Vol.(4),No.(1),(2016),9-13
MUTHANNA JOURNAL OF ENGINEERING AND TECHNOLOGY (MJET)
مجلة المثنى للهندسة و التكنولوجيا
Journal homepage:www.muthjet.com
Print ISSN:2572-0317, Online ISSN:2572-0325

Hydraulic Model Development using HEC-RAS and Determination of Manning Roughness Value for Shatt Al-Rumaith

Ameera Mohamad Awad*
Department of Civil Engineering , College of Engineering , University of Al- Muthanna.

ARTICLE INFO

Received: 1/6/2015

Accepted:1/10/2015

Keywords
Manning's Roughness coefficient , HEC-RAS model , Calibration , water surface profiles, shatt Al-Rumaith

ABSTRACT
Selection of appropriate Manning's coefficient is critical to the accuracy of computed water surface profiles. Moreover , estimation of channel roughness parameter is of key importance in the study of open- channel flow particularly in hydraulic modeling .Hence, it is essential to calibrate the channel roughness coefficient for open channel whether natural or artificial . In the present study , it is attempted to calibrate the value of Mannnig's "n" coefficient by comparing the computed water surface profiles with observed one , using HEC-RAS steady flow model for shatt al-Rumaith channel in Al-Muthanna (Iraq) . For this calibration , the flows for the year 2014 has been considered . It is found that the value of Manning's roughness coefficient for shatt al-Rumaith shows a good agreement between the computed with observed water surface profiles , is n=0.023and n= 0.04 for main channel and floodplain respectively

تطوير نموذج هيدروليكي باستخدام برنامج HEC –RAS وتحديد قيم معامل الخشونة لماننك لشط الرميثة

الخلاصة
الاختيار المناسب لقيم ماننك (n) أمر بالغ الأهمية في احتساب ملامح سطح الماء بشكل دقيق . علاوة على ذلك ، تقدير خشونة القناة له أهمية رئيسة في دراسة تدفق الجريان في القنوات المفتوحة وخاصة في النماذج الهيدروليكية . وبالتالي، فمن الضروري أيجاد قيم معامل الخشونة لماننك للقنوات المفتوحة سواء كانت طبيعية أو اصطناعية. في هذه الدراسة، هو محاولة معايرة قيم ماننك (n) عن طريق مقارنة ملامح سطح الماء المحسوبة مع البيانات المرصودة وذلك بتطوير نموذج هيدروليكي للجريان الثابت لشط الرميثة (العراق) باستخدام برنامج HEC -RAS تم معايره النموذج باستخدام بيانات مرصودة مقاسه لسنة 2014 . تم التوصل إلى توافق جيد باستخدام قيم (n= 0.023) للقناة الرئيسية وقيم (n= 0.04) لمنطقة الجوانب في القناة

الكلمات المفتاحية
معامل الخشونة , برنامج HEC –RAS معايرة , ملامح سطح الماء , شط الرميثة

*Corresponding author:
E-mail addresses: ameer.wisam2005@gmail.com

DOI:10.52113/3/eng/mjet/2016-04-01/09-13

Introduction

All hydraulic computations involving flow in open channels require an evaluation of the roughness characteristics of the channel and also it is one of the keys to successfully predicting water flow in channel networks . At the present state of knowledge, the selection of roughness coefficients for natural channels remains chiefly an art. Since , a direct determination of the roughness coefficient is almost impossible in studying natural river flows, including unsteady and steady channel network flows. Consequently , the ability to evaluate roughness coefficients for natural channels representing a wide range of conditions must be developed through experience. Various factors affecting the values of roughness coefficients were presented by (Chow, 1959). Accordingly, roughness estimation has attracted attention of many investigators . Because an estimation accuracy of roughness coefficients is of vital importance in any open channel flow study, among them Patro et al. , 2009 ; Usul and Turan , 2006 ; Vijay et al. , 2007 ; Parhi et al. , 2012 and Wasantha Lal , 1995 have calibrated channel roughness for different rivers for the development of hydraulic model for simulate open channel flows . Prafulkumar et al. , 2011 calibrated channel roughness for Lower Tapi River, India using HEC-RAS model. Prabeer et al. , 2012 in his study has attempted calibrated the channel roughness coefficient (Manning's "n" value) along the river Mahanadi, Odisha through simulation of floods using HEC-RAS . Luay et al. , 2013 has estimated the Manning's Roughness coefficient for Hilla River in Iraq through calibration using HEC-RAS Model . Ross Doherty , 2010 was calibrated the channel roughness for large number of semiarid rivers of Western Australia having variable channel characteristics for development of rating curves . Therefore , in the above context, there is a need to calibrate the channel roughness coefficient for Shatt Al-Rumaith in Al- Muthanna government (Iraq) , by comparing computed water surface profiles with observed data , using HEC-RAS model .

