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Scopus Compendex and Geobase Elsevier,
Geo-Ref Information Services-USA, List B of Scientific
Journals, Poland, Directory of Research Journals

International Journal of Earth Sciences and Engineering

www.cafetinnova.org

ISSN 0974-5904, Volume 09, No. 02

April 2016, P.P.833-837

Effects of Floods from Tributaries upon Backwater in the Stem Stream of the Yellow River in Inner Mongolia

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Abstract: Using mathematical model tool in this paper, numerical Flow Model is established according to the actual situation of the Inner Mongolia reach of the Yellow River [1-6]. The model verification and calculated results of tributaries inflow show that it can truly reflect flow regime of tributaries flow into the Inner Mongolia reach, and variation among related hydraulic elements. The model can be regarded as one of the research methods of the river planning and construction. Large discharges from tributary in the Inner Mongolia can change main-stream flow regime and water-level obviously. Flow direction Changes, water on the floodplain, backwater is the direct result, which should be paid high attention in the regional flood control planning and river regulation.

Keywords: *MIKE21, mathematical model, Inner Mongolia reach of the Yellow River, water movement.*

1. Introduction

Many tributaries and the process of tributaries inflow changes are the major feature of the Inner Mongolia reach of the Yellow River. The Inner Mongolia reach regulation is bound to consider the impact of tributaries inflow. At the same time, hydrological observation work of the Inner Mongolia reach is relatively weak, thereby lack of basic data can lead to bring difficulties for study of the Inner Mongolia Reach and carry out river regulation work. In view of the fact that many tributaries and lack of hydrological data, the mathematical flow model of the Inner Mongolia reach was established in this paper, according to the actual situation of the Inner Mongolia reach. At the same time, effects of floods from tributaries upon backwater in the stem is simulated by the model, simulation results provide technical support and reference for the river regulation.

2. Establishment of the model and deal with related problems [7]:

The Model establishment based on MIKE21 hydrodynamic calculation software package by DHI Company of Denmark, model control equation and its solution refer to reference [8], the software package has been widely used in the practical calculation of water conservancy projects [9.10].

Select typical reaches range from Sanhu Estuary to Zhaojunfen Station, the reach is transitional river, the river length of 126.4km, river width range from 2000 to 7000 meters, average width about 4000 meters, main channel width in the range of 500 to 900 meters, average width of 710 meters, the river longitudinal gradient is 0.12 per thousand, winding rate is 1.45. Triangular mesh is used to the calculation grid of the regional section, as shown in Figure 1. Interpolate grid node elevation by the terrain elevation data to generate three-dimensional terrain, as shown in Figure 2.Among which, tributaries trench topography is obtained directly by reference to the actual terrain scattered point data.

3. Model Verification

Due to the lack of area measured data, the model parameters are determined according to the physical model test data of Inner Mongolia reach. Compared the discharge of 1594m3/s under the constant flow of Sanhu estuary water level with observation data of the physical model. By determining the roughness of channel (n=0.013) after selections, the range of bottom land roughness from 0.02 to 0.03. Select the 5 points along the path (Figure 2), the results of numerical simulation and model test results are shown in Table 1. The maximum deviation of the difference among the five models of the two models is 0.131m, the results accordance with the requirements of the hydraulic calculation specification.

On this basis on which, the selection of a smaller constant flow 2100m3/s and a larger constant flow 632m3/s as a validation program, verify the results as shown in Table 3, table 2. Maximum deviations, the five measurement points of the two models, are 0.14 meters in the results of the water level under two kinds of difference of flow. Under different water level or discharge, the mathematical model test results of each water level observation point are in good agreement with the physical model test results. This shows that the model is more suitable to simulate the flow field in the simulation area.

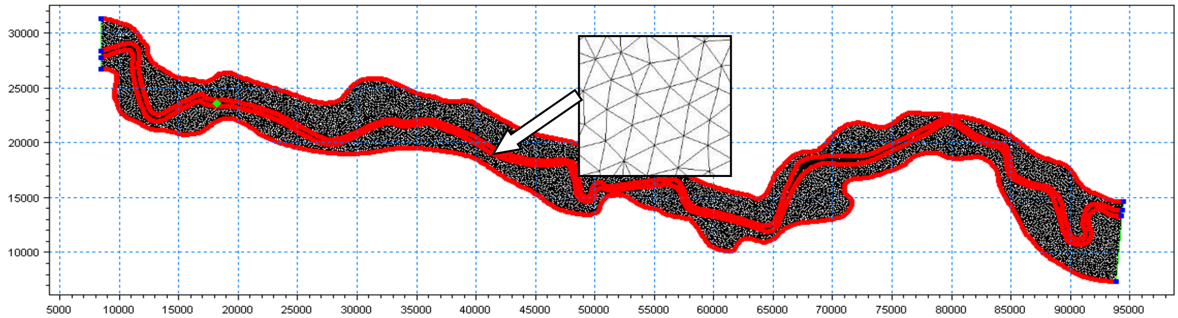

Figure 1: *Grid map of computational domain*

Figure 2: *Simulated domain of three-dimensional*

Table 1: *Comparison of surface elevation between numerical model and physical model*

