

Study the Effect of Tapered Channel on the Flow Over Side Weir

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Abstract

Weir is usually used in different hydraulic purpose, and mainly for head the discharge water relationship in channel. In this research the flow has been carried out over horizontal side weir $(\theta=0^{\circ})$ with a constant crest length and height 15 cm, 5 cm respectively. The tapering part of the channel designed to be 15 cm length and have five values in narrowing of the channel widths. The tapered channel is started with a width of 20 cm, and terminated with a width of 18 cm, 16 cm, 14 cm, 12 cm and 10 cm consequently. The discharge over side weir increase with increasing the degree of constriction, the discharge reach to the maximum value at the highest degrees of constriction. When the construction of tapered channel increase the discharge over the side weir increase as the same time the height of water after side weir increase, that maybe use to supply another sub- channel with water. The water surface profile along the side weir is studied and taken under consideration for side weir and tail weir. The ANSYS program was used to calculate the discharge value over side and tail weir of the channel and compare this result with those calculated theoretically from laboratory work result. ANSYS program also used to show the surface water profile over side and tail weir in all cases of constriction. The water surface a long side weir is stable and close to the straight line in most cases, except the surface profile over tail weir for the last three cases of constriction (20-14) cm, (20-12) cm and (20-10) cm, the shape of water surface will be disturbed and unsteady. The purpose of this study to know the effect of changing the transition section channel on the discharge over the side weir with applying spatially varied flow theories over the weir crest, the effect of the flow velocity in the main channel on the discharge coefficient of the side weir according to tangential and radial flow across the channel and the discharge value and water surface profile a long side weir and tail weir from ANSYS software and compare them with the results that obtained from laboratory work.

الملخص

الهدارات أو السدود الغاطسة تستخدم لمختلف الاغراض الاروائية، وخاصة في علاقة ايجاد عمق الماء والتصريف في القنوات الاروائية، في هذا البحث فان الجريان قد اجري فوق فتحة سد غاطس جانبي ذو فتحة افقية (0 = θ°) وبطول فتحة ثابت وبارتفاع حافة 15 سم و 5 سم على التوالي. أما الجزء الخاص بالقناة المتدرجة العرض فقد صممت بطول 15 سم وتتضمن خمس قيم من تضييق القناة تبدأ بعرض 20 سم وتنتهي بعرض 18 سم ، 16 سم، 14 سم ، 12 سم و 10 سم على التوالي. التصريف فوق الهدارة الجانبية اعطى زيادة في السرعة مع زيادة التضييق في القناة حيث بلغ اكبر تصريف في القناة وفي الوقت نفسه فان ارتفاع الماء يزداد في القناة بعد انتهاء السد الغاطس ولهذا يعطي امكانية استخدام قنوات فرعية الخارى. كذلك فان صورة سطح الماء فوق السر الغاطس الجانبي قد اخذت بنظر الاعتبار وكذلك لاسد الغاطس في نهاية القناة. تم استخدام



برنامج ANSYS لحساب قيم التصريف فوق السد الغاطس الجانبي وقورنت النتائج مع النتائج التي حسبت نظريا ومختبريا. كذلك فان برنامج ANSYS قد استخدم لرسم صورة سطح الماء فوق السد الغاطس الجانبيوكان مستقرا وقريبا من الخط المستقيم في غالب الحالات ما عدا الحالات الثلاث الاخيرة لسطح الماء فوق السد الغاطس في نهاية القناةو هي للتضييقات. (20-14) سم، (20-12) سم و (20- 10) سم، وقد كان سطح الماء منتشر فوق السد الغاطس وغير مستقر.

أن الغرض من هذه الدراسة هو معرفة تأثير المقطع الانتقالي للقناة على التصريف فوق السدود الغاطسة الجانبية وذلك بتطبيق نظرية التغيير التدريجي فوق السد الغاطس الجانبي. أن تاثير سرعة الجريان في القناة الرئيسية على معامل التصريف فوق السدود الغاطسة تبعا للمركبتين المماسية والقطرية للجريان عبر القناة وكذلك قيم التصريف ومستوى سطح الماء على طول السد الغاطس الجانبي والذيلي باستخدام برنامج ANSYS ومقارنة النتائج بالنتائج المتحصل عليها من العمل المختبري وقد كانت متقاربة.

