Study For The Effect of Manning Roughness on Froude number in open channel(subcritical flow)

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Received on:10/9/2013 & Accepted on:7/5/2015

ABSTRACT

Knowing of flow resistance in channels is necessary for many purposes such as the estimation of stage-discharge relationship, and the evaluation of sediment transport from the hydraulic characteristics of the channel by means of transport formulas. All relationships between Froude number (F_r)and Mainning's roughness coefficient(n) lead to obtain useful information in design, implementation, minimization the construction cost, and design the economical section.

The goal of the present work is to investigate experimentally the effect of Manning roughness on Froude number in open channel in subcritical flow, as well as, to establish some relations between different parameters, like Froude number with Manning's Roughness coefficient, velocity and head, in order to find useful relations.

Two different cases have been adopted in this study. The first one is to predict relationships from the concrete lining irrigation canal, and the second is to procedure conducted in a selected reach of a natural stream Main Outfall Drain Project (M.O.D.) with two sectors of Mahmudiya, and J'bala as a case study.

In this invistgation on lined irrigation canal, the relationship between F_r and n appears as a polynomial relation of the fourth degree and a moderate relationship between of them.

In the second case, the relationship between F_r and n gave a significant relationship in the two regions, and gave a good agreement with the observed value. This study reveal a general equation that can correlate the Froude number with friction factor (n).

Keywords: Froude number, Manning's roughness coefficient, Concrete irrigation canal, Main Outfall Drain, Subcritical flow.

دراسة تأثير معامل الخشونة لماننغ على رقم فراود في القنوات المفتوحة- الجريان تحت الحرج

الخلاصة

ان معامل الاحتكاك في القنوات المفتوحة بصورة عامة يتأثر بخواص الجريان و المقطع الهندسي و خواص الطبقة المتاخمة للقناة. ان معرفة مقاومة الجريان في القنوات ضرورية لاغراض عديدة على سبيل المثال ربط علاقة بين المنسوب والتصريف وتقدير الرسوبيات من الخصائص الهيدروليكية للقناة وتحسب عن طريق المعادلات الخاصة بالرسوبيات. ان العلاقات بين رقم فراود ومعامل الخشونة لماننغ تؤدي الى الحصول على معلومات مهمة ومفيدة في التصميم والتنفيذ و تقليل كلفة الأنشاء و تصميم مقطع اقتصادي. ان الهدف من الدراسة الحالية هو دراسة وتبيان تأثير معامل الخشونة لماننغ على رقم فراود في القنوات المفتوحة، من خلال ايجاد بعض العلاقات بين معاملات لابعدية مثل رقم فراود مع معامل ماننغ للخشونة والسرعة وشحنة الارتفاع.

وقد تم اعتماد حالتين مختلفة في هذه الدراسة لايجاد العلاقة بين رقم فراود ومعامل الخشونة لماننغ. الحالة الاولى هي ايجاد العلاقات من قناة ري مبطنة (قناة مبطنة بالخرسانة) والثاني هو مجرى مائي طبيعي مثل مشروع المصب العام باخذ منطقتين هي المحمودية وجبَلة لتبيان العلاقة بالقرب من بداية المقطع عند منطقة المحمودية وباتجاه المصب عند منطقة جبلة . وقد تم استخدام البرمجة والعلاقات الاحصائية (الانحدارات المتعددة لتحليل النتائج).

في الحالة الأولى تم التحليل على قناة ري مبطنة وان العلاقة بين رقم فراود مع معامل الخشونة لماننغ أظهرت علاقة متعددة الحدود من الدرجة الرابعة. في الحالة الثانية لمجرى طبيعى لنهر مثل المصب العام .اظهرت الدراسة الحالية ان العلاقة بين رقم فراود مع معامل الخشونة لماننغ اعطت علاقة جيدة وقيم متوافقة للقيم المحسوبة مع المشاهدة بمنطقتين المحمودية وجبلة. وقد تم التوصل في هذه الدراسة على معادلة عامة التى يمكن ان تربط بين رقم فراود مع معامل الخشونة لماننغ في الحالات الثلاث لمشروع الدراسة.

INTRODUCTION

The flow of water in open channel (a conduit) must have a free surface; a free surface is subjected to atmospheric pressure. So, the flow conditions in open channels are complicated by the fact that the position of the free surface is likely to change with respect to time and space, and also by the fact that the depth of flow, the discharge, and the slope of the channel bottom and of the free surfaces are independent.

