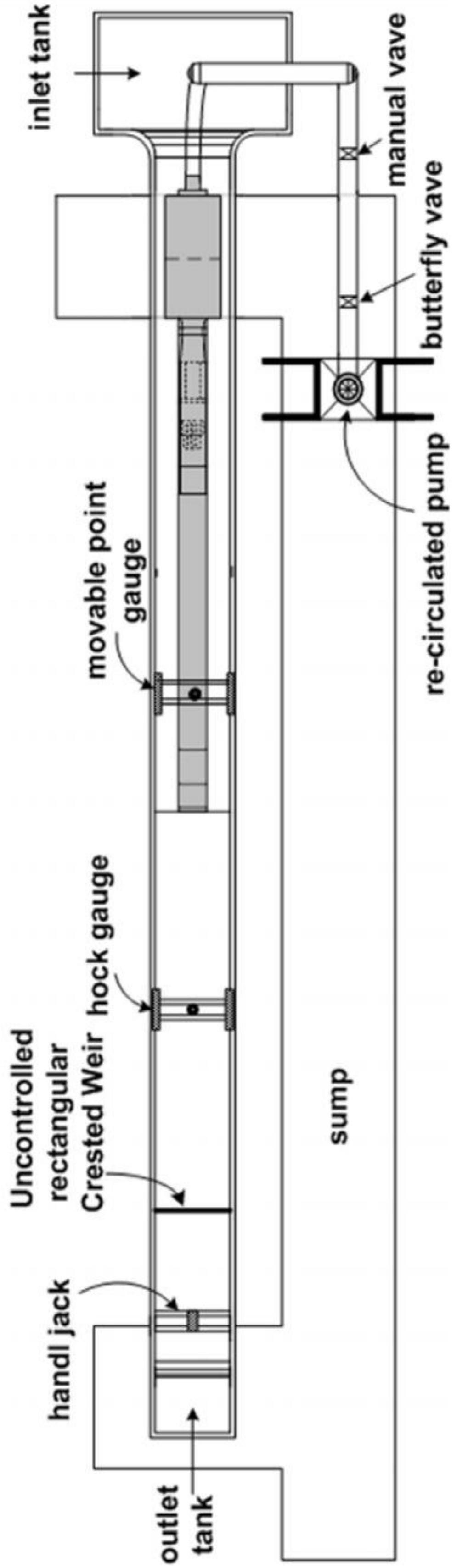

Fig. (2):- Plan of the flume

Fig.(3):- Plan of the First Model

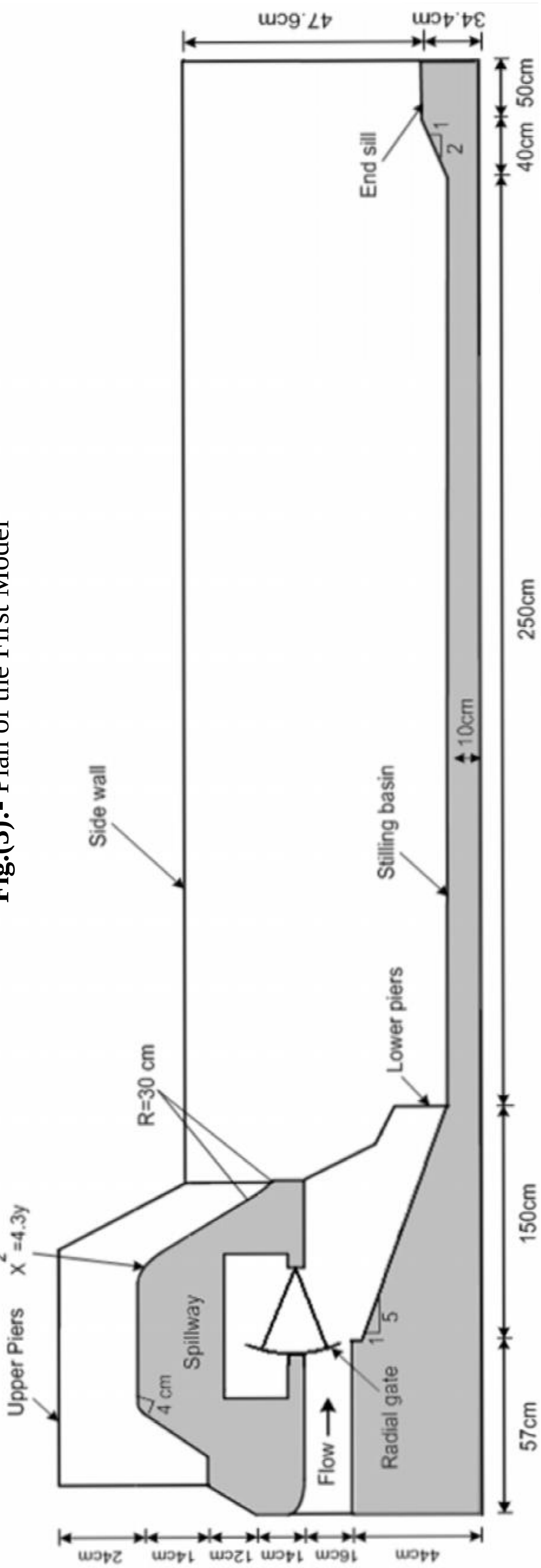

Fig.(4):- Cross Section (A-A)