پوخته

بەنداوەكان بە شێوەيەكى گشتى بەكار ئەھێنرێن بۆ مەبەستى جياواز ، وە بە شێوەيەكى سەرەكى بەكار ئەھێنرێ بۆ بەتاڵ كردنەوەى ئەو ئاوەى كە پەيوەندىيان بە ئاوى چەناڵەكەوە ھەيە. لەم توێژىنەوەدا ھەڵقوڵىنەكە بە شێوەيەكى ئاسۆى ئەبێ لەگەڵ درێژى و بەرزى نەگۆر ١٥ سم ، ٥ سم . بەشىێكى چەناڵەكە بەوشێوەيە دىزاين كراوە كە درێژيەكەى ١٥سم و وە بە ٥ پلە ڕێرەوى پانى چەناڵەكە بەرەو كەم بوونەوە دەروات بە جۆرێك لە سەرەتادا پانيەكەى ١٠سم كەم ئەبێتەوە بۆ ٨ سم، ٢ سم، ٢ سم كەم ئەبێ لەگەڵ درێژەى بەنداوەكە بەتاڵ بوونەكە كەم ئەبێتەوە بۆ بوونى پلەكانا .ئەم بەتاڵبوونە زۆرترين ڕێژەى بەرزى بەنداوەكە بەتاڵ بوونەكە كەم ئەبێ لەگەڵ كەم بەنداوەكە پلەى بەتاڵ بوونەكە كەمى كرد ئەوا رێژەى بەرزى بەنداوەكە بەتاڵ بوونەكە كەم ئەبێ لەگەڵ كەم بەنداوەكە پلەى بەتاڵ بورنەكە كەمى كرد ئەوا رێژەى بەرزى يەنداوەكە لەسەر بەنداوەكە كەم دەركەت ، ھەركاتێك لە بەنداوەكە پلەى بەتاڵ بورنەكە كەمى كرد ئەوا رێژەى بەرزى ئاوەكە لەسەر بەنداوەكە كەم دەكەت ، يەركەت بە

بەكاردىيت بۆ ھەژمار كردنى بەتالكردناكانى پردەكان پاشان لە سەرەتا (the ansys program) وكۆتاى بە راورد ئەكرى لەگەل ئەنچامى يەو ژماردنانەى كە لە تاقيگەدا ئەكرىن ،وە ھەروەھا بە كاردىيت بۆ پىشاندانى رووى ئاو لە تەنىشت و كۆتاى بەنداوەكەدا . ئەم تويزينەوە بۆدەرخستنى كاريگەريەكانى گۆرانى گواستنەوەى بەتال كردنەوە يە بۆ بەشيكىترى چەنالىكى .

<u>1. Introduction:</u>

Side weir is a hole located on the wall of the main channel, which have a crest length and height from the bottom of the main channel, to allow a part of excess water to spill over the side weir, when the water level in the main channel is higher than the edge of the side weir [1][2]. The side weir can be used in the irrigation process by creating a side opening on the wall of the main channel. It also used to control the water level in the irrigation channel, by disposal the excess water into sub channel, can be work as a side escapes [3]. Therefore, it can be used in the sanitary engineering, to drain the excess of rain water from the internal sewage of the cities, and disposal them in the rivers [4]. The flow over the side weir can be considered as a spatially varied flow [5]. This research have been studied the discharge coefficient over the side weir and they used the width



of channel as a variable. The purpose of this study is to know the effect of tapered channel on the flow over side weir and tail weir. Finally, the water surface profile over side weir and tail weir also studied by used ANSYS program. By reducing the width of the channel provides financial amounts due to reduce of quantities of drilling and lining. When the discharge in main channel is low, it is unable to feed another side channel with water, but with using contraction channel, it is possible because contraction channel increases the height of water after the side weir. So that it can feed another sub channel with water.

