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Overflow Characteristic of Cylindrical Shape Crest Weirs Over Horizontal Bed

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Abstract

The most common types of weirs are the broad-crested weir, the sharp-crested weir, the circular crested weir and the ogee crested weir. Advantages of the cylindrical weir shape include the stable overflow pattern, the ease to pass floating debris, the simplicity of design compared to ogee crest design and the associated lower costs. In present study, it was investigated the overflow characteristics of circular weirs in laboratory for various cylinder radii of three sizes (11.4, 9.0, 6.3 cm), and the models fixed on the channel bed vertically to the direction of flow. The result shows that the increase in the ratio of head to weir radius ratio (H_w/R) value causes an increase in discharge coefficient (C_d) value for the same height of weir. It was observed that the cylinder size (i.e. radius of cylindrical weir (R)) has an effect on the (C_d). The flow magnification factor (q_w/q_s) increases with an increase in (H_w/R) value and values of (q_w/q_s) were always higher than one for all values of (H_w/R), this means that weirs of cylindrical shape performed better than those of sharp crest for any value of weir radius tested in this study.

Keywords: Cylindrical weir, Overflow, Experimental study, Discharge coefficient.

دراسة خصائص الجريان أعلى الهدارات الاسطوانية الموضوعة على أرضية مستوية

الخلاصة

إن أغلب الأنواع الشائعة للهدارات تتضمن الهدار ذو الحافة العريضة والهدار ذو الحافة الحادة والهدار ذو القمة الدائرية والهدار ذو القمة البيضوية. إن من أهم مميزات الهدار الاسطواني الشكل، جريانه المستقر وسهولة مرور الشوائب الطافية وسهولة تصميمه المرتبطة بانخفاض كلفة التنفيذ مقارنة بالهدار ذو الحافة البيضوية. في البحث الحالي تم دراسة خصائص الجريان المتمثلة بالعوامل المؤثرة على معامل التصريف (C_d) أعلى الهدارات الاسطوانية الموضوعة على أرضية مستوية. استخدمت ثلاثة نماذج بأقطار مختلفة (11.4, 9.0, 6.3) سم، وتم وضع النماذج على أرضية القناة المختبرية باتجاه عمودي على اتجاه الجريان. وقد بينت النتائج المختبرية أن زيادة نسبة الشحنة إلى نصف القطر للهدار (H_w/R) تؤدي إلى زيادة معامل التصريف (C_d) لنفس الارتفاع للهدار. وتم ملاحظة أن نصف قطر الهدار (R) له تأثير على معامل التصريف. تزداد قيمة معامل التكبير (q_w/q_s) بزيادة قيمة (H_w/R)، وان قيم معامل التكبير هي دائماً اكبر من (1) لجميع قيم (H_w/R)، وذلك يشير إلى أن أداء الهدارات ذات الشكل الاسطواني أفضل من الهدارات ذات الحافة الحادة لجميع إنصاف الأقطار المستخدمة في الدراسة.

الكلمات الدالة: الهدار الاسطواني، الجريان الفوقي، دراسة مختبرية، معامل التصريف.

Introduction

The requirement for building a structure across a river to provide necessary head for adequate delivery of water has been visualized by engineers for many centuries. In any hydraulic structure, means of allowing the passage of excess water must be provided otherwise the structure is threatened to the danger of weakening or collapse due to expected or unexpected floods. A weir structure is an essential feature of many hydraulic structures such as dames, barrages, canal drops or falls regulators, cross regulators, etc .

The most common types of weir crest are the broad-crested weir, the sharp-crested weir, the circular-crested weir and nowadays the ogee crest weir. Advantages of the circular weir shape (fig. 1) are the stable overflow pattern compared to sharp-crested weirs, the ease to pass floating debris, the simplicity of design compared to ogee crest design and the associated lower cost. Circular-crested weirs have larger discharge capacity (for identical upstream head) than broad-crested weirs and sharp-crested weirs[1].

Related applications include roller gates and inflated flexible membrane dams (i.e. rubber dams). These related applications are nevertheless special areas of interest and need to be researched on their own.

In the present study, the characteristics of Normal cylindrical weirs were investigated (tables 1). The experimental setups were described in the next paragraph. The results were presented later and compared with previous studies (tables 3, 5).