Fig.(3):- Plan of the First Model

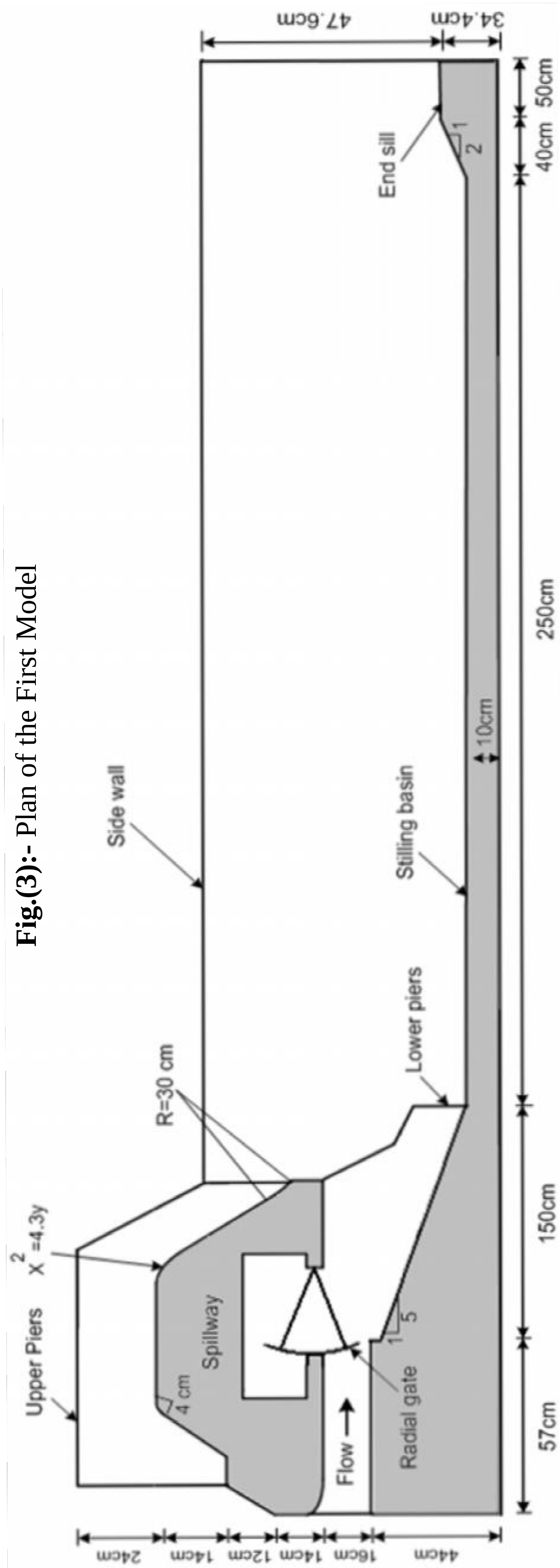

Fig. (4):- Cross Section (A-A)

