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RESEARCH ARTICLE

INVESTIGATE THE COMPLIANCE OF MIKE11 AND MUSKINGUM CUNGE METHOD FOR FLOOD ROUTING IN KARUN RIVER

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ABSTRACT

Flood as an unsteady gradually varied flow has special importance in river engineering. Because with knowing the exact range of water level variations in a certain location of river, we can make better decisions for decrease harmful effects of water on major structures and also prevent of their unreasonable services. Muskingum Cunge is one of the widely employed methods for flood routing that direct calibration of this method based on previous flood events is not required and the routing parameters are determined according to physical characteristics and hydraulic conditions of the stream. In this study we have compared the results of Muskingum Cunge as a simplified hydraulic method and MIKE11 model for Flood Routing in the reach between Mollasani to Ahwaz stations located at desired region of the mentioned river. The results of this study demonstrated successful performance of the simplified routing methods and showed that in situations where the availability of intensive data required by hydrodynamic model are limited, relying on such simplified method would provide satisfactory results. Based on comparison among the results of the employed method with that of the hydrodynamic one, the most suitable method for the studied condition is determined.

INTRODUCTION

One of the most important subjects in river engineering is flow routing analysis of rivers which passes through important areas. Flood routing analysis includes determination of flood hydrograph and water levels at different points of flow route. Flood routing in a prismatic open channel obtained by solving simultaneous equations of continuity and momentum which known for Saint Venant Equations. To solve these equations with analytical and semi analytical methods, some terms should be ignored. If inertia terms in Saint Venant equations removed, hydraulic equation with complete inertia will be converted to diffusive equation. Prediction the manner of flood uprising and its falling could be analyzed by flood routing. Although more hydrodynamic phenomena in rivers are Three-Dimensional physical phenomena, but when the flow followed certain path, One-Dimensional flow can be considered. Mathematical models are useful tool in analysis of river flow or hydraulic structures. Flood routing is a problem of great importance particularly in view of increasing urbanization near river channels. In the unobstructed river channels, storage characteristics of the flood plain strongly influence the flood behavior. The storage characteristics in turn depend on the detailed geometry of the flood plain.

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In many cases, the detailed topographical maps of the flood plain are not available so that the storage characteristics can not be directly determined. In such cases, it is attempted to establish a certain empirical relationship between the storage within the length of the river in which routing is to be performed, and the weighted flow determined from the inflow and outflow records. Such an empirical relationship is then used with the continuity equation to rout future floods [3]. In this paper, according to high performance of One-Dimensional models in river studies, solve the equations governing the river flow has been considered. One-Dimensional equations governing the river flow are known as Saint-Venant equations [2]. To solve these equations depending on simplifications and desired results various methods as approximate, graphical, analytical and numerical methods are presented. Some of these methods that were used for flood routing in the past are Kinematic Wave method, Analogical diffusion method, Muskingum method presented by Cunge (Cunge, 1969) and simple methods for reservoir routing [3]. A graphical conception of flood routing is shown in Fig.1. In this paper we used Muskingum Cunge method and MIKE11 model for flood routing in the mentioned reach of Karun River.

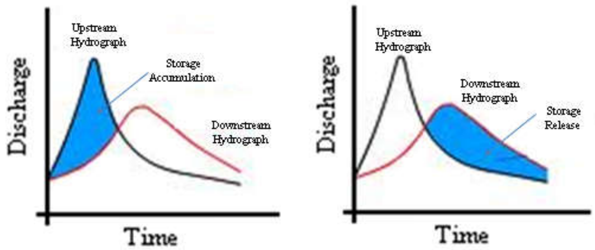

Fig.1 Routed flood wave showing storage accumulation and release

METHODOLOGY

The main concept of flood routing is that if we have flow condition at upstream boundary, how we can determine the hydrograph at specific point of downstream boundary [4]. As it's visible in Fig.1, the hydrographs at upstream and downstream boundary will not be same. Because the path characteristics that water flows on it will change the hydrograph shape.