Bibliographic Review

Cylindrical weirs were common in the late 19th century and early 20th century. Major studies of circular weirs like Sarginson (1972), showed that the discharge coefficient C_d was close to and usually larger than unity, and C_d was primarily a function of the ratio of upstream head to crest radius H_w/R, C_d increasing with increasing values of H_w/R, where H_w is the total head above crest and R is the radius of the circular weir.

Rouve and Indlekofer (1974)[2], investigated particularly the effects of nappe suction and nappe ventilation on the discharge characteristics. this investigation showed that nappe suction prevented flow separation and lead to larger discharge coefficients by up to 15 to 20%.

In 1985, Al-Tabatabie et al[3], studied experimentally the characteristics of flow over normal weirs of semicircular crests. Many laboratory tests were carried out on sixteen weir models in which the crest was varied from semicircular to crescent shape. Each four models were of the same shape and equal ratio of length and width to height of the weir. The most important conclusion was that, the discharge coefficient values observed for crescent and semicircular shape weirs were close.

In 1989, Abid Ali[4], used the finite element technique to study the characteristics of flow over round crested weirs placed normal to the channel axis . He studied three weir models with different height to base length ratios. He found that the discharge coefficient is a function of the geometrical dimensions of the weir and the upstream measured head

Chanson, H., and Montes, J. (1998)[1] describe new experiments of circular weir overflows, with eight cylinder sizes, for several weir heights and for five types of inflow conditions: partially developed inflow, fully developed inflow, upstream ramp, upstream undular hydraulic jump and upstream (breaking) hydraulic jump. Within the range of the experiments, the cylinder size, the weir height D/R and the presence of an upstream ramp had no effect on the discharge coefficient, flow depth at crest and energy dissipation. However, the inflow conditions had substantial effects on the discharge characteristics and flow properties at the crest.

Dimensional Analysis

The relevant parameters in the study of cylindrical weirs come from the following groups :

(A) Fluid properties and physical constants: the density of water ρ_w (kg/m^3), the dynamic viscosity of water μ_w (N.s/m^2), (Hw)and the acceleration of gravity g (m/s^2).

(B) Channel geometry: the channel width b (m).

(C) Weir geometry: the cylinder radius R (m) , or the crest height above channel bed D (m).

(D) Upstream flow properties : the depth of flow over the weir crest H_w (m), flow velocity V_1 (m/s), or discharge per unit width q_w(m^3/s/m)

Taking into account all the above parameters, dimensional analysis yields[5].

$$f_1 (\rho_w , \mu_w, g, b, R, H_w, q_w) = 0 \quad \text{--(1)}$$

Dimensionless Numbers:

The above variables give the following dimensionless numbers:

- Froude number $Fr = q_w / \sqrt{g * R^3}$ -(2)

-The dimensionless upstream flow variable H_w / R

- The dimensionless geometric variables b/R.

- Reynolds number $Re = \rho_w * q_w / \mu_w$ (3)

Note that any combination of these numbers is also dimensionless and may be used to replace one of the form the above considerations the relationship may be rewritten in terms of dimensionless parameters:

$$f_2\left(Fr; \frac{H_w}{R}; \frac{b}{R}; Re; \right) = 0 \text{---------------(4)}$$

Channel and Cylindrical Weir Description

All the experiments were performed in the lab. of the Technical Institute / Mosul. The channel used is 0.2m width and 4m long and of height 0.25m. It can be fixed at horizontal level or any other bed slopes. The bottom was made of aluminum and the sidewalls were made of glass. The intake is a smooth three dimensions convergent section of rectangular shape, and the cylindrical weirs were placed at 2 m, and 1.5 m downstream of the channel entrance.

The cylinders used in the experiments were made of PVC pipes with three sizes. The downstream face of the cylindrical weirs was not ventilated in all experiments. Neither free–falling nappe nor air cavity was observed with the cylindrical weirs.

Instrumentations

To get the amount of discharge during each experiment, a sharp crested rectangular weir were provided at the end of channel by which the values of (q_s) are obtained from the equation of (Frank M. White 1998)[6] as:

$$Q = \left(0.564 + 0.0846 \frac{H}{Y}\right) b g^{1/2} H^{3/2} \text{ -5)}$$

where (Y) is the rectangular weir height (10 cm).

