EXPERIMENTAL WORKS FOR DETERMINE MANNING'S COEFFECIENT ROUGHNESS IN OPEN CHANNELS

ZOHUL Abdul Hadi , AHMED N. A. HAMDAN

Civil Engineering Dep. , College of Engineering , University of Basrah

Keywords: Manning's roughness ,experimental work, open channels

Abstract

A Laboratory study was conducted in a tilting flume,0.6 m wide and 3.0 m long to study the effect of regular and irregular bed material on the resistance to the flow of different bed material.

The results show that the maximum increase in Manning's roughness coefficient happens when the bed is regular and the maximum reduction in Manning roughness coefficient happens when the bed is irregular .

تجارب عملية لحساب معامل ماننك في القنوات المفتوحه

زحل عبد الهادي ادـد ناصح احمد حمدان

الخلاصة:

تجارب مختبريه أجريت لدراسة معامل ماننك في القنوات المفتوحة وتمثيل واقع حال الانهر والتي تنشأ تحت تأثير جريان الماء . ولقد بينت النتائج إن هناك زيادة في معامل ماننك في حالة كون القعر منتظم ونقصان في معامل ماننك في حال كون القعر غير منتظم .

1- Introduction

The design and executing of irrigation projects need to spend a high cost and a big fatiguing in accomplishing the part of open channel work which is almost built in or overlaid by concrete that have a high cost .

Open channel flow is defined as flow in any channel where the liquid flows with a free surface.

Open channel flow is not under pressure ; gravity is the only force that can cause flow in open channels and a progressive decline in water surface elevation always occurs as the flow moves downstream. It is divided into :-

1. Naturally open channel which include : rivers ,streams, creeks , discharges from tailings ponds , and other uncovered conduits. The naturally open channel is distinguished by its non uniform hydraulic characteristics.

2. Artificial open channel such as navigational channels , electrical channels, drainage channels, adits, tunnels and ventilation shafts, can be treated as open channels when flowing partially full and not under pressure.

The hydraulic characteristics of this type of channels is governed by design requirements. The artificial channels shape is different in its section ,that it can be rectangular, triangular or trapezoidal .

The increasing requirements to water resources require to search and find the economical easy way to build irrigation systems which is easy in design, execution, maintenance and management .

Water flow in natural or artificial open channel is exposed to losses in energy due to friction between water and channels' bed or walls.

In bed rivers, when the bed forms are ripples or dunes, resistance to flow is mainly due to shape of these roughness elements. However, in rivers whose beds are composed of different materials will cause main effects on the roughness resistance to flow in the latter type of river which have been studied by many researchers, such as Arcement [1], Collins [4], Downs [6] , Leopold [8], and Ringman [12].

The basic parameters which affect the manning roughness coefficient are shape and spacing of roughness ,the channel shape, alignment and stage.

Many researchers have found out theoretical relations that connect between various flow parameters and velocity of flow such as: Dingman [5] ,Motgomery [9], Naiman [10] and Rogen [11].

In this study , the effect of bed material will be considered .

The experimental work conducted to test the roughness coefficient of open channel bed simulate what happened in rivers. That is done by replacing channel bed materials by many types of materials. Also, the section of the channel was changed by being contracted. This was done by putting an obstacle in one or both sides.

The aims of this study is to do an experimental study to calculate Manning coefficients and measure the discharge in the channel by changing the type of the bed material.

2- Experimental procedure

The experimental programming was conducted in a tilting flume 3 m long, 0.6 m wide. Fig.(1)

The equipment consists of a recirculating rectangular open flume. There are three main parts of the flume: the inlet tank, the working section and the discharge reservoir tank. A drop – tight adjustable overshot weir with upstream sand trap is accommodated within the discharge tank. The inlet tank incorporates a perforated baffle plate which spreads the flow evenly across the width of the channel. A pair of adjustable instrument rails are fitted to the top flange of the channel and they extend over the full length of the working section. One rail also carries a positioning scale. A depth gauge is used to measure the water level. The flow of water is provided by a centrifugal pump. The flow rate is measured by a water meter.