Open channels are designed to transport water at atmospheric pressure and may be constructed in a wide variety of shapes. The parameters affecting the design of open channels include the cross-sectional shape, slope, and roughness coefficient (Manning's n). Determining the depth of flow and velocity are important for selection of an appropriate lining material. High velocities require special liners which are not affected by erosion, such as concrete. The Manning's equation is the most widely accepted channel design calculation (French, 2004).

In hydraulic engineering, the friction coefficient is a crucial parameter in designing water structures, and the flow profile calculation, velocity and discharge plays a significant roles in water resources project, flood management planning and the determination of hydraulics effects for river conservation.

The Froude number F_r prediction may help in assessing the resistance to the flow in alluvial channel. The prediction of flow resistance in alluvial channels is needed for two major purposes: ***i.***The estimation of stage discharge relationship,***ii.*** The estimation of sediment transport from the hydraulic characteristics of the channel by means of transport formula.

Moreover, knowledge of the resistance characteristics of alluvial streams is of great value when dealing with the study of many applications in water resources, such as scouring and silting, the location of bridges, training works, flood control works, flood forecasting, navigation and channel improvement, backwater computation due to confluences and barrages, mathematical and physical modeling of flow, prediction of aggradations and degradation due to presence of hydraulic structures, prediction of bed forms and so on (Khatua et al., 2007).

Irrigation open channel lining is an effective way to control the seepage and erosion to the channel bottom and banks. Lining permits channels to transport more flow than larger unlined channels because of reduced roughness. This efficiency means that less land is needed for channel construction.

The aim of this research is to investigate experimentally the effect of Manning's roughness coefficient on Froude number in open channel and resistance to flow through channel in a sub critical flow , as well as, to establish some relations between different parameters, especially Froude number (F_r) with Manning roughness coefficient (n), and other factors velocity (V) and head (h), in order to find useful relations. Different procedures have been adopted for this aim as follows:

- Concrete lining irrigation canal.
- Natural stream river like Main Outfall Drain Projects (M.O.D) as a case study, by taking a spesified reach in M.O.D between Mahmudiya, and J'bala.

Flow Resistance

Flow resistance describes the influences of friction to the flow due to channel characters. Roughness equations are used for its quantification. Magnitude of the resistance can be described as a resistance coefficient. Flow resistance in open-channel is very complicated concept, and there are no exact methods to determine it (Järvelä, 1998). The factors that have the greatest influence on the coefficient of roughness are described below. It should be noted that these factors are to a certain extent interdependent. The factors affecting flow resistance are; (Chow, 1959, 1973; French, 1986; and Bin Abrahim, 2011).

1. **Surface roughness** is represented by the size and shape of the grains of the material forming the wetted perimeter and producing a retarding effect on the flow. Bottom irregularity has also a great influence to the retarding effect.
2. **Vegetation** markedly reduces the flow capacity of the channel and retards the flow. This effect depends mainly on height, density, distribution, stiffness, and type of vegetation. Seasonal change affects the growth of aquatic plants, grass, weeds, willow, and trees in the channel or on the banks.
3. **Channel size, shape and irregularity** refer to variations in the channel cross-section, shape, and wetted perimeter along the longitudinal axis.
4. **Sedimentation and erosion** may change a channel either to more irregular or more regular form. The effects depend on the soil material.
5. **Obstructions,** such as fallen trees, debris flows, stones, bridges, and log jams can have a significant impact on the flow resistance.
6. **Stage and discharge** are normally affecting the flow resistance such a way that when those increase, the roughness coefficient decreases.

7. **Sinuosity** is the nature of a meandering and winding stream system. It can be notified as a ratio of the thalweg length.
8. **Ice** is an important factor affecting flow resistance, especially in the cold weather.

Open Channel Type In The Study

Trapezoid is the most widely used shape for irrigation channels and natural stream, for trapezoidal channel hydraulic computations of flow cross –sectional area (A), wetted perimeter (P),top width (T) and hydraulic radius of channel (R) from respectively:

$$A = (b + z\,y)\,y \qquad \dots (1)$$

$$P = b + 2y\sqrt{1 + z^2} \qquad \dots (2)$$

$$T = b + 2z\,y \qquad \dots (3)$$

$$R_h = \frac{A}{P} = \frac{(b + z\,y)\,y}{b + 2y\sqrt{1+z^2}} \qquad \dots (4)$$

where:

A = Cross-sectional area normal to the direction of flow (m^2),
P = Wetted perimeter (m),
b = Width of a cross section along the water surface (m),
y = Flow depth at a cross section (m),
z = Side slope of the channel,
T = Top width of the channel in (m), and
R_h = Hydraulic radius of the channel cross-section (m).