The flow depths were measured using a point gauge and it was rail-mounted and the distance along the flume from the channel entrance was measured with a metric line. In addition, photographs were taken during the experiments.

Experimental Apparatus and Method:

The overflow characteristics of cylindrical weirs were investigated in laboratory for several configurations, i.e., three cylinder sizes (R = 0.057 m, 0.045 m, 0.0315 m).

A channel of rectangular cross-section was used (figs. 2, 3). The flume is supplied with re-circulating water supplied by a constant head tank. All cylindrical weirs were smooth (PVC) and the downstream face of the cylinders was not ventilated in all the experiments.

The water discharge was measured by a rectangle sharp crested weir. The percentage of error is expected to be less than 5%. The flow depths were measured using point gauge at the center of the channel to avoid the error of adherence at the glass sides of the channel. The error on the flow depth was about 0.2-mm in the channel. In addition, photographs were taken during the experiments and used to visualize the flow patterns. Experiments investigated the discharge characteristics of cylindrical weirs in a horizontal channel with the inflow conditions was partially developed. Altogether, the authors performed over 19 experiments.

Results

Figs.2 and three show the overflowing water of a cylindrical weir that occur and change the direction of the streamline upstream of the weir, nappe adherence on the downstream aspect of the cylindrical weir. This change of streamlines was observed at a distance one to two weir heights.

As the water passes over the weir crest, the nappe free surface remains smooth and clear and the falling nappe adherence to the weir face. On the lows of the cylinder, the nappe keeps on adhering the cylinder wall. (fig. 1).

The separation of the nappe occurs near the weir bottom, because of the presence of the channel bed.

At larger ratio of head on crest to radius (H_w/R), nappe separation was observed on the downstream face of weirs. Such a separation occurred in absence of nappe ventilation. Vo and Ramamurthy (1993)[7] found out a similar behavior with ventilated nappes[1].

Discharge Coefficient:

In open channels, the maximum discharge per unit width at a weir crest equals[8]:

$$q_w = \sqrt{g} * \left(\frac{2}{3} * H_w\right)^{3/2}$$ For ideal fluid flow ------------------------------- (6)

Where g is the gravity acceleration and H_W is the upstream total head above the weir crest. Equation (6) derives from the Bernoulli equation assuming hydrostatic pressure distribution at the crest and a uniform velocity distribution for a rectangular channel. In practice the observed discharge differs from equation (6) because the pressure distribution on the crest is not hydrostatic and the velocity distribution is not uniform (e.g. Vo 1993). Usually the flow rate is expressed as[1]:

$$q_w = C_d * \sqrt{g} * \left(\frac{2}{3} * H_w\right)^{3/2} \quad \text{---------- (7)}$$

where C_d is the discharge coefficient. It equals unity for an ideal broad-crested weir.

Experimental Results: General Trends

New experimental observations reported in (fig. 4). The discharge coefficient data plotted as functions of the ratio H_w/R where R is the radius of the weir. The data show consistently an increase of the discharge coefficient with increasing dimensionless head above crest, also shows that the discharge coefficient is mostly larger than unity: i.e., for a given upstream head, the discharge on a circular weir is larger than that on a broad-crested weir[1].

For the range of the experiments (table 2), the data analysis indicate that the value of cylinder size (R) affects on the discharge coefficient (C_d), where the average tangent slope which derived from the mathematical models showed in table 3 increased with the increasing of (R) which causes an increasing in (C_d) values.

Remarks

The present study showed that for the same height of weir, an increase in H_w/R values causes an increase in C_d values (fig. 4). Chilmeran (1996)[9] and Al-Moula (2004)[10] also proved that for the similar height of weir, raise in H_w/P values lead to an increase in C_d values where P is the weir height. Vo and Ramamurthy (1993) observed a maximum discharge coefficient for H_W/R ~ 5 and, for larger ratios (H_W/R), C_d decreased and tended to sharp-crested weir values, While Chanson (1998) notice that the cylinder size has no effect on the discharge coefficient.