Different materials were used to the bed flume .

Thirty six experimental runs were performed. In each three of them there were the same bed materials whereas both the depth of water and the discharge were varied, when the material were fed to the system .

Uniform flow was achieved when both the water depth and discharge became constant along major portion of the flumes length.

At this point, depth of water at different sections and discharge were recorded .

After the collection of pertinent data the flow of water was stopped, the bed was cleared out completely and the flume was set ready for another run,

Measured and calculated variables are given in Table (1).

3- procedure of work

1. Maintain a desired discharge in the channel.
2. Measure the depth of flow at three cross-sections a long the length of the channel by using the depth gauge. Also measure at each cross-section the depth of flow at three places. (transversely).
3. Note the initial and final readings in the water meter and the time taken for this volume of water.
4. Determine the bed slope of the channel by finding the difference in the depth to the known length of the channel..
5. Repeat the procedure of the experiment for a different discharge.

The method used to calculate the discharge in an open channel was a Manning's equation .

Manning's equation used to calculate the average velocity of flow (V) through the channel section is:-

$$V=\frac{1}{n_c}(R)^{2/3} S_o^{1/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

And by using the equation of continuity :-

$$Q=V.A \quad \ldots\ldots\ldots\ldots\ldots 2$$

thus ,

$$Q=\frac{1}{n_c}(R)^{2/3} S_o^{1/2} .A \ldots\ldots\ldots 3$$

Where :-

Q : discharge through channel section (m^3/s)

n_c : equivalent roughness coefficient ($m^{1/6}$)

R: Hydraulic radius of channel section (m).

S_o : channel bed slope in longitudinal direction.

A : Area of cross section of the channel (m^2).

4- Results and discussion

Roughness coefficient represents the resistance to flood flows in channels and flood plain management , in flood insurance studies ,and in the design of bridge and highway across flood plains.

Suggested values for Manning's n , tabulated according to factors that affected roughness are found in Chow [3] and Grant [7].
Roughness characteristics of natural channels are given by Barners [2] .

In this work we attempt to broaden the scope of that work by doing many experiments to find manning's coefficient.

The variation of Manning's roughness coefficient and the discharge are shown in Figs.(2-7)

The resistance of flow seems to continuously increase as the discharge was increased if the bed is regular as shown in figs (2),(5) because surge waves are formed and propagated upstream and downstream of the obstruction. A positive surge is one which results in an increase in the depth of the stream. The resistance of flow seems to continuously decrease as the discharge was increased if the bed is irregular as shown in figs. (3), (6). In this case negative surge waves cause a decrease in depth of the stream in spite of the occurrence of a surge in an unsteady flow phenomenon.

Figs.(4), (7) show that the resistance to flow in a different bed can become more than two times smoother if there is enough particle to fill the spacing between its roughness elements.

5-Conclusions

When the watershed of a river, whose bed is formed of different size of materials, such as gravel or sand, is subjected to a major storm a large in flow of sand and gravel size sediment to the river can result. This is especially true in semi-arid and arid region of the world. The sand and gravel size sediment gradually fill the spaces between the large roughness elements and may submerge them completely. Eventually, the river behaves as a sand bed river.
As a result , the resistance to flow can be changed .

According to the results of the study , the conclusions can be summarized as the following :-

1. It was noticed that the Manning's roughness coefficient increases whenever the bed of the channel is regular.

2. It was noticed that the Manning's roughness coefficient decreases whenever the bed of the channel is irregular.

3. Manning's incorporates many physical factors including the channel roughness, irregularity of the channel cross section , channel alignment and bends, vegetation, sedimentation, scouring and channel obstructions.

4. A general knowledge of water discharge distributions is extremely important in evaluating and selecting a method of flow measurement.