The trapezoidal channel sectional elements are shown in Figure -1.

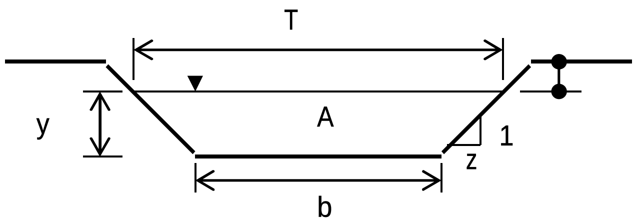


Figure (1): Trapezoidal channel section.

Methodology

In the present study, the investigation in more details have been carried out to find relationships between Froude number and Manning's roughness coefficient in a sub critical flow by adopting the experimental tests in natural and lining channel.In order to extracted the relationship between Froude number and Manning's roughness coefficient in a subcritical flow.

Concrete lining irrigation canal

Concrete linings are widely used, with benefits justifying their relatively high cost. They are tough, durable, relatively impermeable and hydraulically efficient (Pencol, 1983). The most important purposes for lining irrigation canals are to reduce seepage, stabilize channel bed and banks, avoid piping through and under channel banks, decrease hydraulic roughness (flow resistance), promote movement rather than deposition of sediments, avoid water logging of adjacent land, control weeds growth, decrease maintenance costs, facilitate cleaning, and reduce movement of contaminated groundwater plumes (Özcan, A., (2005).

Concrete canal lining in Iraq is normally unreinforced and placed by slip from paver or by hand. Cement concrete lining made from selected aggregate gives very satisfactory service. Cement concrete linings are best suited for main canals which carry a huge flow at high velocities. The smooth surface of the concrete lining increases the conveyance of the channel. Channel banks are kept at self-supporting slope 1.5H: 1V to 1.25 H : 1V, so that the lining is not required to stand earth pressures and its thickness does not increase. Figure-2 show the concrete lining for irrigation canal profile.

Figure(2): Concrete lining for irrigation canal.

Field work and data collection for irrigation concrete canal lining

In the present study, irrigation concrete canal was taken as an applicable case to investigate the relation between friction factor and Froude number in the study - state flow with a subcritical flow. The irrigation canal has different hydraulic features along its length, such as transition flow, meanders, branches ,outlets, and different section sizes. Al Hurrya -Daghare project was taking as a case study of investigation the relation between froude number and Manning's roughness coefficient. The length of irrigation concrete canal is 62,000 m, and it is located within Al-Diwaniyia governorate, southern Iraq.

Table-1 shows the hydraulic parameters and dimensional measurements of the irrigation concrete canal lining. The side slopes of concrete canal lining for all sections 1V:1.5H. The data were provided by Ministry of Water Resource.

Table(1): The hydraulic parameters and measurements of the irrigation concrete canal lining (where each discharge represents on o the canal section).

canal section	Q (m^3/sec)	V (m/sec)	Y (m)	B (m)	S	A (m^2)	R_h (m)	F_r	n
1	5	0.595	1.61	2.8	0.0001	8.396	0.975	0.181095	0.0165110
2	3.5	0.543	1.4	2.5	0.0001	6.44	0.853	0.176831	0.0165490
3	2.5	0.548	1.2	2.0	0.00015	4.56	0.721	0.193890	0.0179620
4	1.5	0.546	0.88	1.8	0.00015	2.746	0.552	0.221666	0.0150870
5	1.2	0.422	1.01	1.3	0.0001	2.843	0.575	0.166273	0.0163820
6	1.1	0.413	0.99	1.2	0.0001	2.658	0.557	0.165160	0.0163580
7	1.05	0.407	0.97	1.2	0.0001	2.575	0.548	0.165368	0.0164220
8	0.89	0.387	0.90	1.2	0.0001	2.295	0.516	0.161071	0.0165890
9	0.78	0.377	0.84	1.2	0.0001	2.066	0.488	0.161515	0.0164170
10	0.73	0.431	0.78	1	0.00015	1.692	0.557	0.193337	0.0164960
11	0.49	0.392	0.66	0.9	0.00015	1.247	0.380	0.190201	0.0163520
12	0.39	0.370	0.59	0.9	0.00015	1.053	0.347	0.188108	0.0163290
13	0.32	0.350	0.65	0.8	0.0001	0.918	0.325	0.183669	0.0165050
14	0.277	0.338	0.53	0.75	0.00015	0.818	2.66	0.182521	0.0164590
15	0.270	0.339	0.52	0.75	0.00015	0.795	0.303	0.184496	0.0162680
16	0.207	0.316	0.316	0.49	0.00015	0.654	0.276	0.179785	0.0164031
17	0.164	0.337	0.41	0.6	0.0002	0.486	0.233	0.208786	0.0158680