Water Surface Profiles for Normal Weirs

The experimental results of measurements of water surface profiles along the center line of the channel shows a descending trend from the point become horizontal is (6.3h, 11.2h) respectively. This is the nearest upstream location where a point

Comparison between Past and Present Investigations:

The flow depth at crest, (fig. 6), presents experimental measurements of the flow depth at the crest: i.e., at the location where the weir is tangent to the channel bed. Circular weir data include past observations of the data of Vo (1993)[7] and Chanson (1998)[1] shown in (fig. 6). The results show a similar trend between the present set of data (experiments series 2, 3) and the work of Vo and Chanson.

Weir Performance:

The hydraulic performance of a normal weir having a circular crest may best studied by comparing the discharge passing over it with the discharge passing over the sharp- crested weir occupying the same lateral width. The flow magnification factor (defined as the ratio of the discharge passing over normal weir of circular crest (q_w) to the discharge passing over an imaginary normal sharp-crested weir (q_s)) of the same height, can be considered as a good criterion for assessing the performance of circular weir The values of (q_w, q_s) obtained from the equation (5). Gauge should be located for accurate measurements of upstream water head.

Discussion

It is worth noting that, although Chanson data were obtained with fully developed inflow conditions[1], his measurements show the same trend as the present study, and Vo data [8] (fig. 6). Further the data of present study, and both VO and Chanson indicated clearly that the ratio d_{crest}/d_c is less than unity for $H_w/R > 0.5$.

The flow magnification factor (q_w/q_s) was plotted against (H_w/R) in (fig. 7) for different values of crest radius (R = 5.7 cm, 4.5 cm, 3.15 cm), it can be concluded from this figure, one can conclude that (q_w/q_s) increases with increasing in (H_w/R) value and the magnification factor are always higher than one for all ranges of (H_w/R). This means that weirs of cylindrical shape perform better than those of sharp-crests for any values of weir radius tested in this study.

Conclusions

In present study, the overflow characteristics of circular weirs were investigated in laboratory for various cylinder radii (3 sizes). A result of the whole study, conclusion may be summarized as:

1. Water surface profiles for all weirs were smooth and continuous showing a descending trend with a steep drop near the downstream face of the weir.
2. The water surface profiles became horizontal at distance (6.3 – 11.2)h. This is the suitable location where a point gauge should be located for accurate measurements of upstream water head.
3. A relation between discharge coefficient (C_d) and head to weir radius ratio (H_W/R) was found. For the same height of weir, the increase in (H_W/R) value causes an increase in (C_d) value.
4. The flow magnification factor (q_w/q_s) increases with an increase in (H_W/R) and the magnification factor were always higher than one for all values of (H_W/R). this means that weirs of cylindrical shape performed better than those of sharp crest for any value of weir radius tested in this study.
5. Experimental observations indicate that the overflow characterized by nappe adherence on the downstream cylinder face at low to medium overflows(0.009 – 0.012m^2/2), and rapid flow redistribution upstream of the cylindrical weir.
6. For the range of the experiments (table 1), it was observed that the cylinder size (i.e. radius of cylindrical weir (R)) has an effect on the discharge coefficient.
7. The study shows that the flow depth at the weir crest is usually lower than the critical depth (in rectangular channels), and d_{crest}/d_c is typically about 0.85.

References

1. Chanson, H., and Montes, J.S., "Overflow Characteristics of Circular Weirs : Effect of Inflow Conditions", J. of Irrigation and Drainage Eng, Vol. 124, No. 3. 1998
2. Rouve, G., and Indlekofer, H., “Discharge Over Straight Weirs with Semi Cylindrical Crest”, Der Bauingenieur Vol. 49, No. 7, pp. 250-256. (1974).
3. Al-Tabatabaie, F.A., Al-Nasssiri,A.M., and Al-Zubaidie,R.M. “Characteristics of Flow Over the Semicircular Crested Weirs”, J. of Eng. and Technology, No. 3, Vol. 4, Baghdad, Iraq, 1985.
4. Abid Ali, H.S.,”Characteristic of Flow Over the Round Crested Weirs”, M.Sc. thesis, dept. of Civil Eng., University of Basrah, Iraq, 1989.
5. Y. Nakayama and R. F. Boucher, “Introduction to Fluid Mechanics”, Butterworth-Heinemann, pp. 171, 2000.
6. White, Frank M.,. “Fluid Mechanics”, McGraw-Hill Fourth Edition, 1998.
7. Vo, N.D. and Ramamurthy, A.S., "Characteristics of Circular-Crested Weirs." J. of Hydraulic eng., vol. 119, No.9, September. 1993
8. R. M. Khatsuria,” Hydraulics of Spillways and Energy Dissipaters”, Marcel Dekker, New York, pp. 48, 2005.
9. Chilmeran, T., “Charachteristics of Flow Over Normal and Oblique