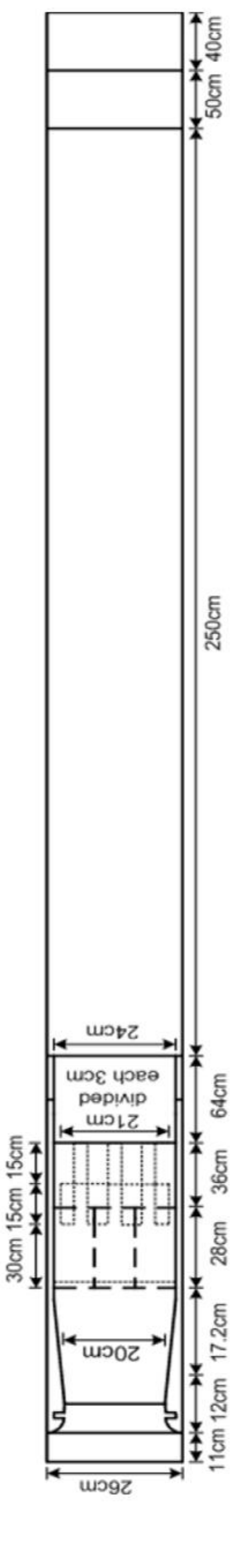

Fig.(5):- Plan view of the Second Model

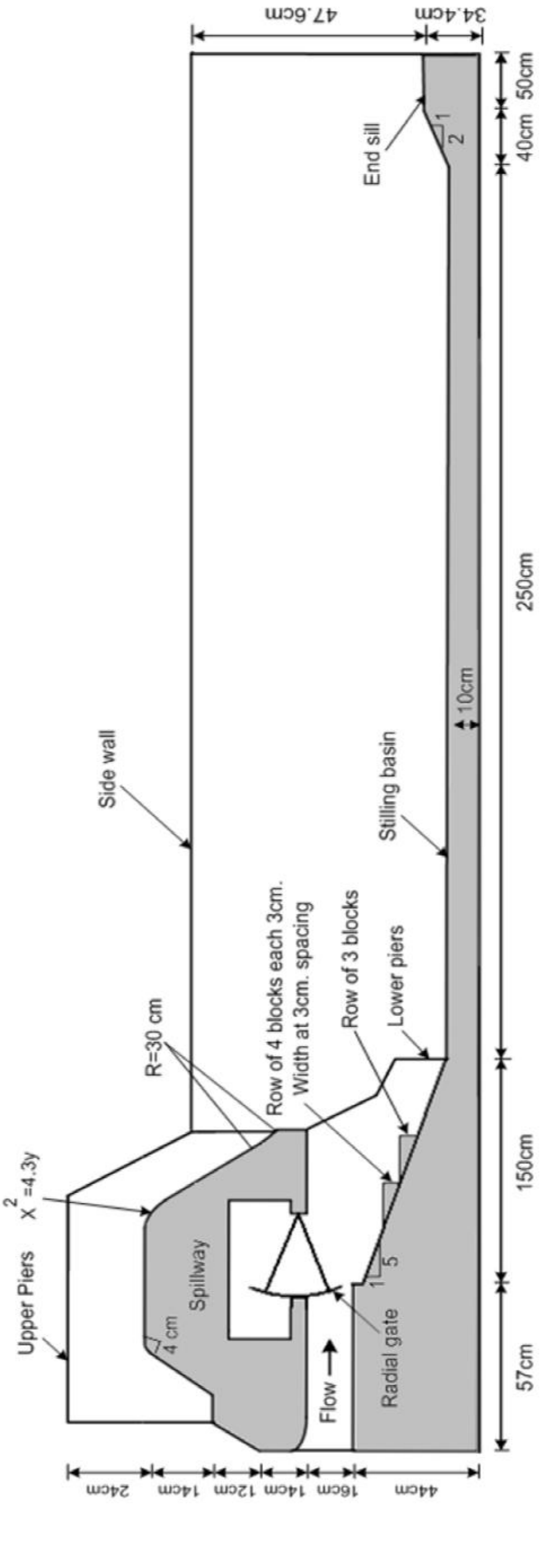

Fig.(6):- Cross Section (B-B)