Natural Stream -The Main Outfall Drain (M.O.D)

Study area of the Main Outfall Drain

Main outfull drain was designed in th mid of last century to flow between the Tigris and Euphrates rivers, and then it crosses the Euphrates river bed, via large pump station east of Al Nassiriyah city, toward the Arabian Gulf, but the entire project was not completed until December-1992 when the final section, linking the seaward end to that built at Al Dalmaj Lake, was constructed (CEB, 2010).

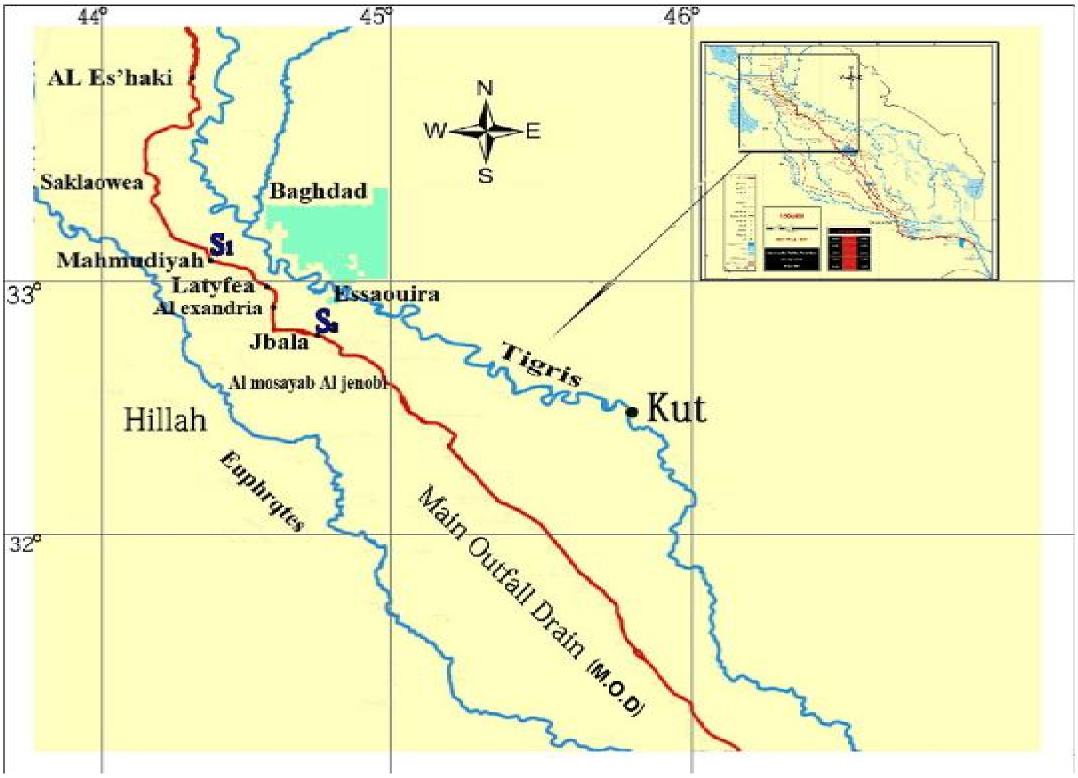
M.O.D discharges the water collected from the irrigation projects, where it takes the total length of 565 km from Al Es'haki area in the North of Baghdad, to its mouth at the Khor Azzubair, and south of Basra. M.O.D was divided into three sectors, based on the construction stage. These sectors are the northern sector, the central sector, and the southern sector. The first sector has length of about 168km, which cross and drained regions of Al Es'haki, Saklaowea, Abu Graib, Al Yosefyia, Al Latyfea, Alexandria. The top width is 52m and display the bottom 13 m and the maximum capacity discharge of 63 m^3/sec.