Weirs with Semi-Circular Crest". M.Sc. thesis, university of Mosul, Iraq, 1996.
10. Al-Moula, S., "Affect of Downstream Face Slope of Normal and Oblique Weirs with Semi-Circular Crests on Characteristics of Flow ". M.Sc. thesis, university of Mosul, Iraq, 2004.

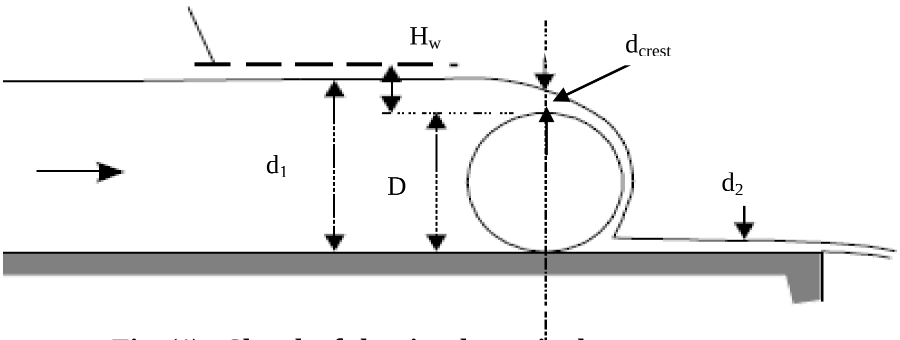

Fig. (1) - Sketch of the circular weir shape

Fig.(2): Side view of cylinder No. 1 in the

Fig.(3): Front view of cylinder No. 1 in the channel.

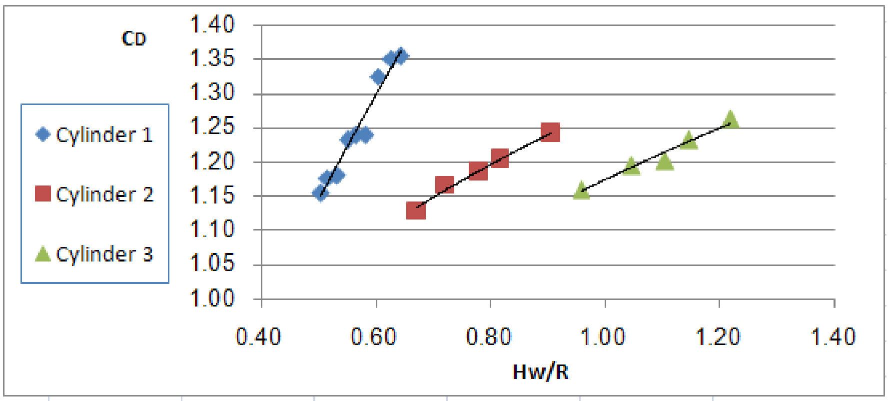

Fig.(4): Relationship between Discharge Coefficient C_d and the ratio of (H_w / R)