location	Material model water level	Mathematical model water level	Deviation
Sanhu Estuary	1018.675	1018.59	0.085
NO.208 Risky section	1017.411	1017.28	0.131
Wulanshidui	1010.906	1010.96	0.054
Dabusu	1007.720	1007.59	0.130
Sanchakou Risky section	1006.626	1006.75	0.124

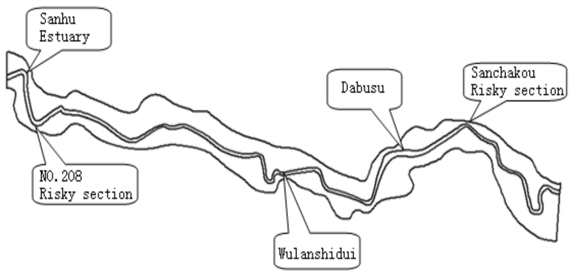

Figure 3: *Location of measurement points*

Table 2: *Comparison of surface elevation with discharge of 2100m^3/s between numerical model and physical model*

location	Material model water level	Mathematical model water level	Deviation
Sanhu Estuary	1018.675	1018.59	0.085
NO.208 Risky section	1017.411	1017.28	0.131
Wulanshidui	1010.906	1010.96	0.054
Dabusu	1007.730	1007.59	0.140
Sanchakou Risky section	1006.626	1006.75	0.124

Table 3: *Comparison of surface elevation with discharge of 632m^3/s between numerical model and physical model*

location	Material model water level	Mathematical model water level	Deviation
Sanhu Estuary	1016.464	1016.59	0.126
NO.208 Risky section	1015.157	1015.28	0.123
Wulanshidui	1007.989	1007.96	0.029
Dabusu	1005.477	1005.59	0.113
Sanchakou Risky section	1003.927	1003.79	0.137

Table 4: *Discharge of mainstream and branch*

Time (min)	Discharge of mainstream (m^3/s)	Discharge of Maobula branch (m^3/s)	Discharge of Xiliugou branch (m^3/s)
0~6650		0	0
6650~6800		1200	1500
6800~6930	800	5600	6600
6930~7070		2500	3000
7070~10690		2500	0

4. Model Application

The model application used calculation analysis of flow regime of tributaries inflow as the example. Flood process of the Maobula tributary happened in July 1989, floods from both the Maobula and Xiligou tributaries flow into the main-stream occurred at the same time, the flood peak discharge of the Mabula tributary is 5600 m^3/s, and Xiliugou's flood peak discharge is 6600 m^3/s. The floods of both tributaries have high peak flow, precipitous fall, the characteristic of short duration and the general characteristics; meanwhile have also a strong disaster, which is the most unfavorable situation since have the observed hydrological data. The model calculation based on the flood occurred in July 1989 and the process of water ladder type , the flow of tributaries as shown in Table 4, when the small water-discharge (Q= 800 m^3/s) in the intersection , the lower boundary with the relationship of water level and discharge at the downstream cross-section .

4.1. Effects of floods from tributaries upon backwater in the stem:

When the peak flood of the Maobula tributary flow into main stream, water level changes as shown in Figure 4, the positive value said rising water level in the figure, the blue area said the water level increased, marginally, the yellow area said the water level increased by a large margin. The maximum variation of main stream water level is 2.19 meters. When the inflow of tributaries happened, the water level is obvious changes near the confluence of upstream and downstream, which bring great pressure to flood control at the intersection.

Used the confluence of inflow of the Maobula tributary as the origin of coordinates, along the river to the upper reaches is negative, to the downstream is positive, and apply different minutes respectively mapped into the area of the water line as shown in Figure 5. In the diagram the horizontal coordinate is the length, along the distance from the river into the grand entrance. The ordinate is the water surface elevation. Extracted the 133th, 135th, 138th, 146th and 166th moment from the results of the model calculation with each 50 minutes, which were used to draw out five water surface lines of the Mabula tributary confluence at different time. As can be seen from the Figure 5.

(1) The inflow of tributaries have not happened at 133th moment, the discharge of main-stream is 800m^3/s.

(2) When the floods of tributaries began to flow into the mainstream at 135th moment, and caused water-level rise in the confluence of the main-stream and tributaries. Upstream backwater caused by the inflow water is not obvious, and the backwater region is small, backwater height is not very high.