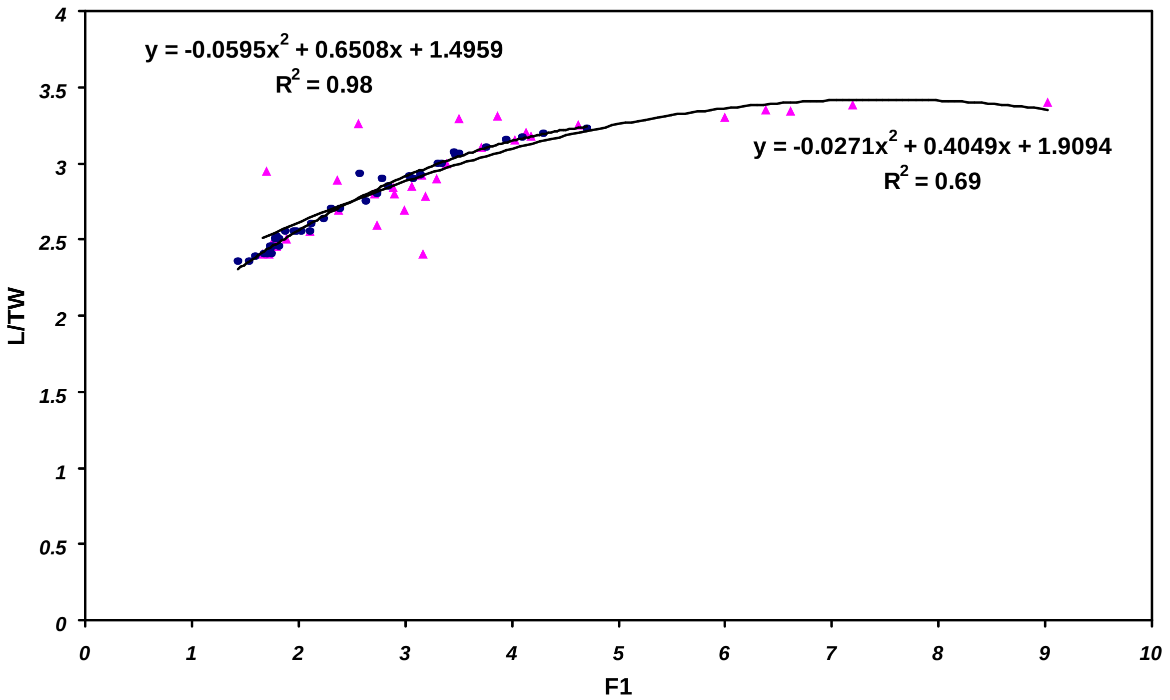

Fig.(7):- The Relation between (F_1) and (L/TW)

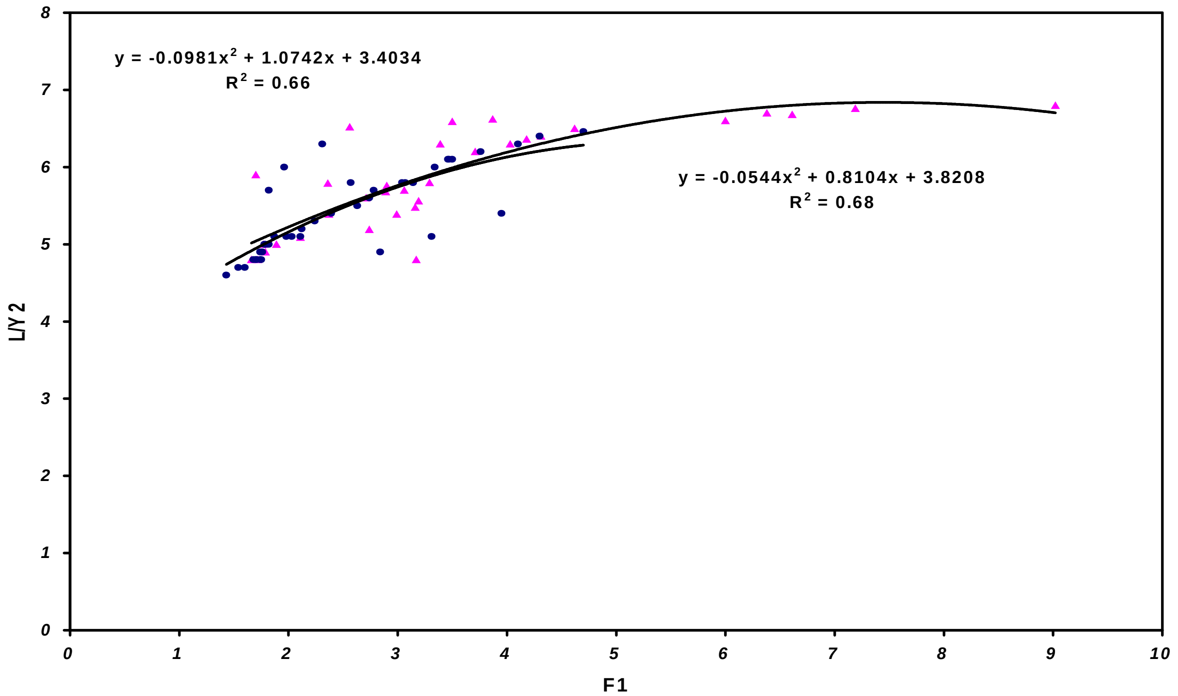

Fig.(8):- The Relation between (F_1) and (L/Y_2)