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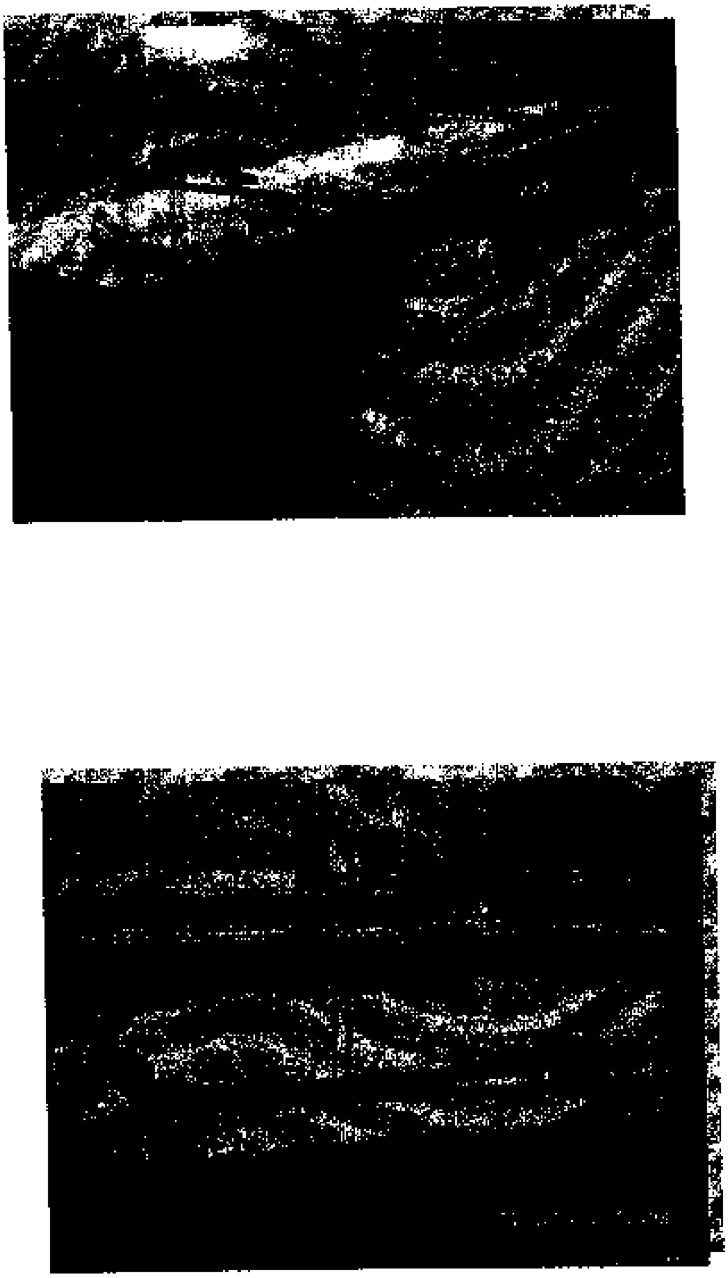