The first who carried out the laboratory experiment tests on structures of side weir were Engels (1918);Coleman and Smith(1923) and Forchheimer (1930). They solved the problem by analytical solution to assume the energy line parallel to the weir crest and the channel bottom with linear water surface profile over the crest.

De Marchi (1923), Gentilini (1938), Nimmo(1928), Favre (1933), Noseda (1955), Schmidt (1954), Mostkow(1956), Ackers(1957), and many others has theoretical approach to prove that the energy head along the weir crest is essentially constant. When rising in sub critical flow and dropping in supercritical flow.

2. Theoretical work:

The water surface profile along the side weir for tapered channel can be known depend on this equation theoretically.

$$A = By$$

(1)

A=area of channel

B=channel width

y=the channel height

$$\frac{dA}{dx} = B\frac{dy}{dx} + y\frac{dB}{dx}$$
(2)

The total energy at a channel section is:

$$E = y + z + \frac{v^2}{2g} \tag{3}$$

By differentiate equation (1) obtained the following equations

$$\frac{dH}{dx} = \frac{dz}{dx} + \frac{dy}{dx} + \frac{\alpha}{2g} \left(\frac{2Q \, dQ}{A^2 \, dx} - \frac{2Q^2}{A^3} \frac{dA}{dx}\right) \tag{4}$$

Hence, substitute equation (2) into equation (4) it becomes

$$so - sf - \frac{\alpha Qqx}{gA^2} = \frac{dy}{dx} - \frac{\alpha Q^2 \frac{dA}{dx}}{A^3g} = \frac{dy}{dx} - \frac{\alpha Q^2 \left(B\frac{dy}{dx} + y\frac{dB}{dx}\right)}{gA^3}$$
(5)



With more simplification:

$$so - sf - \frac{\alpha Qqx}{gA^2} + \frac{\alpha Q^2 y \frac{dB}{dx}}{gA^3} = \frac{dy}{dx} \left[1 - \frac{\alpha Q^2 B}{gA^3} \right]$$
(6)

The final differential equation for water surface variation in tapering channel with a decreasing discharge [6]:

$$\frac{dy}{dx} = \frac{so - sf - \frac{\alpha Qqx}{gA^2} + \frac{\alpha Q^2 y \frac{dB}{dx}}{gA^3}}{1 - \frac{\alpha Q^2 B}{gA^3}}$$
(7)

The discharge over the side weir depend on the height of water over it, it is represent theoretical discharge as follows:

$$Q = \frac{2}{3} \sqrt{2g} B h^{1.5}$$
 (8)

Where:

h=(y-s)

y=total water height in the channel

B=the length of the weir crest

s=sill crest height above the channel bed

h= water height over the weir

The actual discharge calculation by dividing the volume of water spilling over the weir on the certain time, which is represented experimental discharge [7].

The discharge coefficient Cd can be calculated by dividing experimental discharge on the theoretical discharge [8].

The water surface profile was drawn and calculated by used ANSYS program the commercial CFD-Code has been used in this study, by ANSYS¹⁸ FLUENT package [9]. That depended on the finite element method that has more recently entered the fray. It can be used for helping in design consideration for the experimental work that can achieve optimum condition. Conducting numerical simulation for test across section of the impingement effusion and the impingement/effusion, confirmation with conducting a three – dimensional model. The continuity solution, conservation, and momentum equations can be used, to analyze the flow field inside three systems.

3. Experimental work:

The experimental work has been carried out in the engineering workshops, of the college of engineering at the University of Wasit.