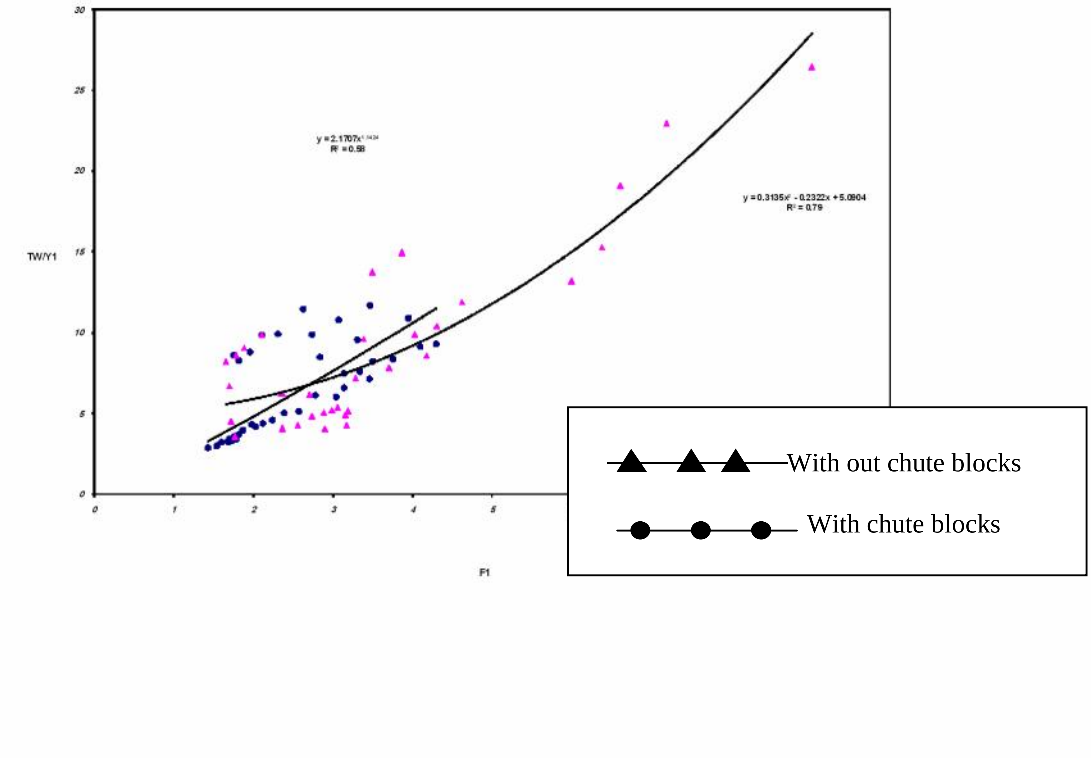

Fig.(9):- The Relation between (F_1) and (TW/Y_1)

EXPERIMENTAL DATA OBTAINED FROM THE FIRST MODEL

Table(5-1):- For Q_m=9 L/s (Q_p=2545.6 m^3/s)

Water Temperature(C̊)=20.5
ν (m^2/s)=0.996*10^{-6} | B_1=20cm | Y_3(cm)=10
h_w (cm)= 3 | B_2=26cm | T.W.L.(cm)=34.4
Q (L/s)= 9 | Y_2(cm)=17.2 | V_2(cm/s)=20.13

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
2.0	49.0	40.80	117.0	1.3	322.00	21.00
2.3	41.9	38.76	116.3	1.5	275.86	21.75
2.5	34.9	36.72	115.0	1.8	277.77	21.25
2.7	31.7	34.68	106.6	2.3	184.14	21.00
3.0	29.0	33.66	113.5	2.5	173.49	20.75
3.5	19.0	32.64	87.7	3.5	123.92	20.75
4.0	16.0	31.62	86.0	3.8	115.53	20.50
6.0	09.0	30.60	84.3	4.0	112.50	20.00
6.5	08.5	29.58	82.6	4.2	107.14	20.00

Table(5-2):- For Q_m= 17L/s (Q_p=4808.3 m^3/s)

Water Temperature(C̊)=30
ν (m^2/s)= 0.804*10^{-6} | B_1=20cm | Y_3(cm)=13.8
h_w (cm)=4.6 | B_2=26cm | T.W.L.(cm)=38.2
Q (L/s)=17 | Y_2(cm)=19. | V_2(cm/s)=34.23

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
3.4	58.3	38	127.97	2.5	316.3	21.5
3.5	53.2	35	124.15	3.2	259.1	20.5
4.0	44.5	32	120.33	4.0	212.5	20.0

Table(5-3):- For Q_m=21 L/s (Q_p=5939.7 m^3/s)

Water Temperature(C̊)=30
ν (m^2/s)= 0.804*10^{-6} | B_1=20cm | Y_3(cm)=15.2
h_w (cm)=5.3 | B_2=26cm | T.W.L.(cm)=39.6
Q (L/s)=21 | Y_2(cm)=19.8 | V_2(cm/s)=40.79

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
4.5	52.5	38	130.68	3.0	325.6	21.5
4.8	43.3	36	126.72	3.8	263.2	21.0
5.2	40.1	34	124.74	4.0	253.0	20.75

Table(5-4):- For Q_m=31.5 L/s (Q_p=8909.5 m^3/s)