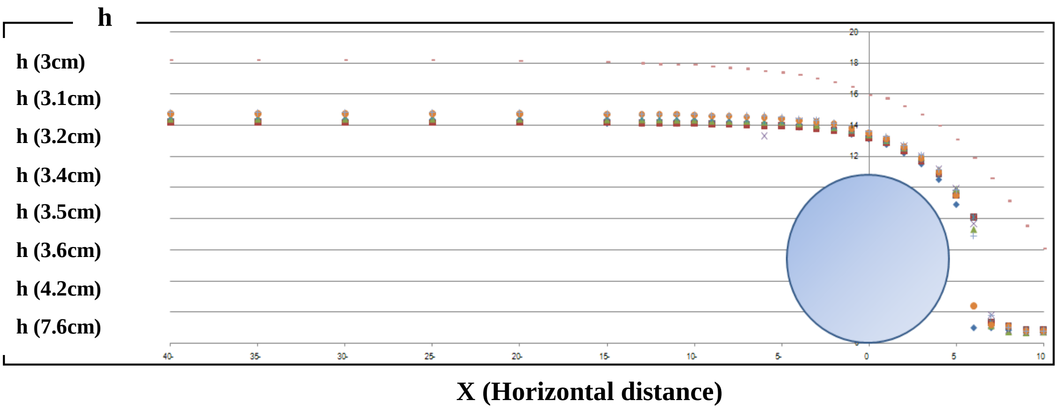

Fig.(5): Water surface profile of cylinder (1) (D = 11.4 cm)

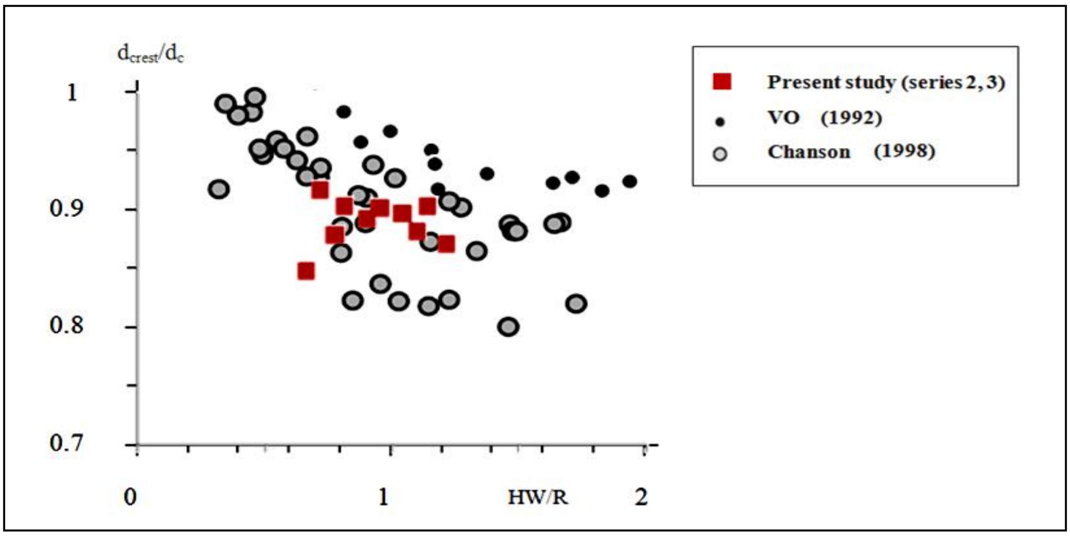

Fig. (6): Comparison between experimental data of present study and ancient studies of the flow depth at crest

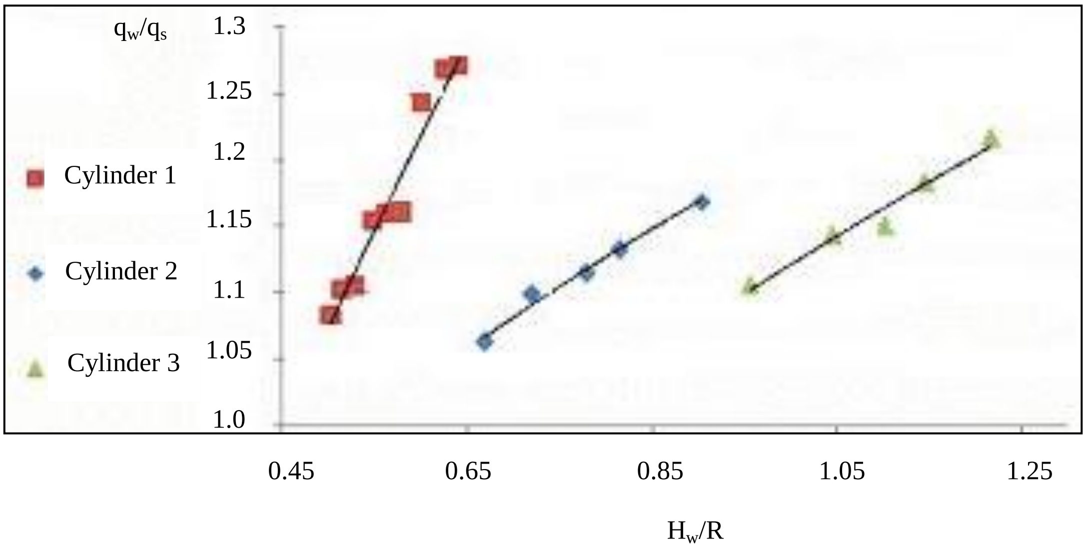

Fig. (7): Variation of (q_w/q_s) with (H_w/R) for cylindrical weir.