In present study two sections have been selected within the north part of M.O.D, these sections are at Mahmudiyah, J′bala.

Field work

In this category of the investigation and in order to predict the relation between Froude number and Manning's roughness coefficient , two different locations were selected along of the study area in the northern sector of the Main Outfall Drain, represented areas of Mahmudiyah, and J′bala. Figure-3, shows the map of Main Outfall Drain illustrate the study locations on two regions along the stream.

The period for data collection was done along one year, starting from April 2012 until March 2013, including taking the 12 monthly records of each site with total of 24 records of the two sites. Tables-2&3, shows the results of the data of hydraulic measurements in the two regions; Mahmudiyah, and J′bala.



Figure(3); Map of the Main Outfall Drain illustratethe study locations on two regions(Mahmudiyah, and J′bala along the stream.

Note S_1, S_2, represented to sampling locations on two regions Mahmudiya, and J'bala. Map(not to scal).

Table(2): The hydraulic measurements in the Main Outfall Drain (Mahmudiyah region).

Data of monitoring (Month)	Q(m^3/s)	V(m/sec)	Sediments concentration (ppm)	S	A(m^2)	R_h (m)	n	F_r
Apr. 2012	24.26	0.24	223	0.000012	101.08	2.36	0.02558	0.05496
May 2012	26.115	0.30	201	0.000008	87.05	2.12	0.01556	0.07400
Jun. 2012	25.48	0.27	195	0.000007	94.37	2.01	0.01561	0.06399
Jul. 2012	25.38	0.26	221	0.000011	97.61	2.36	0.02261	0.06058
Aug. 2012	34.81	0.33	252	0.000013	105.48	2.60	0.02066	0.07398
Sep. 2012	36.86	0.32	254	0.000013	115.18	2.14	0.01871	0.06865
Oct. 2012	32.64	0.33	236	0.000013	98.90	2.45	0.01985	0.07639
Nov. 2012	43.53	0.37	276	0.000012	117.64	2.56	0.01752	0.07854
Dec. 2012	43.67	0.38	283	0.000015	114.92	2.38	0.01817	0.08161
Jan. 2013	44.13	0.43	269	0.000017	102.62	2.42	0.01728	0.09773
Feb. 2013	31.58	0.26	277	0.000014	121.46	2.36	0.02551	0.05432
Mar. 2013	30.61	0.24	243	0.000013	127.54	2.25	0.02579	0.04893

Table(3): The hydraulic measurements in the Main Outfall Drain (J'bala region).

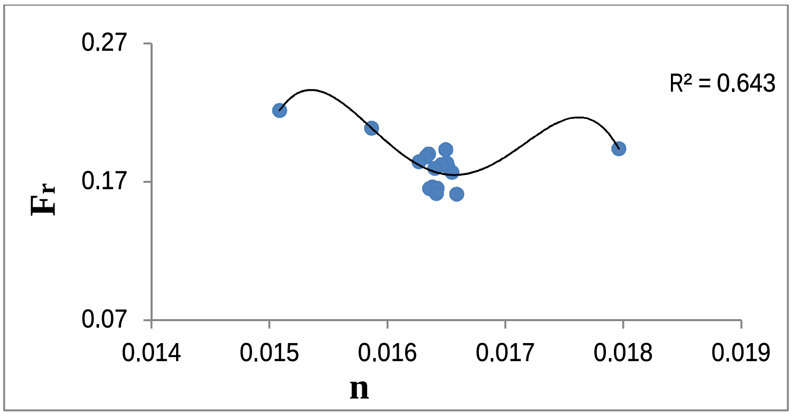
Date of monitoring (Month)	Q(m^3/sec)	V(m/sec)	Sediments concentration (ppm)	S	A(m^2)	R_h (m)	n	F_r
Apr. 2012	28.14	0.27	315	0.000013	104.3	2.10	0.02192	0.06087
May 2012	29.36	0.31	256	0.000009	94.70	2.07	0.01572	0.07334
Jun. 2012	27.52	0.32	215	0.000008	86.0	2.08	0.01440	0.07945
Jul. 2012	31.645	0.34	321	0.000015	93.05	2.14	0.01891	0.08115
Aug. 2012	40.34	0.35	358	0.000017	115.25	2.35	0.02082	0.07506
Sep. 2012	44.71	0.36	367	0.000018	124.19	2.36	0.02089	0.07437
Oct. 2012	36.17	0.31	341	0.000018	116.67	2.23	0.02336	0.06607
Nov. 2012	48.67	0.34	390	0.000015	143.14	2.18	0.01915	0.06543
Dec. 2012	50.14	0.37	398	0.000022	135.51	2.01	0.02019	0.07318
Jan. 2013	49.05	0.37	378	0.000025	132.56	2.01	0.02152	0.07398
Feb. 2013	32.49	0.27	392	0.000025	120.33	2.04	0.02978	0.05667
Mar. 2013	40.84	0.34	358	0.000016	120.118	2.04	0.01892	0.07142