Fig. 1 : Plan view of open channel

Table (1): Collected data and Computed parameters

No. of experiment	Q (cm^3/sec)	Y_{ave}(cm)	A (cm^2)	W.P (cm)	R (cm)	So	n_c	Type of the bed
1	69.4	3.5	210	67	3.1	.0003	.11	Uniform sand
2	83.3	4.2	249	68.9	3.7	.0037	.14	
3	138.9	4.4	267	68.3	3.9	.00037	.29	
4	69.4	3.37	202	66.74	3.03	.0017	.24	Non uniform sand
5	88.9	3.35	201	66.7	3.02	.001	.15	
6	125	3.39	203	66.78	3.05	.001	.11	
7	41.7	2.96	177.6	65.92	2.69	.0007	.22	Uniform sand with one obstruction
8	50	3.25	195	66.5	2.93	.001	.27	
9	55.6	3.24	194.62	66.48	2.93	.0031	.4	
10	69.4	2.89	172	65.78	2.61	.002	.21	Uniform sand with two obstruction
11	94.4	2.97	178	65.94	2.7	.0034	.214	
12	138.9	3.6	216	67.2	3.2	.017	.44	
13	69.4	3.23	193.6	68.46	2.91	.0071	.48	Non uniform sand with one obstruction
14	97.2	4.01	240.6	68.02	3.54	.0066	.47	
15	138.9	3.82	229.2	67.64	3.39	.005	.26	
16	69.4	2.67	160.4	65.34	2.45	.032	.76	Non uniform sand with two obstruction
17	94.4	2.92	175.2	65.84	2.66	.016	.45	
18	138.9	4.19	251.5	68.38	3.68	.00282	.23	
19	75	3.07	184.4	66.14	2.79	.0204	.69	Uniform gravel
20	91.7	4.39	263.4	68.78	3.83	.0124	.79	
21	138.9	4.57	274	69.14	3.96	.052	.13	
22	69.4	3.18	191	66.36	2.87	.024	.86	Non uniform gravel
23	88.9	4.13	248	68.26	3.63	.011	.69	
24	119.4	4.08	245	68.16	3.59	.015	.59	
25	77.8	4.08	244.8	68.16	3.59	.0232	.00939	Uniform gravel with one obstruction
26	86.1	4.77	286	69.54	4.11	.02	.0174	
27	119.4	4.73	284	69.46	4.1	.014	.038	
28	69.4	3.1	184	66.2	2.78	.00326	.3	Uniform gravel with two obstruction
29	91.7	3.4	202.6	66.8	3.03	.00446	.31	
30	97.2	3.4	202.6	66.8	3.03	.0131	.5	
31	55.6	3.6	216	67.2	3.21	.038	1.66	Non uniform gravel with one obstruction
32	76.4	4.4	264	68.9	3.83	.0069	.71	
33	111.11	4.3	258	68.6	3.76	.014	.67	
34	69.4	2.92	175	65.84	2.66	.0173	.64	Non uniform gravel with two obstruction
35	94.4	2.93	175.8	65.86	2.67	.0015	.29	
36	138.8	4.2	253	68.4	3.7	.00187	.19	

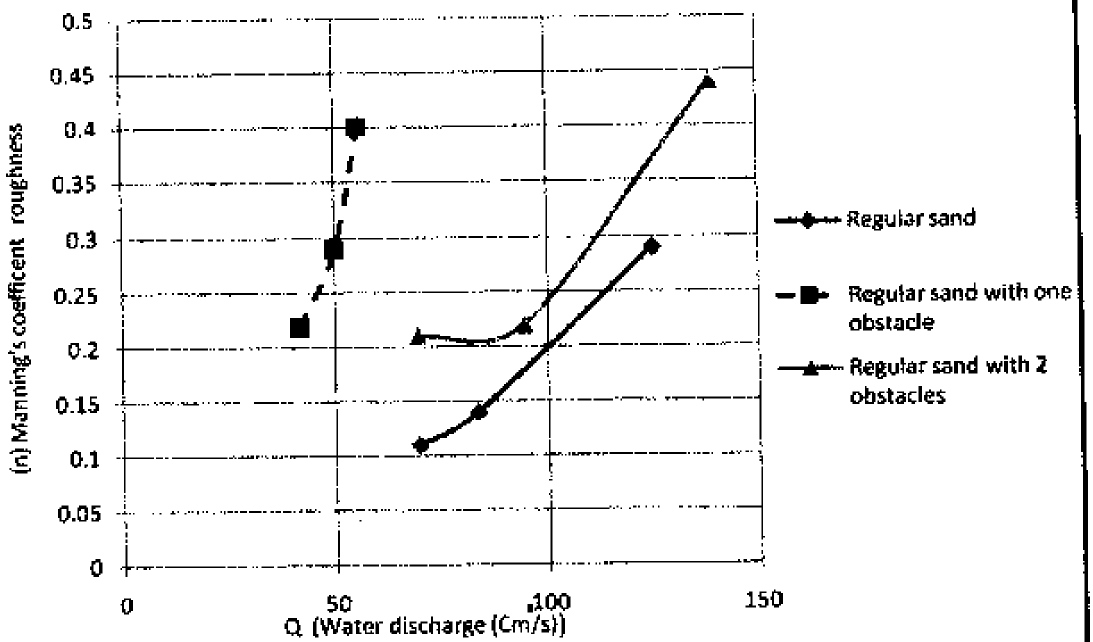

Fig.(2): The relation between Manning's coefficient roughness and water discharge