Table(1): Cylindrical weirs characteristics

Cylinder No.	Angle with channel wall	Series No.	Cylinder Radius (mm)	Remarks
1	90^o	A	57	Cylinder made of PVC pipes
2	90^o	B	45	Cylinder made of PVC pipes
3	90^o	C	31.5	Cylinder made of PVC pipes

Table(2) : Discharge Coefficient data

S. No.	Run #	R (m)	D (m)	H (m)	q_w (m^2/s)	d_1 (m)	H_1 (m)	H_w (m)	H_w/R	C_d
Series 1	1	0.057	0.114	0.03	0.0096	0.1425	0.1426	0.0286	0.5	1.16
	2	0.057	0.114	0.031	0.0101	0.1431	0.1432	0.0292	0.51	1.18
	3	0.057	0.114	0.032	0.0106	0.1440	0.1441	0.0301	0.53	1.19
	4	0.057	0.114	0.034	0.0116	0.1450	0.1452	0.0312	0.55	1.24
	5	0.057	0.114	0.035	0.0122	0.1458	0.1460	0.0320	0.56	1.25
	6	0.057	0.114	0.036	0.0127	0.1467	0.1469	0.0329	0.58	1.25
	7	0.057	0.114	0.039	0.0144	0.1479	0.1482	0.0342	0.6	1.34
	8	0.057	0.114	0.041	0.0156	0.1492	0.1495	0.0355	0.62	1.36
	9	0.057	0.114	0.042	0.0162	0.1500	0.1503	0.0363	0.64	1.37
Series 2	10	0.045	0.09	0.031	0.0101	0.1198	0.1199	0.0299	0.67	1.14
	11	0.045	0.09	0.034	0.0116	0.1220	0.1222	0.0322	0.71	1.18
	12	0.045	0.09	0.037	0.0133	0.1245	0.1247	0.0347	0.77	1.20
	13	0.045	0.09	0.039	0.0144	0.1260	0.1263	0.0363	0.81	1.22
	14	0.045	0.09	0.044	0.0174	0.1298	0.1302	0.0402	0.89	1.27
Series 3	15	0.0315	0.063	0.0315	0.0103	0.0925	0.0926	0.0296	0.94	1.19
	16	0.0315	0.063	0.035	0.0122	0.0951	0.0953	0.0323	1.03	1.23
	17	0.0315	0.063	0.037	0.0133	0.0968	0.0970	0.0340	1.08	1.24
	18	0.0315	0.063	0.039	0.0144	0.0980	0.0983	0.0353	1.12	1.28
	19	0.0315	0.063	0.042	0.0162	0.1000	0.1003	0.0373	1.19	1.31

To calculate the q_w which represent the discharge of rectangular weir:

$$Q = \left(0.564 + 0.0846\frac{H}{Y}\right) b g^{1/2} H^{3/2}$$

Example:

As shown in table (2): Run # 1:

H = 0.03 m

Y = 0.1 m

b = 1 m (unit width).

$q_w = (0.564 + 0.0846 * (0.03/0.1))*1* (9.81)^{0.5} * (0.03)^{1.5}$

$= 0.0096\ m^3/s/m$

To calculate C_d :

$$q_w = C_d * \sqrt{g} * \left(\frac{2}{3} * H_w\right)^{3/2}, \quad 0.0096 = C_d * (9.81)^{0.5} * [2/3 * 0.0286]^{1.5} \quad \dashrightarrow \quad C_d = 1.16$$

Table (3): Best Fitted curves for the relationships between C_d and H_w/R and the average derivatives of the curves.