Analysis and Discussion of Experimental Results

The experimental results have been plotted, correlated and compared the data which have been obtained from the experimental work from open channel laboratory flume as well as concrete lining irrigation canal, and natural stream river contains sediments, in order to construct the relationship between Froude number and Manning's roughness coefficient n for subcritical flow condition.

Concrete lining irrigation canal

The relationships between F_r and n in subcritical flow were predicted according to aforementioned calculation procedure as shown in Table-1. Figure-4 shows the relationship between F_r and n for the irrigation concrete canal.



Figure(4): Relationship between F_r and n for the irrigation concrete canal.

The functional relationship has been correlated between F_r and n for all ranges of discharge adopted in canal under consideration was;

$$F_r = -3E+10n^4 + 2E+09n^3 - 5E+07n^2 + 55070n - 2262, \quad R^2 = 0.643 \qquad ....(5)$$

The relationship between Froude number and friction factor appeared as a polynomial of the fourth degree and showed a moderate relationship between them. There are many reasons to make relationship like this due to channel irregularity comprises of irregularities in wetted perimeter and variation in cross section, size, shape along the channel length and meandering, ripples, which cause small pitches or grooves outstanding in the bottom of the channel. These irregularities definitely introduce roughness in addition to that caused by the surface roughness and other factors (Abdul Ameer, 1989). Also, vegetation may be regarded as a kind of surface roughness, and markedly reduces the capacity of the channel and retards the flow. Ebrahimi et. al., (2008) revealed that the Manning's roughness coefficient increases as vegetations density increases, while it decreases when the flow depth and velocity increases. Also, the presence of sediment and erosion of particles affects the Manning's roughness coefficient.

On the other hand, silting may change a very irregular channel into a comparatively uniform one and decrease Manning's roughness coefficient n, whereas scouring may do the reverse action and increase n (Al Jawad, 1994). Side slope of the channel sides (the banks) caused a great effect on velocity, and plant growth also led to obtain the different values for n.

In lined irrigation canal when the flow depth decreases, it will lead to reduce the velocity and Froude number while the value of n increase (Sukhaimi, 2009).

So, from all those affecting parameters, the multi regression analysis does not give a good understanding for the relation between F_r and n and requires more detailed study for the concrete irrigation canal.

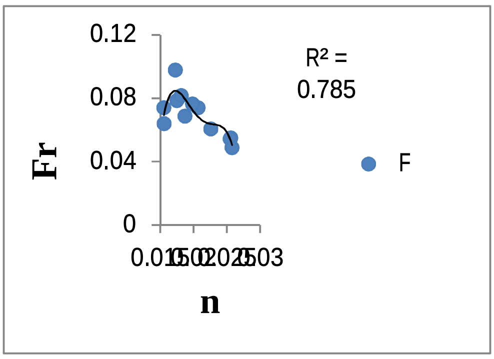
Result of natural stream river (Main Outfall Drain M.O.D)

The relation of Froude number and friction factor (n) was also investigated for the natural stream river (M.O.D), to make more and good understanding for this relation, and to produce fruitful knowledge for designing and solve problems for the hydraulic structures on river, such as dams, weirs, bridges, etc... .