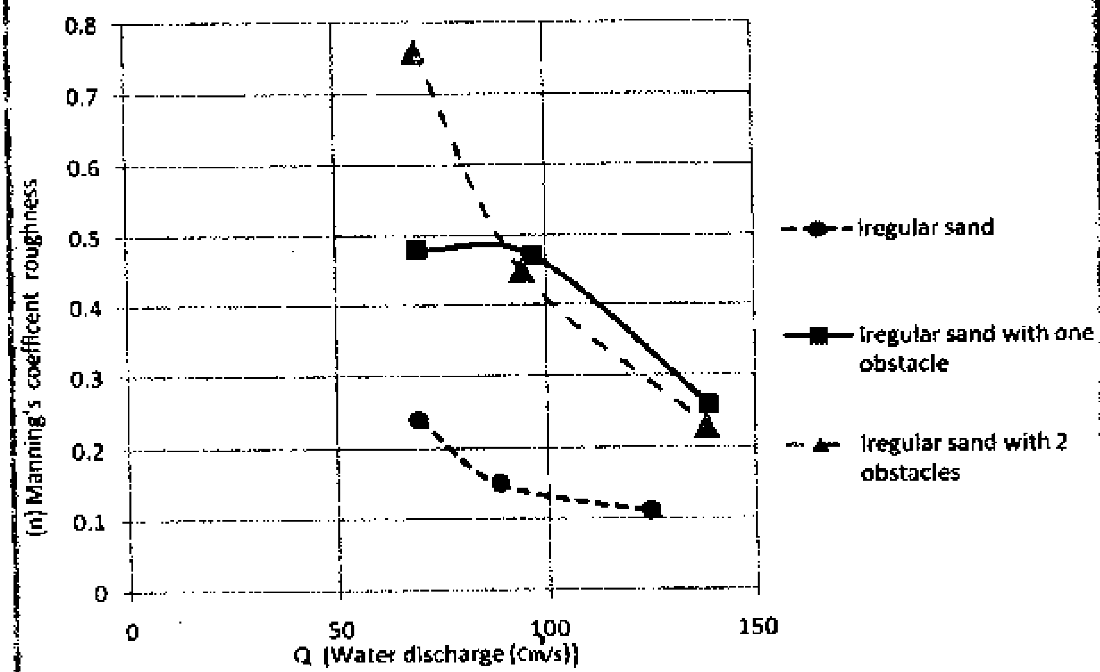

Fig.(3): The relation between Manning's coefficient roughness and water discharge