II. A solution scheme in Muskingum Cunge method

As we mentioned before, in this study two different methods have been used. Governing equation of Muskingum Cunge method in open channel is given by:

$$\frac{\partial Q}{\partial t}+\frac{\partial Q}{\partial x}=D\frac{\partial^2 Q}{\partial x^2}+cq_{lat} \tag{1}$$

This method is derived from convection-diffusion equation that as we know is a simplification of fully dynamic equations. In other words Muskingum Cunge Method is based on a simplification of the conservation of momentum equation (convection-diffusion) and the conservation of mass. It is theoretically more accurate than simplified routing models based only on the conservation of mass. In this method routing coefficients (K, X) are determined from hydraulic properties of the reach and these coefficients are changing over the time [1].

II. B Solution scheme in mike11

The solution of the equations of continuity and momentum is based on an implicit finite difference scheme developed by Abbott and Ionescu (1967). The finite difference scheme used in MIKE11 (6-point Abbott scheme), allows Courant numbers up to 10-20 if the flow is clearly sub-critical (Froude number less than 1). A graphical view of this method showed as below [3]:

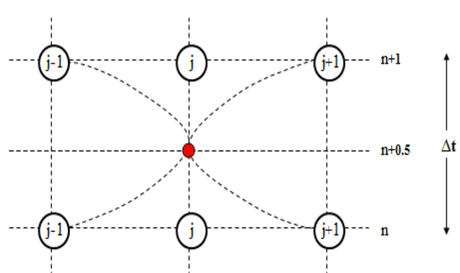

Fig.2. Centered 6-point Abbott scheme

As we can see, at n+1/2 step the model bring data from steps n and n+1, so unknowns will obtain simultaneously for each time step. MIKE11 model is fully implicit method to solve the problems and usually there is no limitation about computational steps [6].

Karun river

Karun River is only navigated River in the past that contain wide area of Iran. Its basin has been covered by provinces of Khouzestan, Lorestan, Charmahal Bakhtiari and Boyer Ahmad, respectively. Karun basin is located at middle Zagros folding and south of Karkheh river basin. Karun river length is about 890 KM and its basin included 66930 Sq. KM and only a little part of it including plain and foothill regions. This river has a large content of permanent flow. The annual water volume of this river is more than 24 milliard cubic meters and its instantaneous average discharge value is 736 cubic meters per second in measured data. The sedimentations of this river form Khouzestan plain and expand it [1]. One useful satellite picture from the case study zone is taken as follow as below:

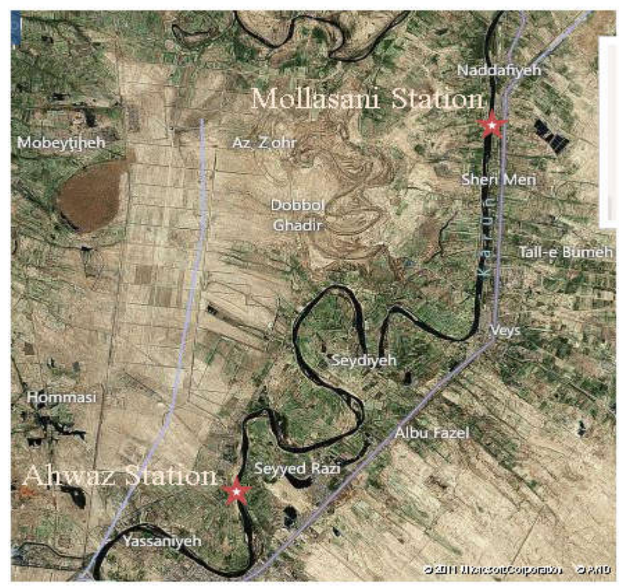

Fig.3. Satellite picture from the case study zone

Model run

After gathering the information of river network and cross sections in the reach between Mollasani and Ahvaz stations, about 61957 meter in length and 70 cross sections imported to MIKE11 software. The upstream boundary condition for Mollasani station that used in the model was flood hydrograph related to January sixth 1996. The downstream boundary condition for Ahvaz stations that introduced to the model is rating curve [2]. According to upstream hydrograph the model will calculate this curve at downstream. In the simulation process MIKE11 performed with approximate hydrodynamic conditions (Manning's n), after that the model calibrated by changing value of Manning's n insofar as observed and measured data reached to good agreement. Thus the average resistance factor in whole of reach was obtained 0.028 in value. In Fig.4 and Fig.5 results of model calibration have been shown.

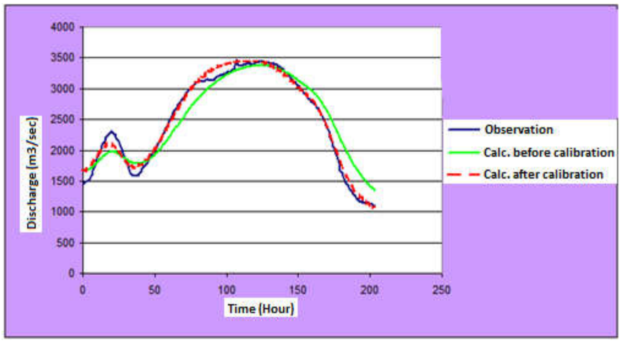

Fig. 4. Graphical results of MIKE11 calibration (a)

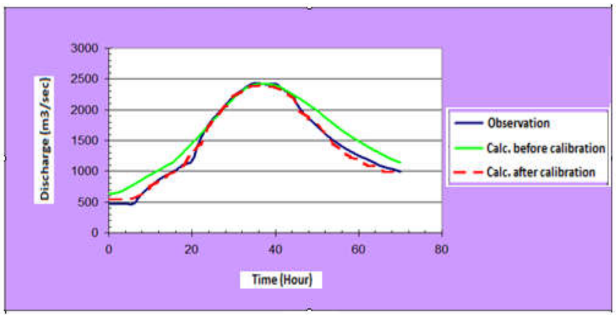

Fig. 5. Graphical results of MIKE11 calibration (b)

As we can see in Fig.4 and Fig.5, before calibration the model, observed and calculated hydrograph don't match very well, this means Manning's n incorrectly introduced to the model, but after calibration the mentioned hydrographs have more accurate status. After this step Flood routing was repeated by Muskingum Cunge method. Fig.5 shows results of Muskingum Cunge method and its reasonable agreement with observed data at downstream boundary condition.

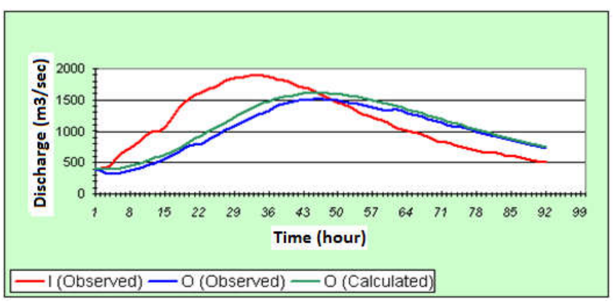

Fig.6. Results of Flood Routing by Muskingum Cunge method

As we can see in Fig. 6, the observed and calculated data has a good agreement in this method. The statistical analysis of MIKE11 model and Muskingum Cunge results were done and have been showed in Table 1.

Table1. Comparison of Statistical analysis results of MIKE11 model and Muskingum Cunge method

Performance Criteria	Statistical Analysis Results	
	MIKE11	Muskingum Cunge
STD	0.033	0.072773
R^2	0.94	0.901
MSE	0.001095	0.005597
RMSE	0.033083	0.074814
MAD	0.024449	0.054194
SSE	0.157608	0.805982
Min Absolute Error	0.000153	0.000426
Max Absolute Error	0.91739	0.23306

Very close to MIKE11 model. Thus for this reach of Karun river we can use both of these methods with high accuracy. The error distribution of Fully Dynamic method of flood routing that calculated by MIKE11 is shown as Fig.7.