Study Area

Shatt al-Rumaith is a natural extension of the Shatt al-Hilla . Generally , Shatt al-Hilla is the main channel that branches from the left side of the Euphrates River just at the upstream of the New Hindiya Barrage . Hence , the water entering al Hilla River , crosses Hilla City, and then its takes a south course thereafter up to the town of al – diwaniya away to the al Hamz- al Shrqee. The case study for this research , Al-Rumaith river extending over a length of 30 km from al Hamza bridge to alnajame regulator . Muthanna Province depends solely on the Al- Rumaith River for maintaining all its water needs. Shatt Al- Rumaith through a system of branch canals and distributaries it irrigates an area of a bout(50000 ha.), all information are taken from Department of Water Resources, Al- Muthanna (Iraq) .

Steady Flow Water Surface Profile Calculations

The present version of HEC-ARS supports the calculation of one-dimensional water surface profile for steady gradually varied flow in natural channels or network of channels . Subcritical, supercritical, and mixed flow regime water surface profiles can be calculated .
So , water surface profiles are computed from one cross section to the next by solving the energy equation with an iterative procedure . The energy equation is only applicable when flow is steady gradually varied and flow is assumed to be one-dimensional . At locations where the flow is rapidly varied, the program switches to the momentum equation (USACE , 2008) .

Equation (1) and Fig. (1) illustrate the main computing process based on solution of one-dimensional energy equation and basic profile calculation, in steady flow (USACE , 2008) .

$$y_1 + \frac{\alpha_1 v_1^{2}}{2g} + z_1 = y_2 + \frac{\alpha_2 v_2^{2}}{2g} + z_2 + h_e ....(1)$$

Where:

y_1, y_2 : depth of water at cross-section, m.
z_1, z_2 : elevation of the main channel inverts, m.
v_1, v_2 : Averaged velocity at the section, m/sec.
α_1 , α_2 : is the weighted speed coefficient
g : gravitational acceleration,m/sec2.
h_e : head loss (the total energy loss) ,m.

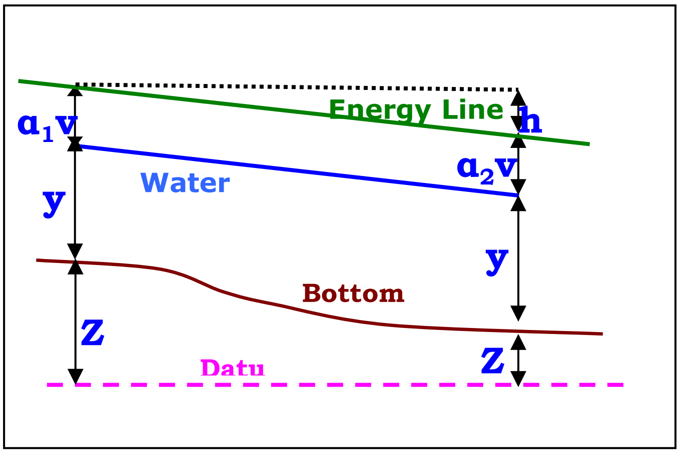

Figure 1. Longitudinal Section of Channel Reach

The energy losses are evaluated based on friction loss (Manning's equation), expansion and contraction . The head loss in a reach of length L may be calculated as :

$$h_e = L * \bar{S}_f + C\left[\frac{\alpha_1 v_1^{\,2}}{2g} + \frac{\alpha_2 v_2^{\,2}}{2g}\right] ......(2)$$

Where:

$\bar{S}_f$: Representative friction slope between the two sections.