Open channel was constructed of iron sheets of 3 m long, 20 cm wide and 20 cm height. The side weir is located on the side of the main channel, at a distance of 1.425 m from the beginning of the channel, the side weir is horizontal at a height of 5 cm from the bottom of the main channel for all cases, and the side weir is a sharp crested weir. The tapering part of the channel designed to be 15 cm length and have five degree in narrowing of the channel widths. The tapered channel is started with a width of 20 cm, and terminated with a width of 18 cm, 16 cm, 14 cm, 12 cm and 10 cm consequently, as shown in figure (1). Three tanks have been used; the main tank dimensions are 0.91 m wide, 0.9 m long and 1 m height. The other tanks one is fixed below side weir and the second is fixed below the tail of the channel with dimensions of 0.68 m wide, 0.68 m long and 1m height. The main tank has been connected to the pumps to supply the water for the channel, and for get a continuation of flow in the main channel. The flow in the channel can be changed, by controlling a number of operations pumps along the experimental work. Part of the water spill over the side weir, and the other part of flow was continuing to flow at the end of the channel. The actual discharge can be calculated by volumetric method, by dividing the volume of spilling water over the weir on a certain time required. The theoretical discharge is calculated by depending on the height of water over the weir. Therefore, the discharge coefficient Cd for each case will get by dividing the actual discharge on the theoretical discharge.



Figure (1): Tapering channel



4. Results and discussions:

The discharge coefficient and water surface profile was calculated with depending on the following:

- 1. Calculation of the theoretical discharge over the side weir. The average depth of water over the side weir is measured, to be used in equation (8) which is mentioned before [10].
- 2. From the tank which is below the side weir, also the tank in the end of the channel, the actual discharge can be measured depending on the water depth, which is rising in the tank for a certain time, and the cross section area of the tank .So, by applying equation (9) can be found the actual discharge as follows [11][12].

$$Q = \frac{volume}{time}$$

(9)

3. Finally, to find the discharge coefficients Cd for both side weir and tail weir of the channel, it can be found by dividing the results of the experimental discharge on the theoretical discharge [13][14].

$$Cd = \frac{Qexp}{Othe}$$
(10)

The discharge coefficient has been measured five times for each case of construction.

4. The water surface profile over side weir and tail weir as well as the value of discharge over both side and tail weir was found depend on ANSYS to compare that result with those was calculated from laboratory work.

Table (1), (2), (3), (4) and (5) represents the discharge calculation for tapered channel. These tables contain three main columns, the first column represent the results for the tank below the side weir. The second column represents the results, for the tank at the end of channel. The third column represents the discharge result, for the channel before side weir.

The symbols which are mentioned in those tables and what does it mean

Yav=the height of water inside the tank

h=the height of water over the weir

Qsth= theoretical discharge over side weir

Q2th = theoretical discharge over tail weir

Qsact=actual discharge over the side weir

Q2act=actual discharge over the end weir

Q1= total discharge in the main channel

Y1 = height of water in the channel before the weir

Cd₁ =discharge coefficient for side weir

 Cd_2 = discharge coefficient for end weir



V1=the velocity in main channel before the side weir

Fr₁=Froude number in the main channel before side weir



 Table (1): Tapered channel of width (20-10) cm with a horizontal side weir

Tank below side weir					Та	nk below	the end o	of channel	l	Discharge and velocity before side weir			
H=(y-s) m *10 ⁻³	Qsth m^3/s $*10^{-4}$	Yav m	Qsact m^3/s $*10^{-4}$	Cd ₁	H=(y-s) m *10 ⁻³	Q2th m^3/s $*10^{-4}$	Yav m	Q2act m^3/s $*10^{-4}$	Cd ₂	Q1=(Qsact+ Q2act) m^3/s $*10^{-4}$	Y1 m	V1 m/s	Fr1
5.8	1.956	0.07	1.078	0.55	6.3	1.45	0.07	1.078	0.74	2.156	0.075	0.0143	0.0166
5.5	1.806	0.065	1	0.55	5.9	1.314	0.065	1	0.76	2	0.07	0.0142	0.0171
5.2	1.661	0.06	0.924	0.55	5.6	1.215	0.057	0.878	0.72	1.802	0.065	0.0138	0.0172
5	1.566	0.052	0.801	0.51	5.4	1.151	0.052	0.801	0.69	1.602	0.06	0.0133	0.0173
4.6	1.382	0.048	0.739	0.53	4.8	0.964	0.051	0.786	0.81	1.525	0.055	0.0138	0.0187