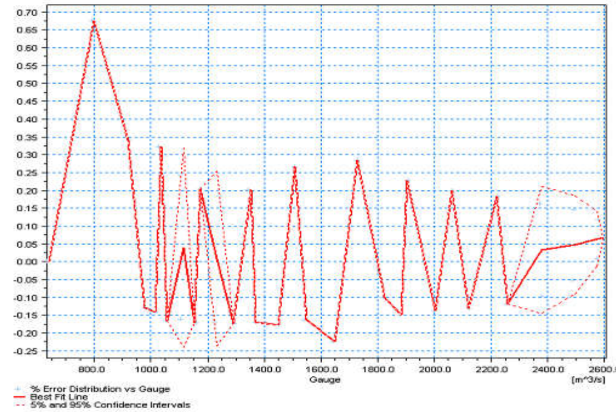

Fig.7. Best fit line in error distribution vs. gauge estimated by MIKE11

RESULT AND DISCUSSION

AS we can see in Fig.5 and Table.1, there is a good accuracy by selecting Fully Dynamic method for flood routing in this reach of Karun river By MIKE11 model. Obviously the calculated error of this method in this reach is acceptable. On the other hand, usage of Muskingum Cunge method as simplified one can be useful when observational data are insufficient. So ignoring inertia terms in Saint – Venant equations at the case study zone not seem to be unreasonable approximation. Thus Muskingum Cunge method can be used for flood routing between the reach Mollasani to Ahvaz stations of Karun River with high accuracy, and numerical solution, semi analytical and analytical schemes of this method are usable. According to Table 1. Performance of MIKE11 as a numerical model is higher than Muskingum Cunge method, because this model uses Fully Dynamic method for solving Saint -Venant equations. Unfortunately application of Muskingum Cunge method for Flood Routing In mountainous regions can lead to absolutely wrong results, because of wrong approximation of Flood storage in this regions and rapidly variations of momentum value [1]. So we recommend Fully Dynamic method for this reaches of river. The inherent mathematical diffusion of Muskingum Cunge method, with possible under prediction of downstream water levels, is a potential problem. It is tentatively suggested that the simplest and best way of solving flood propagation problems is to use the full equations with an explicit forwards-timecentred- space scheme [5]. The principal advantage of the approximate methods are that the Muskingum Cunge parameters can be directly estimated from the properties of the inflow and outflow hydrographs. Thus eliminating the need for trial-and-error and other types of numerical solutions. On the other hand, their accuracy depends on the reliability of the plotted hydrographs.

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REFERENCES

[1] Delphi M, 2010. Flood routing in Mollasani – Ahvaz reach of Karun River by using MIKE11 model and comparison with Muskingum and Muskingum-cunge methods. M.S. Thesis. Islamic Azad University – Shoushtar Branch. 150p.

[2] Delphi M, Shooshtari M. M. and Hassoni Zadeh H. 2010. Application of Diffusion Wave Method for Flood Routing in Karun River, Journal of Environmental Science and Development, 3p..

[3] Shooshtari M. M. 2008. Principles of Flow in Open Channels, Shahid Chamran University Press, 15(2), pp 643-745.

[4] DHI Group, 2009. MIKE11 Reference Manual.

[5] Ferrick MG. 2005. Simple wave and monoclinal wave models: river flow surge applications and implications. Water Resources Research, 41(W11402): 1–19.

[6] Fenton John D. 2010. Accuracy of Muskingum-Cunge flood routing, Institute of Hydraulic and Water Resources Engineering, 8p.

[7] Price, R. K. 2009. Volume-conservative nonlinear flood routing, *Journal of Hydraulic Engineering*, 135(10), pp 838-845.

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