C: Expansion or contraction loss coefficient

L : is the direction length

Al-Rumaith Steady Flow HEC-RAS Model Development

Today, computer models play a pivotal role in the hydraulic model development and hydraulic analysis . From many hydrologic software, HEC-RAS is a good choice for one-dimensional hydraulic calculations in natural and constructed channel systems . Fig. (2) shows the main menu of HEC-RAS model . A number of studies have showed that HEC-RAS is often suitable for providing a reliable reproduction of the flow simulation in natural rivers and streams (e.g. Horritt and Bates, 2002; Castellarin et al. 2008).

For present study , HEC-RAS requires several inputs for conducting flow simulation , the most important of which are; channel geometry and an estimate of channel roughness. The channel geometry includes the definition of the profile of the river channel in the study reach. This is primarily achieved by a combination of surveyed cross sections which longitudinally define the channel shape. Hence , the modeler develops the geometric data by first drawing in the river system schematic from upstream to downstream , as shown in Fig.(3).

The cross section data of the Shatt al-Rumaith used for the present analysis that extending over a length of 30 km were collected from the Department of Water Resources, Al- Muthanna / Iraq . Total 25 cross-sections at various important locations on the river have been used , each cross section is defined by a series of lateral and elevation coordinates, Fig.(4) shows the information required that has been displayed on the cross-section data editor . Once the geometric data are entered , the modeler can then enter the steady flow data .

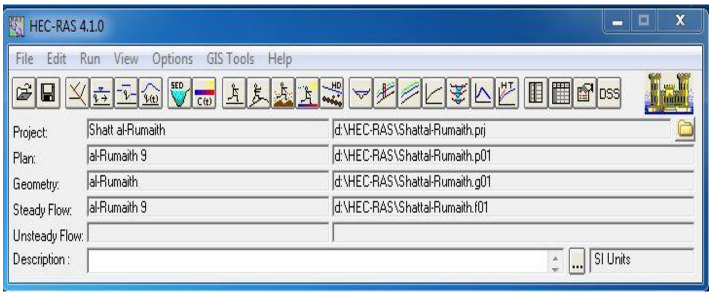

Figure 2. Main Menu of HEC-RAS model.