 Table (2): Tapered channel of width (20-16) cm with a horizontal side weir

	Tank b	elow side	weir		Та	nk below	the end o	f channel	Discharge and velocity before side weir				
H=(y-s) m *10 ⁻³	Qsth m^{3}/s *10 ⁻⁴	Yav M	Qsact m^3/s $*10^{-4}$	Cd ₁	H=(y-s) m *10 ⁻³	Q2th m^{3}/s $*10^{-4}$	Yav m	Q2act m^{3}/s $*10^{-4}$	Cd ₂	Q1(Qsact +Q2act) $m^3/s *10^{-4}$	Y1 m	V1 m/s	Fr1
5.3	1.709	0.053	0.816	0.47	5.8	2.076	0.066	1.0172	0.49	1.833	0.075	0.0122	0.0142
5.1	1.613	0.05	0.77	0.47	5.5	1.917	0.06	0.924	0.48	1.694	0.07	0.0121	0.0146
4.8	1.473	0.043	0.663	0.45	5.2	1.762	0.053	0.816	0.46	1.479	0.065	0.0113	0.0141
4.5	1.337	0.038	0.585	0.43	4.8	1.563	0.045	0.693	0.44	1.278	0.06	0.0106	0.0138
4	1.121	0.033	0.508	0.45	4.5	1.418	0.04	0.616	0.43	1.124	0.055	0.0102	0.0138



Table (3): Tapered channel of width (20-12) cm with horizontal side weir

	Tank b	elow side	weir		Ta	nk below	the end o	f channel		Discharge	and veloc	ity before s	side weir
H=(y-s) m *10 ⁻³	Qsth m^3/s *10 ⁻⁴	Yav M	Qsact m^3/s $*10^{-4}$	cd	H=(y-s) m *10 ⁻³	Q2th m ³ /s *10-4	Yav m	Q2act m^{3}/s $*10^{-4}$	cd	Q1(Qsact +Q2act) $m^3/s *10^{-4}$	Y1 m	V1 m/s	Fr1
5.6	1.856	0.068	1.048	0.56	6.1	1.667	0.067	1.032	0.61	2.08	0.075	0.0138	0.016
5.4	1.757	0.06	0.924	0.52	5.8	1.546	0.065	1	0.64	1.924	0.07	0.0137	0.0165
5	1.566	0.055	0.847	0.54	5.5	1.427	0.056	0.863	0.6	1.71	0.065	0.0131	0.0164
4.8	1.473	0.05	0.77	0.52	5.3	1.35	0.052	0.801	0.59	1.571	0.06	0.013	0.0169
4.4	1.292	0.045	0.693	0.53	4.8	1.163	0.048	0.739	0.63	1.432	0.055	0.013	0.0176



Table (4): Tapered channel of width (20-14) cm with a horizontal side weir

	Tank be	low side	weir		Та	nk below	the end o	of channel	Discharge and velocity before side weir				
H=(y-s) m *10 ⁻³	Qsth m^{3}/s $*10^{-4}$	Yav M	Qsact m^3/s $*10^{-4}$	Cd ₁	H=(y-s) m *10 ⁻³	Q2th m ³ /s *10 ⁻⁴	Yav m	Q2act m^3/s $*10^{-4}$	Cd ₂	Q1=(Qsact +Q2act) $m^3/s *10^{-4}$	Y1 M	V1 m/s	Fr1
5.5	1.806	0.065	1	0.55	6	1.905	0.066	1.0172	0.53	2.0172	0.075	0.0134	0.0156
5.3	1.709	0.06	0.924	0.54	5.6	1.718	0.062	0.955	0.55	1.879	0.07	0.0134	0.0161
4.9	1.519	0.055	0.847	0.55	5.3	1.582	0.058	0.893	0.56	1.74	0.065	0.0133	0.0166
4.6	1.382	0.05	0.77	0.55	5	1.449	0.05	0.77	0.53	1.54	0.06	0.0128	0.0167
4.1	1.162	0.04	0.616	0.53	4.6	1.279	0.041	0.631	0.49	1.247	0.055	0.011	0.0149