Water Temperature(C̊)=23
ν (m^2/s)=0.941*10^{-6} B_1=20cm Y_3(cm)=18.6
h_w (cm)=7.0 B_2=26cm T.W.L.(cm)=43
Q (L/s)=31.5 Y_2(cm)=21.5 V_2(cm/s)=56.4

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
7.5	51.4	40.80	136.7	5.0	293.0	21.5
8.0	49.3	34.68	133.3	5.5	272.7	21.0
9.0	39.2	32.64	124.7	6.0	253.0	20.7
10.0	33.7	30.60	120.4	7.0	255.0	20.0
12.5	19.0	28.56	103.2	9.5	165.8	20.0

Table(5-5):- For Q_m=40.5 L/s (Q_p=11455.1 m^3/s)

Water Temperature(C̊)=21.25
ν (m^2/s)= 0.9795*10^{-6} B_1=20cm Y_3(cm)=22.5
h_w (cm)= 8.3 B_2=26cm T.W.L.(cm)=46.9
Q (L/s)= 40.5 Y_2(cm)=23.45 V_2(cm/s)=66.4

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
10.0	47.8	48.75	138.4	7.0	263.0	22.00
12.0	35.7	36.40	136.0	7.5	257.1	21.00
13.5	31.0	31.62	126.6	9.0	222.2	20.25
15.5	22.5	33.66	112.6	11.0	177.43	20.75

Table(5-6):- For Q_m=57 L/s (Q_p=16122 m^3/s)

Water Temperature(C̊)= 23
ν (m^2/s)= 0.941*10^{-6} B_1=20cm Y_3(cm)=24
h_w (cm)= 10.4 B_2=26cm T.W.L.(cm)=48.4
Q (L/s)= 57 Y_2(cm)= 24.2 V_2(cm/s)=90.6

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
13.5	48.0	47.94	138.0	9.0	287.87	22.00
14.0	44.0	40.80	137.5	9.5	279.06	21.50
15.0	38.5	37.74	125.8	10.0	271.42	21.00
16.0	31.5	33.66	121.0	13.5	203.48	20.75

Table(5-7):- For Q_m=78.66 L/s (Q_p=22248.4 m^3/s)

Water Temperature(C̊)= 21.25
ν (m^2/s)= 0.9795*10^{-6} | B_1=20cm | Y_3(cm)=28.5
h_w (cm)= 12.8 | B_2=26cm | T.W.L.(cm)=52.9
Q (L/s)= 78.66 | Y_2(cm)= 26.45 | V_2(cm/s)=114.4

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
15	60.0	61.02	147.1	10.25	319.75	24.0
16	45.5	54.06	142.8	13.00	267.73	22.6

Table(5-8):- For Q_m=83 L/s (Q_p=23475.9 m^3/s)

Water Temperature(C̊)= 21.55
ν (m^2/s)= 0.9729*10^{-6} | B_1=20cm | Y_3(cm)=29.5
h_w (cm)= 13.3 | B_2=26cm | T.W.L.(cm)=53.9
Q (L/s)= 83 | Y_2(cm)=26.95 | V_2(cm/s)=118.5

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
15	64.3	61.2	157.4	11.00	328.00	23.00
16	47.2	57.14	175.7	12.75	286.14	22.75

Table(5-9):- For Q_m=100 L/s (Q_p=28284.3 m^3/s)

Water Temperature(C̊)= 21
ν (m^2/s)= 0.985*10^{-6} | B_1=20cm | Y_3(cm)=30.25
h_w (cm)=15 | B_2=26cm | T.W.L.(cm)=54.65
Q (L/s)= 100 | Y_2(cm)= 27.33 | V_2(cm/s)=140.7

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
16	63.0	58.65	157.4	13.5	330.64	22.85

EXPERIMENTAL DATA OBTAINED FROM THE SECOND MODEL

Table(5-10):- For Q_m=9 L/s (Q_p=2545.6 m^3/s)

Water Temperature(C̊)=30
ν (m^2/s)= 0.804*10^{-6} B_1=20cm Y_3(cm)=10
h_w (cm)= 3 B_2=26cm T.W.L.(cm)=34.4
Q (L/s)= 9 Y_2(cm)=17.2 V_2(cm/s)=20.13

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
2.0	49	38	111.1	2.0	209.3	21.5
2.3	41.9	36	94.6	3.0	142.8	21.0
2.5	34.9	34	87.72	3.5	123.9	20.75
2.7	31.7	31	82.56	4.0	110.0	20.45

Table(5-11):- For Q_m=12 L/s (Q_p=3394.1 m^3/s)

Water Temperature(C̊)= 27
ν (m^2/s)= 0.8598*10^{-6} B_1=20cm Y_3(cm)=11.2
h_w (cm)=3.7 B_2=26cm T.W.L.(cm)=35.6
Q (L/s)= 12 Y_2(cm)=17.8 V_2(cm/s)=25.93