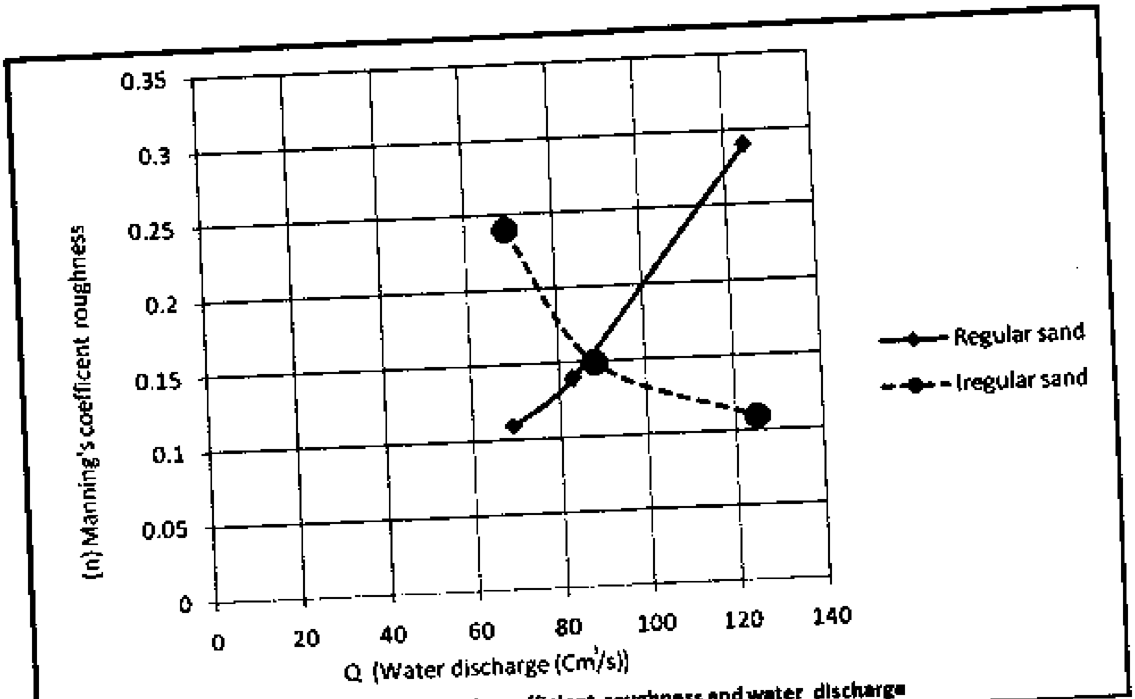

Fig.(4):The relation between Manning's coefficient roughness and water discharge

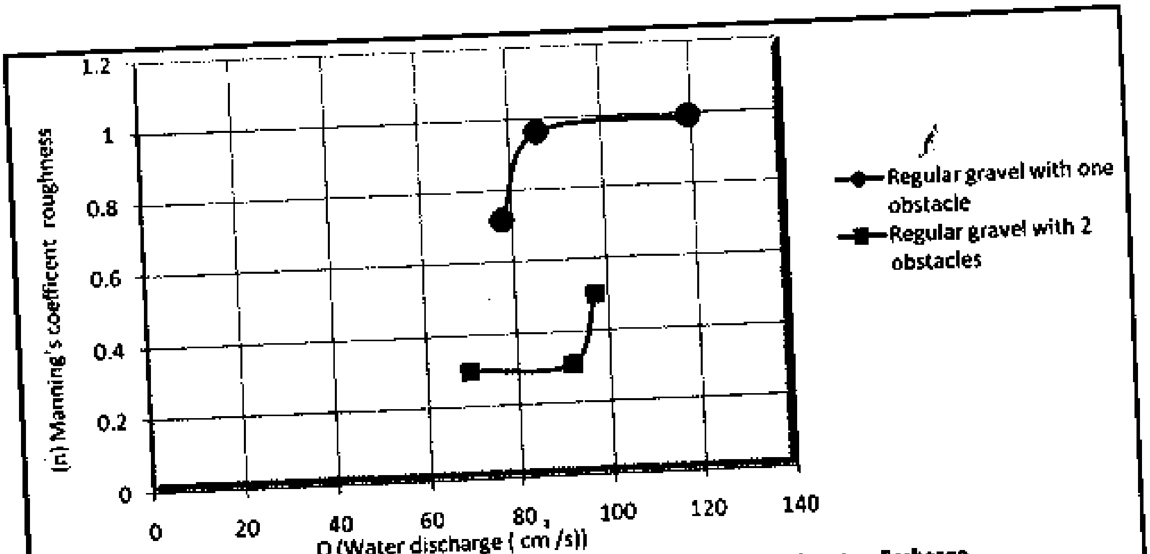

Fig.(5): The relation between Manning 's coefficient roughness and water discharge