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Table (5) Tapered channel of width (20-18) cm with a rectangular side weir:

H=(y-s) m *10 ⁻³	Qsth m ³ /s *10 ⁻⁴	Yav m	Qsact <i>m³/s</i> *10 ⁻⁴	cd	H=(y-s) m *10 ⁻³	Q2th m ³ /s *10 ⁻⁴	Yav m	Q2act <i>m³/s</i> *10 ⁻⁴	cd	Q1=(Qs act +Q2ac) <i>m³/s</i> *10 ⁻⁴	Y1 M	V1 m/s	Fr1
5.2	1.661	0.048	0.739	0.44	6	2.058	0.065	1	0.48	1.739	0.075	0.0115	0.0134
5	1.566	0.04	0.616	0.39	5.5	1.806	0.06	0.924	0.51	1.54	0.07	0.011	0.0132
4.5	1.337	0.033	0.508	0.37	5.3	1.709	0.05	0.0.77	0.45	1.278	0.065	0.0098	0.0122
4	1.121	0.026	0.4	0.35	5	1.566	0.045	0.693	0.44	1.093	0.06	0.0091	0.0118
3.6	0.956	0.023	0.354	0.37	4.6	1.382	0.04	0.616	0.44	0.97	0.055	0.0088	0.0119



Figure (2) shows the relationship between the theoretical and the actual discharge was drawn in the case of the tapered channel of five degree of constriction as mentioned before. It found that the coefficient of discharge increased, with the increasing of constriction. These increment is **Cd=0.52** for tapered channel (20-18) cm, **Cd=0.54** for tapered channel (20-16) cm, **Cd=0.57** for tapered channel (20-14) cm, **Cd=0.6** for tapered channel (20-12) cm and **Cd=0.62** (where Cd represented the average value of discharge coefficient for tapered channel (20-10) by depend on the actual discharge and theoretical discharge as shown in figure 2) cm. It has been observed that the discharge coefficient Cd increases when the narrowing of the channel increases, so that the water flow over the side weir should be increases also. At the same time, the height of water still in the channel increases with increasing of constriction, which helps to provide another sub channel with water when it is needed.



Figure (2): The relationship between theoretical and actual discharge for tapered channel (20-10) cm

The relationship between the height of water over the side crest weir and the discharge passing over it drawn in figure (3) for tapering channel .It is found that the maximum discharge occurs at the highest value of constriction. The discharge over the side weir should be increase with the increase of constriction degree. The discharge over side weir decreases when the height of water over it decreases.



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Figure (3): The relation between height of water over side weir and discharge over it for tapering channel

Figure (4) shows the relation between the water height over the side weir and Froude number, for tapered channel for all degree of constriction. It is found that the Froude number should be increases when the constriction degree increase until the constriction of tapering channel reach to (20-12) cm. Froude number behavior changes, and must be unstable for tapering channel at the degree of constriction (20-12) cm and (20-10) cm. That must be belong to the change in the channel width when the tapered channel reach to maximum degree of constriction, Froude number shall be un stable, which is fluctuated between high and low level.



Figure (4): The relation between height of water over the weir and Froude number for tapering channel.

PP: 13-30



ANSYS

Figure (5), (6) and (7) shows the water surface profile over side and tail weir in tapered channel. The water over the side weir is stable and close to the straight line in all cases of constriction while the water surface profile over tail weir special for the last three degree of constriction (20-14) cm, (20-12) cm and (20-10) cm shall be disturbed and un stable. This is return to the sudden increase, of the water height after the side weir. Due to increased speed of movement of water molecules, this must be lead to this disturbance, caused by water molecules collision. Where the number in figure 5 represented the main discharge in the main channel (where take three experimental discharge and show the height of water over side weir for each one).