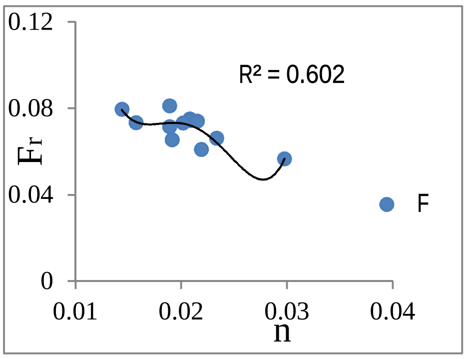
The values of F_r and n was calculated and determined as shown in tables-2 and 3 for Mahmudiyah, and J'bala region respectively. Figure-5 shows the relationship between Froude number F_r and Manning's roughness coefficient n in the two regions. The relationships between F_r and n in both sectors are proportional inversely.

The equations and corresponding R^2 values obtained from the are presented in Table-4. The best fit curve from this analysis appeared as polynomial relations of four degree. This result is quite compatible with results of Andharia and Samtani, (2011a).

The four degree of polynomial relation gave significant to moderate results and a good correlation coefficient. The causes of polynomial relations of fourth degree, which gave the only high correlation, are due to presence of many variables belong to the hydraulic conditions and river morphology phenomena which affecting the measurements and relationships.



(A)



(B)

Figure(5): Relationship between Froude number and Manning's roughness coefficientfor Mahmudiyah region(A), and J'bala region(B).

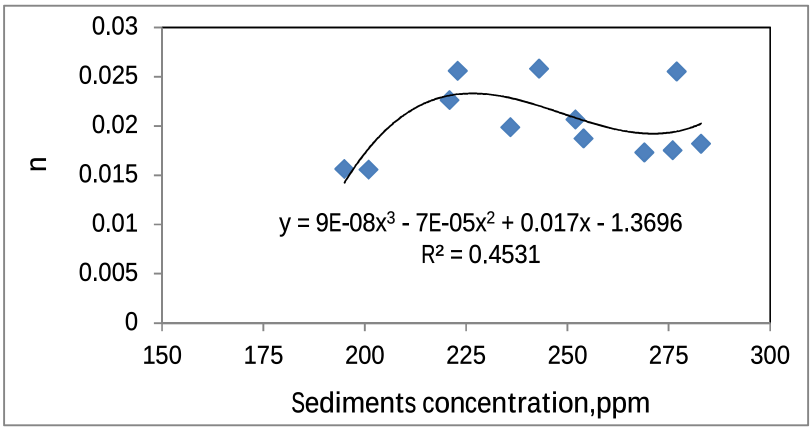
Table(4): Summary of relation between Froude number and Manning's roughness coefficient in the two locations of M.O.D.

Study regions	Equations	R^2	Eq. no.
Mahmudiyah	F_r=5E+07n^4 + 4E+06n^3 – 14062n^2 +1946.n – 9.912	0.75	……..(6)
J'bala	F_r = 1E+07n^4 – 84300n^3 + 26344n^2 - 358.9n + 1.877	0.62	……..(7)

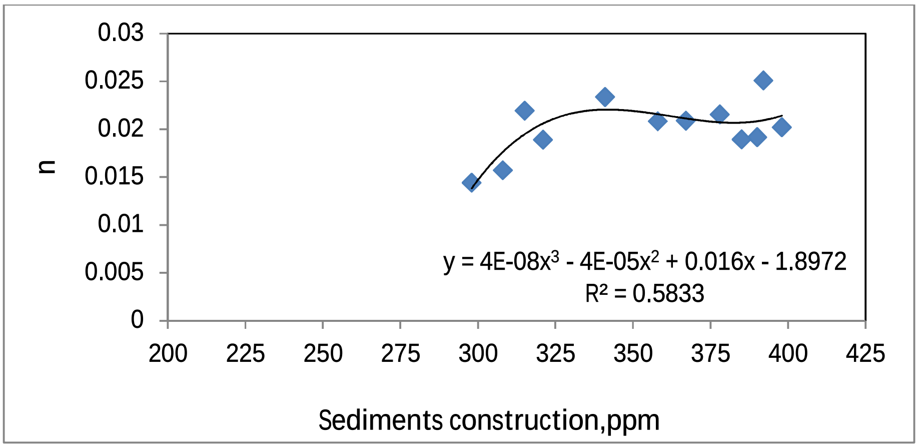
When the velocity of the flow increases in Mahmudiyah region, the value of Fr will increase. During the initial stage of stream flow, the resistance of the flow is more, because some of the energy is utilized for the threshold condition (Srinivas, 1993; Abdul Aziz, 2009), so the Manning's roughness coefficient increases. Furthermore, with the increase in the velocity, at medium Fr, the effective shear stress also increases. The energy required for the motion of mobilized particle increases, so the friction decreases as in J'bala region, because of the entire utilized energy for the motion of the mobilized particle (Andhari and Samtani, 2011a). In the higher range of Froude number (in Mahmudiyah region), the losses due to the accelerating fluid should increase when the flow remains confined. And, the depth of the flow decreases in the limited length of the reach. Therefore, losses remains confined, so the Manning's roughness coefficient decreases. There are many factors and causes, which affect on the natural stream (river), having significant effects to the relation between F_r and n. However, the dominant effect of silting will depend on the nature of the material deposited. The amount and uniformity of scouring will depend on the material forming the wetted perimeter. The energy used in eroding and carrying the material in suspension or rolling it along the bed will also increase the n value (Abdul Ameer, 1989). As well, vegetation may be regarded as a kind of surface roughness, but it also markedly reduces the capacity of the channel and retards the flow.