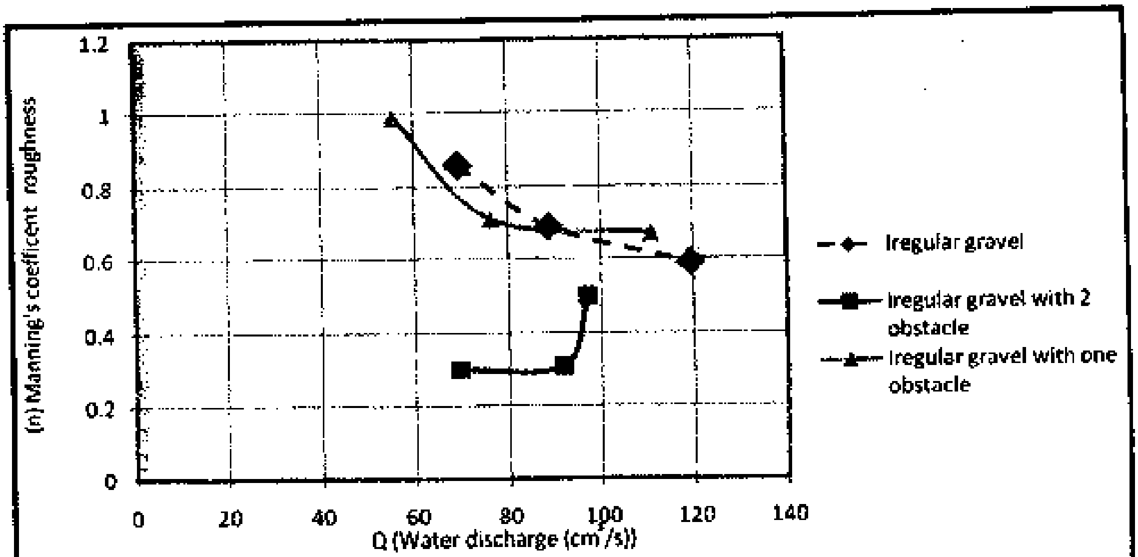

Fig.(6): The relation between Manning coefficient roughness and water discharge

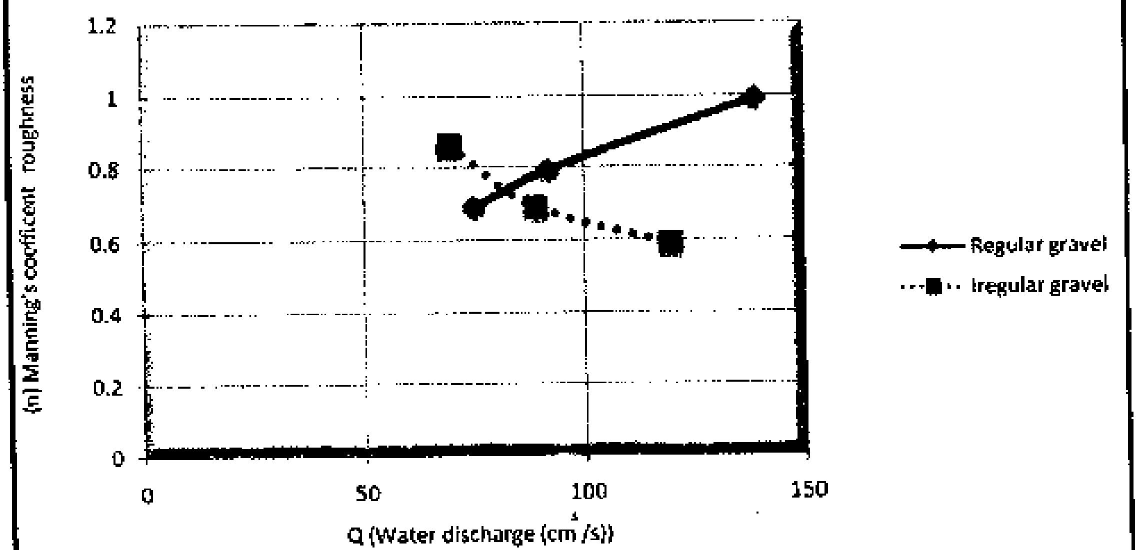

Fig.(7): The relation between Manning 's coefficient roughness and water discharge