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
2.6	51.3	40	108.6	3.0	188.23	21.25
3.0	41.8	38	103.2	3.3	173.16	21.00
3.5	31.6	35	99.7	3.6	162.60	20.50

Table(5-12):- For Q_m=17 L/s (Q_p=4808.3 m^3/s)

Water Temperature(C̊)= 28
ν (m^2/s)= 0.8412*10^{-6} B_1=20cm Y_3(cm)=13.8
h_w (cm)= 4.6 B_2=26cm T.W.L.(cm)=38.2
Q (L/s)= 17 Y_2(cm)=19.1 V_2(cm/s)=34.23

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
3.4	58.3	36	120.3	3.5	231.29	21.0
3.5	53.2	33	114.4	4.0	207.32	20.5
4.0	44.6	30	108.9	4.5	188.88	20.0

Table(5-13):- For Q_m=21 L/s (Q_p=5939.7 m^3/s)

Water Temperature(C°)= 27.25
ν (m^2/s)= 0.85515*10^{-6} B_1=20cm Y_3(cm)=15.2
h_w (cm)=5.3 B_2=26cm T.W.L.(cm)=39.6
Q (L/s)= 21 Y_2(cm)=19.8 V_2(cm/s)=40.79

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
4.5	52.5	36	106.9	4.0	144.57	20.75
4.8	43.8	34	101.0	4.5	130.08	20.50
5.2	40.1	32	97.0	4.8	125.00	20.00

Table(5-14):- For Q_m=26 L/s (Q_p=7353.9 m^3/s)

Water Temperature(C°)= 27
ν (m^2/s)= 0.8598*10^{-6} B_1=20cm Y_3(cm)=16.7
h_w (cm)= 6.2 B_2=26cm T.W.L.(cm)=41.1
Q (L/s)= 26 Y_2(cm)=20.55 V_2(cm/s)=48.66

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
5.2	59.0	40	130.3	4.5	271.89	21.25
6.0	50.3	38	125.8	5.0	247.62	21.00
7.0	39.5	35	120.0	5.5	230.59	20.50

Table(5-15):- For Q_m=28 L/s (Q_p=7919.6 m^3/s)

Water Temperature(C°)= 27
ν (m^2/s)= 0.8598*1 B_1=20cm Y_3(cm)=17.4
h_w (cm)= 6.5 B_2=26cm T.W.L.(cm)=41.8
Q (L/s)= 28 Y_2(cm)=20.9 V_2(cm/s)=51.53

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
6.0	56.6	42	133.3	4.5	286.10	21.75
6.5	44.4	38	129.6	5.0	263.53	21.25
7.0	42.4	34	125.4	5.5	245.34	20.75

Table(5-16):- For Q_m=35.5 L/s (Q_p=10040.9 m^3/s)

Water Temperature(C̊)= 27
ν (m^2/s)= 0.8598*10^{-6} B_1=20cm Y_3(cm)=18.4
h_w (cm)= 7.6 B_2=26cm T.W.L.(cm)=42.8
Q (L/s)= 35.5 Y_2(cm)=21.4 V_2(cm/s)=63.8

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
7.5	56.7	50	131.4	6.0	265.92	22.26
8.5	47.8	46	124.9	6.5	251.11	21.75
9.3	41.0	43	124.1	7.0	230.52	21.25

Table(5-17):- For Q_m=45 L/s (Q_p=12727.9 m^3/s)

Water Temperature(C̊)= 28
ν (m^2/s)= 0.8412*10^{-6} B_1=20cm Y_3(cm)=20.8
h_w (cm)= 8.9 B_2=26cm T.W.L.(cm)=45.2
Q (L/s)= 45 Y_2(cm)=22.6 V_2(cm/s)=76.58

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
10.0	57.0	56	131.5	7.5	260.87	23.00
10.8	49.0	49	122.0	9.0	224.72	22.25
12.0	40.5	41	115.3	10.5	201.68	21.25

Table(5-18):- For Q_m=50 L/s (Q_p=14142.1 m^3/s)

Water Temperature(C̊)= 27.25
ν (m^2/s)= 0.85515*10^{-6} B_1=20cm Y_3(cm)=21.6
h_w (cm)= 9.5 B_2=26cm T.W.L.(cm)=46
Q (L/s)= 50 Y_2(cm)=23 V_2(cm/s)=83.61

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
10.8	54.5	58	134.8	9.0	241.50	23.00
11.5	50.0	50	120.9	10.0	222.20	22.50
12.0	46.0	48	119.6	10.5	214.98	22.15
12.5	42.5	42	117.3	11.0	211.42	21.50