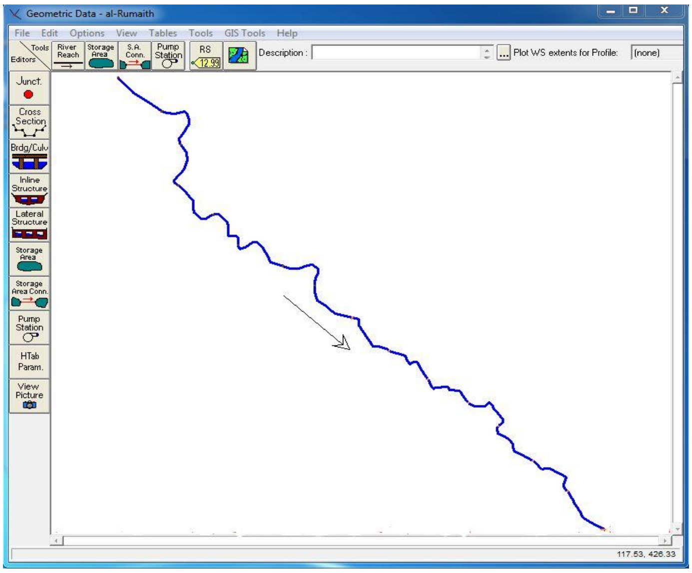

Figure 3. Input menu of geometrical data

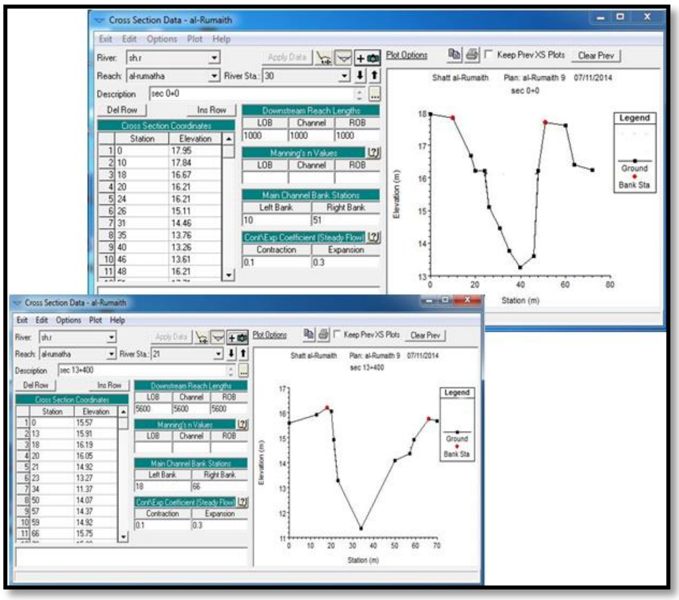

Figure 4. cross sections data editor

Al-Rumaith River HEC-RAS Hydraulic Model Calibration

Despite the various methods proposed , which published in the literature, but any studies to estimate roughness coefficients in Al- Muthanna are inexistent . Hence , this paper proposed a method to estimate roughness , the data pertaining to the flow for 2014 have been used for calibration of Manning's roughness coefficient, 'n'. On the basis of calibration process which are used to choose the appropriate value of (n) , it has been decided to use a model with two effective roughness values for the whole region (lower roughness values of the main channel are associated with high overbank Manning values). This is due to the presence of field crops, weeds located in the banks . Hence , in this research , it can be reasonably argued that the use of just two roughnesses may represent the heterogeneity of the region.

An n-value is first estimated based on Basic references for selecting the Manning (n) may be found in (Chow ,1959) , (Henderson ,1966) . For example , the value of (n) for natural rivers channels(Winding with shoals) is ranged from (0.033-0.04) (Henderson , 1966) . Hence, In this steady flow simulation model, the assumed values of Manning's roughness coefficient (n) for Al-Rumaith river range between 0.023 and 0.03 for channel and (0.03-0.04) for floodplain roughness , this is due to the presence of field crops, desert vegetation located in the banks .

In this study has been used the average difference, D, in the water surface is computed using,

$D = (\Sigma_{i=1,t} (Ei-Eci)^2/n)^{½}$

Where Ei is the measured water surface elevation, Ec is the computed water surface elevation at each cross-section i and t is the total number of sections. This metric represents the average vertical distance, over the study reach, that the computed elevation is above or below the measured elevation and provides an intuitive measure of the accuracy. So , the computed water surface profile is compared to the measured profile and D are determined.

Calibration on the shatt Al-Rumaith began and results of the model with these values of (n) are compared with observed water surface profiles . Note that the HEC-RAS run using the best user estimate of n is shown on Fig. 5 . For clarity, only the measured water surfaces and HEC-RAS calibrated are shown with different values of (n) . The average difference, D gives a clear view for these differences . Consequently, table (1) . provides the smallest values of D . Hence , the results of the steady flow HEC-RAS model show that the values of (n) is (n=0.023) for channel and (n= 0.04) for floodplain roughness give the closest agreement between computed water surface profiles with observed data .

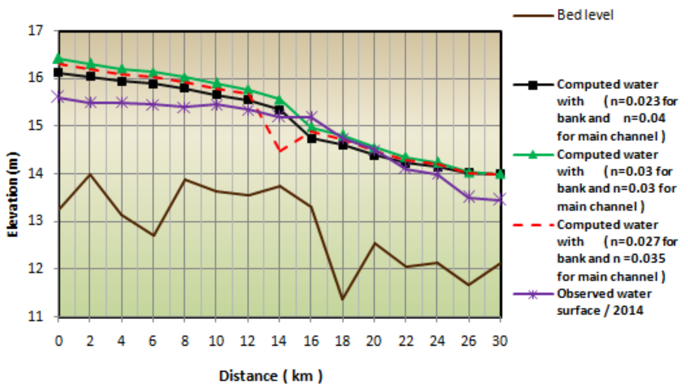

Figure 5. Water surface profiles for the Shatt al-Rumaith

Table (1) : The average difference, D

Description of site	n		average difference, D, in the water surface
	Main channel	Over bank	
	0.023	0.04	0.371
	0.027	0.03	0.5157
	0.03	0.035	0.4822