Cylinder No.	Cylinder Radius (R) (cm)	Best Fitted Curve	R^2	Average ${dy}/{dx}$
1	5.7	$C_d = 1.905\left(\frac{H_w}{R}\right)^{0.724}$	0.959	1.62
2	4.5	$C_d = 1.314\left(\frac{H_w}{R}\right)^{0.334}$	0.989	0.53
3	3.15	$C_d = 1.215\left(\frac{H_w}{R}\right)^{0.422}$	0.962	0.49

Table(4): Water surface profile data

h (4.2cm)	h (3.6 cm)	h (3.4 cm)	h (3.2 cm)	h (3 cm)	X (cm)
14.8	14.75	14.6	14.41	14.2	-40
14.8	14.75	14.59	14.41	14.2	-30
14.8	14.75	14.5	14.4	14.2	-20
14.75	14.7	14.5	14.36	14.1	-15
14.7	14.65	14.5	14.34	14.1	-10
14.5	14.4	14.3	14.19	14	-5
14.4	14.3	14.3	14.1	13.85	-4
14.3	14.2	14.3	14	13.8	-3
14.13	14.08	14	13.85	13.65	-2
14	13.8	13.8	13.7	13.4	-1
13.6	13.5	13.5	13.4	13.1	0
13.25	13.13	13.15	13.02	12.75	1
12.7	12.6	12.7	12.55	12.2	2
12.1	11.9	12.07	11.95	11.5	3
11.15	11	11.2	11.13	10.5	4
9.82	9.9	9.99	9.9	8.9	5
0.8	0.8	0.7	0.7	0.85	10

Table (5):Experimental Investigations of discharge relationship above round crested weirs

Reference	R (m)	H_w/R	Inflow conditions	Comments
Vo and Ramamurthy (1993)	0.0095 – 0.1516	0.33 - 18	P/D	Laboratory experiments (W = 0.254 m)
Chanson (1998)	0.0418 – 0.1165	0.087 – 2.629	F/D	Laboratory experiments (W = 0.25 m)
Present Study	0.0315 – 0.057	0.67 – 1.22	P/D	Laboratory experiments (W = 0.20 m)

Table (6): Experimental data (series 2, 3) of crest flow depth on circular weir.

d_{crest}/d_c	H_w/R	H_w (m)	d_c (m)	d_{crest} (m)	R (m)
0.85	0.67	0.0302	0.0218	0.0185	0.045
0.92	0.72	0.0325	0.0240	0.022	0.045
0.88	0.78	0.0351	0.0262	0.023	0.045
0.90	0.81	0.0367	0.0277	0.025	0.045
0.89	0.90	0.0407	0.0313	0.028	0.045
0.90	0.96	0.0301	0.0222	0.02	0.0315
0.90	1.05	0.0329	0.0247	0.0222	0.0315
0.88	1.10	0.0348	0.0262	0.0231	0.0315
0.90	1.15	0.0361	0.0277	0.025	0.0315
0.87	1.22	0.0383	0.0299	0.026	0.0315

Notations

The following symbols are used in this paper:

C_d ---------discharge coefficient

d_c --------- critical flow depth in a rectangular channel (m);

d_{crest} --------- flow depth measured at the weir crest (m);

d_1 --------- flow depth upstream the weir (m);

d_2 --------- flow depth downstream the weir (m);

Fr --------- Froude number defined as; $Fr = \dfrac{v}{\sqrt{g*d}}$

g --------- gravity constant : g = 9.80 m/s2 in Brisbane, Australia;

h ----------- height of cylindrical weir (cm).

Hw --------- upstream total head above crest(m): $H_W = H_1 - z_{dam}$ (or $H_W = H_1 - D$ if the upstream channel bed is taken as datum);

H_1 --------- total head upstream of the weir (m);

Q_w --------- water discharge (m^3/s);

q_w --------- water discharge per unit width (m^3/sec/ m);

qs --------- water discharge per unit width passing over normal sharp crested weir (m^3/sec/ m);

R --------- curvature radius of crest (m);

Re ------------- Reynold number ; $Re = \rho_w * q_w/\mu_w$

$Re_{critical}$ ----------------- critical Reynold's number $Re_{critical}$

ρ_w ----------- mass density of the flowing liquid (kg/m^3)

μ_w ----------- dynamic viscosity of the flowing liquid (N.s/m^2)