Figure (5): Water surface profile over the side weir for tapering channel (20-16) cm



Figure (6): The height of water over side weir for tapering channel (20-16) cm





Figure (7): Water shape over the weir at the end of tapering channel (20-14) cm

5. Conclusions:

The discharge coefficient was calculated for the side weir depending on the degree of tapering channel, it is found that:



1. The large discharge over the side weir occurs in the maximum degree of construction (20-10) cm.

2. The discharge over side weir increase the discharge remain in the channel increase also that return to used tapered channel

3. The water surface profile over the weir at the end of the channel is stable and close to the straight line in most degree of constriction except for the last three degree of constriction (20-14) cm, (20-12) cm and (20-10) cm. The shape of water surface is disturbed. That must be return to the sudden increase of the water height after the side weir. Due to increase the speed of water molecules movement which is lead to this disturbance, caused by the collision of water molecules.

4. Froude number values in a contraction channel increased with increasing the constriction of the channel, but this behavior reaches to unstable of Froude number in maximum constriction case (20-16) (20-18).

5. From ANSYS software that found the profile of water level over the weir at the end of channel is linear, except the three cases of construction (20-14) (20-16) and (20-18) the water surface profile be distributed and unsteady.

References:

[1] Venutelli, M. "Method of solution of nonuniform flow with the presence of rectangular side weir" Journal of irrigation and drainage engineering, .(2008), 134(6), 840-846.

[2] Borghei, S. M., Vatannia, Z., Ghodsian, M., & Jalili, M. R. **"Oblique rectangular sharp-crested weir"**. In Proceedings of the Institution of Civil Engineers-Water and Maritime Engineering(Vol. 156, No. 2, pp. 185-191). Thomas Telford Ltd. (2003, June)

[3] Vanishree, B. R., & Manjula, R. **"Analysis of various parameters affecting weir design and fabrication of Weirs: An Overview**". In MATEC Web of Conferences ,(2018). (Vol. 144, p. 01006). EDP Sciences.

[4] Aydin, I., Altan-Sakarya, A. B., & Sisman, C.'' **Discharge formula for rectangular sharpcrested weirs'**'. Flow Measurement and Instrumentation, (2011), 22(2), 144-151.

DOI: <u>http://dx.doi.org/10.25098/3.1.2</u>



[6] Al-Tabatabaie ,F.A."**The behaviour of bellmouth spillways with feeder channels** "Ph.D.Thesis ,Dep of civil and structural Engineering , The university of Sheffield , 1979.

[7] Seyedian, S. M., Jalili Ghazizadeh, M., & Tareghian, R''Determining side-weir discharge coefficient using Anfis''. In Proceedings of the Institution of Civil Engineers-Water Management . (2014, April). (Vol. 167, No. 4, pp. 230-237). Thomas Telford Ltd.

[8] Bonakdari, H., & Zaji, A. H.'' New type side weir discharge coefficient simulation using three novel hybrid adaptive neuro-fuzzy inference systems''. Applied Water Science, (2018), 8(1), 10.

[9] Fluent 14 use ,guide ,programing and tutorial guide "Fluent ; version15 Ansys Inc" ., 2010.

[10] Szymkiewicz, R. "Numerical modeling in open channel" hydraulics (Vol. 83). Springer Science & Business Media,2010

[11] Samiee, S., Heidarpour, M., & Bagheri, S. "Flow characteristics of rectangular sharp-crested side weirs in the presence of guide vanes". ISH Journal of Hydraulic Engineering.
(2016), 22(1), 109-114.

[12] Mahmodinia,S., Javan,M., & Eghbalzadeh, A. "The effects of the upstream Froude number on the free surface flow over the side weirs". Procedia Engineering (2012), 28, 644-647.

[13] Keshavarzi, A., & Ball, J." Discharge coefficient of sharp crested side weir in trapezoidal channel with different side-wall slopes under subcritical flow conditions". Irrigation and drainage, (2014), 63(4), 512-522.

[14] Muslu, Y. **"Lateral weir flow model using a curve fitting analysis"**. Journal of Hydraulic Engineering, (2002) 128(7), 712-715.