Conclusions

The purpose of this study is to assess HEC-RAS's ability to compute water surface profiles by comparing measured data with model results . Therefore , Steady flow HEC-RAS model is developed for Al-Rumaith River to predict the value of Manning's coefficient through calibration procedure . The average difference, D is 0.371m .

Hence ,the appropriate value of Manning's coefficient is (0.023) for channel and (n= 0.04) for floodplain roughness, since it gives reasonable agreement between computed and observed data .

Acknowledgements

I would like to express my gratitude to all the staff of the Department of Water Resources, Al-Muthanna , Iraq for their help .

Sincere thanks also go to engineers Faleh Abdelnaby Hassan and Ibtisam Hassan Mohamed jawad for their support during my stay at the Department of Water Resources .

Author is also grateful to the engineer Mahdi **Abdul Ameer** for his help .

References

1. A . M. Wasantha Lal, 1995 "Calibration of Riverbed Roughness," Journal of Hydraulic Engineering, Vol. 121, No. 9 , pp. 664-671.
2. Castellarin, A., Di Baldassarre, G., Bates, P. D., and Brath, A.2008" Optimal cross-section spacing in Preissmann scheme 1D hydrodynamic models", J. Hydr. Eng., 135(2), pp.96–105,.
3. Chow, V.T. 1959. Open-channel hydraulics. McGraw-Hill, New York.
4. Henderson, F. M. 1966 ,"Open Channel Flow", Macmillan Publishing Company ,New York.
5. Horritt, M. S. and Bates P. D. 2002" Evaluation of 1-D and 2-D models for predicting river flood inundation", J. Hydrol., 268,pp. 87–99.
6. L. K. Hameed and S. T. Ali 2013 " Estimating of Manning's Roughness Coefficient for Hilla River through Calibration Using HEC-RAS Model ," Jordan Journal of Civil Engineering, Volume 7, No. 1.
7. N. Usul and T. Burak,2006 "Flood Forecasting and Analysis within the Ulus Basin, Turkey, Using Geographic Infor- mation Systems," Natural Hazards, Vol. 39, No. 2, pp. 213-229.
8. P. K. Parhi, R. N. Sankhua and G. P. Roy, 2012 "Calibration of Channel Roughness of Mahanadi River (India) Using HEC-RAS Model," Journal of Water Resources and Protection, Vol. 4, No. 10, pp. 847-850
9. P. V. Timbadiya, P. L. Patel and P. D. Porey, 2011 "Calibration of HEC-RAS Model on Prediction of Flood for Lower Tapi River, India," Journal of Water Resources and Protection, Vol. 3, , pp. 805-811.
10. R. Doherty, 2010 "Calibration of HEC-RAS Models for Rating Curve Development in Semi Arid Regions of Western Australia," AHA 2010 Conference, Perth.
11. S. Patro, C. Chatterjee, S. Mohanty, R. Singh and N. S. Raghuwanshi, 2009 "Flood Inundation Modeling Using Mike Flood and Remote Sensing Data," Journal of the Indian Society of Remote Sensing, Vol. 37, No. 1, pp. 107- 118. doi:10.1007/s12524-009-0002-1
12. US Army Corps of Engineers, 2008 "HEC-RAS, Hydraulic Reference Manual," Hydrologic Engineering Center, Davis Version 4.0.
13. Vijay, A. Sargoankar and A. Gupta, 2007 "Hydrodynamic Simulation of River Yamuna for Riverbed Assessment: A Case Study of Delhi Region," Environmental Monitoring Assessment, Vol. 130, No. 1-3, pp. 381-387.