The relationship between the friction factor and Froude number was established for the M.O.D., and a statistical analysis was carried out. Froude number calculation may help in assessing the resistance to the flow in alluvial channel. Knowing of flow resistance in alluvial channels is needed for purposes of estimation of stage discharge relationship, and to estimate the sediment transport from the hydraulic characteristics of the channel by means of transport formula. The objective of the relationship between Froude number and friction factor leads to useful information in design, implementation and minimizing the construction cost. Moreover, knowledge of the resistance characteristics of alluvial streams is of great value when dealing with the study of many applications in water resources, such as scouring and silting, the location of bridges, training works, flood control works, flood forecasting, navigation and channel improvement, backwater computation due to confluences and barrages.

Morever, the relation between sediments concentration and manning-n was also invistegated for both sectors in MOD (Figures-6 and 7). The results showed that there are moderate relation between those veriables with polynomial thired degree, as the sediments concentration increase the friction factor increase also for both sectors, and in the same manner F_r was decrease with sediments increase. So, finding such relationships in sub critical flow for natural stream (river), benefits designers in studying of reducing costs in the construction, and solving problems, such as raising sediments or scouring, etc.



Figure(6); Relationship between sediments concentration and manning-n for Mahmudiyah region.



Figure(7);Relationship between sediments concentration and n for Mahmudiyah region.

General formulas

From previous analysis of collected data it can extract the general formula to correlate the F_r and n for solid boundary channel (i.e; lined canals). According to average data taken from middle of open canal and filed canal. The general formula is:

$$F_r = 0.196 - 1.51n \quad , \quad R^2 = 78.2\ \% \qquad \ldots (8)$$

This is an acceptable correlation between F_r and n.

It should be presented here, the formula that correlate F_r and n to be used in earthen channel by employing the data were collected from the two sections in M.O.D (Mahmudiyah and J`bala) was resulted as;

F_r= 0.111-2.00 , R^2 =69.2% … (9)

That reveal a moderate correlation between F_r and n.

CONCLUSIONS

Based on the analysis of experiments which was investigated in experimental tests on open channel, a summary of the findings and conclusions drawn from the present study as follows:

1. The relation between Froude number and Manning's roughness coefficient n in subcritical flow was appeared inverse relation having a good agreement with the observed value.
2. The relation between Froude number and Manning's n in concrete lining irrigation canal is inverse relation with polynomial of fourth degree and showed moderate relation.
3. The relationships between F_r and n in the natural stream in the figures of two regions (Mahmudiyah, and J′bala) are inverse relations having showed good agreement with observed values, as well as appeared significant, moderate relation and polynomial of fourth degree. The causes of the polynomial relation of fourth degree, which gave a high correlation, is due to the presence of many variables belong to the hydraulic conditions, and river morphology which affecting the measurements and relationships.
4. The relation between Froude number F_r and Manning's roughness coefficient n in Mahmudiyah gave the best equation and correlation coefficient. The value of n in upstream in Mahmudiyah region increased that is due to coarse grain in upstream (of the study area).
5. This research reveald general equation to correlate F_r and n for natural channel the following relationship was resulted; F_r = 0.111-2.00 n , R^2 =69.2%
6. Further study on the influence of the presence of vegetation in channels, irrigation canal and river to show the effect of vegetation on flow is nessesary. Also, studying the effect of distribution of the sediment in the longitudinal and lateral sections in a natural stream (river) as well as, study the effect of erosion of bank in meandering reach is rccommended.

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