Table(5-19):- For Q_m=65 L/s (Q_p=18384.8 m^3/s)

Water Temperature(C°)= 27.25
ν (m^2/s)= 0.85515*10^{-6} B_1=20cm Y_3(cm)=25.2
h_w (cm)= 11.3 B_2=26cm T.W.L.(cm)=49.6
Q (L/s)= 65 Y_2(cm)=24.8 V_2(cm/s)=100.8

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
13.5	57.0	58	124.0	13.5	209.34	23.0
14.0	53.0	50	122.0	14.0	206.35	22.5
14.5	49.3	45	119.0	14.5	203.76	22.0
15.0	44.3	40	118.5	15.5	197.34	21.25

Table(5-20):- For Q_m=70 L/s (Q_p=19798.9 m^3/s)

Water Temperature(C°)= 28.5
ν (m^2/s)= 0.8319*10^{-6} B_1=20cm Y_3(cm)=25.9
h_w (cm)= 11.8 B_2=26cm T.W.L.(cm)=50.3
Q (L/s)= 70 Y_2(cm)=25.15 V_2(cm/s)=107.05

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
14.0	55.5	56	128.30	14.0	219.78	22.75
14.5	51.5	50	125.75	14.5	214.56	22.50
15.0	47.5	48	122.70	15.0	210.68	22.15
15.5	43.0	44	120.70	15.5	207.64	21.75

Table(5-21):- For Q_m=75 L/s (Q_p=21213.2 m^3/s)

Water Temperature(C°)= 28.75
ν (m^2/s)= 0.82725*10^{-6} B_1=20cm Y_3(cm)=27.4
h_w (cm)= 12.4 B_2=26cm T.W.L.(cm)=51.8
Q (L/s)= 75 Y_2(cm)=25.9 V_2(cm/s)=111.37

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
15.0	55.2	58	130.5	15.0	217.39	23.0
15.5	51.0	51	126.9	15.5	215.10	22.5
16.0	42.0	45	121.7	18.0	189.39	22.0

Table(5-22):- For Q_m=78.66 L/s (Q_p=22248.4 m^3/s)

Water Temperature(C°)= 27.5
ν (m^2/s)= $0.8505*10^{-6}$ B_1=20cm Y_3(cm)=27.8
h_w (cm)= 12.8 B_2=26cm T.W.L.(cm)=52.2
Q (L/s)= 78.66 Y_2(cm)=26.1 V_2(cm/s)=115.9

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
15.0	58.7	60	130.5	15.5	220.64	23.00
15.5	53.5	54	125.3	16.0	213.75	23.00
16.0	44.0	48	122.7	17.5	202.00	22.25

Table(5-23):- For Q_m=83 L/s (Q_p=23475.9 m^3/s)

Water Temperature(C°)= 29
ν (m^2/s)= $0.8226*10^{-6}$ B_1=20cm Y_3(cm)=28.5
h_w (cm)= 13.3 B_2=26cm T.W.L.(cm)=52.9
Q (L/s)= 83 Y_2(cm)=26.45 V_2(cm/s)=120.69

G_0(cm)	H_u(cm)	L_0(cm)	L(cm)	Y_1(cm)	V_1(cm/s)	B_3(cm)
15	64.3	58	134.8	16	259.37	23

دراسة تجريبية على حوض سد مكحول الساكن

مهند محمد عباس

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الخلاصة

في هذا البحث تم فحص الأداء الهيدروليكي مختبريا لأحواض التهدئة المركبة من القفزة الهيدروليكية وبرك الغمر لمنشآت سد مكحول والتي تم تشغيلها تحت ضغط ماء عالي.

اجري العمل ألمختبري على شكل سلسلتين من الفحوصات، السلسلة الأولى استخرجت من النموذج كما هو مصمم والسلسلة الثانية استخرجت من نفس النموذج بعد تحسينه بإضافة صفين من مصدات تشتيت الطاقة (chute blocks) .

تم إجراء (٨١) تجربة على كل من النموذجين، بالنسبة للنموذج الأول أظهرت النتائج بأنه يمكن تقليل أطوال أحواض التهدئة مع وجود اضطراب عالي وعدم اسقرارية سطح الماء، وتضمنت التجارب أيضا قياس توزيع الضغوط.

وبعد إضافة مصدات تشتيت الطاقة (chute blocks) أظهرت النتائج بأنه يمكن تقليل أطوال أحواض التهدئة ووجد إن هنالك اضطراب واطئ و استقرارية معقولة لسطح الماء، لذلك أوصي بإضافة مصدات تشتيت الطاقة (chute blocks).