(3) When the peak floods from tributary flow into the main-stream of the Inner Mongolia reach at 138th moment, water-level of the confluence is maximum value, and upstream water-level effected by flood backwater will reached the maximum value, influence region also reaches the maximum.

(4) In the process of 146th and 166th moment, the peak floods gradually spread to the downstream, the influence of the peak floods gradually weakened. The water level near the river mouth of the Maobulao tributary is gradually reduced to the status when tributaries do not flow into the main-stream of the Inner Mongolia reach.

(5) Consistent in water-level all the time from the river mouth of the Maobula tributary at about 9000m upstream, which illustrate that effects range of floods from tributary upon backwater in the main-stream from about 9000m to the river mouth of the Maobula tributary.

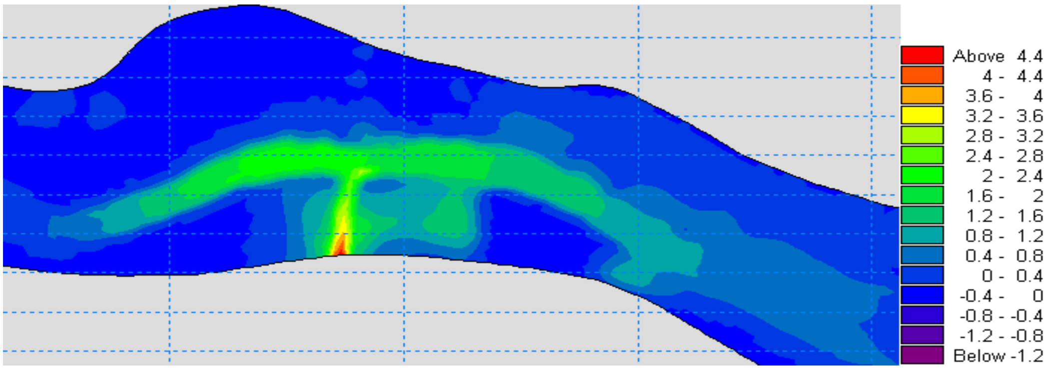

Figure 4: *Surface change after the inflow flood of Maobula*

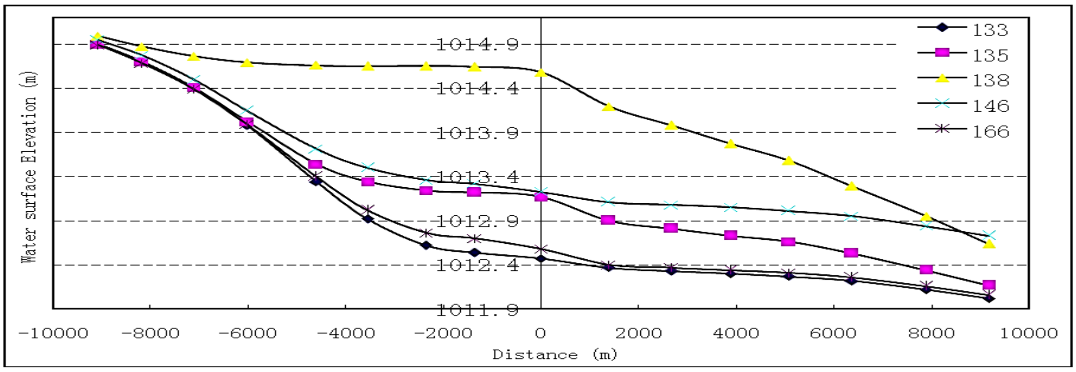

Figure 5: *Water surface profile change by inflow of the Maobula floo*

4.2. Effects of floods from tributaries upon flow fields in the stem:

Peak discharge of 5600m^3/s from Maobula tributary is seven times up the main-stream discharge of 800m^3/s, the stream have three features as follow, peak flood with high velocity flow, rise and fall of floods,a short duration of time. In the confluence area of main flow of the Maobula tributary, thereby the hydraulic conditions of the peak flood inflow have happened great change, compared with the original river under small flow hydraulic conditions, the flow fields have changed. There is no tributaries inflow condition, when the main stream discharge is 800m^3/s, the current in the main-channel. When the peak flood from tributary flow into main-stream, the calculation results of flow field in the inflow area are shown in Figure 6. Analysis of the flow distribution can be concluded:

(1) The peak flood flow into main-stream is divided into three flow zone, the main-channel and the both sides each have a flow zone, the flow on both sides of the bottom land will flow into the mainstream.

(2) Due to the flood backwater effect on the upstream of main-stream, flow near the upstream entrance door from the left on the beach.Upstream current flow on the left bottom land near the river outlet of Maobula.

(3) The current on the right bottom land of the Maobula tributary, which flow into main-stream near the downstream of the river outlet, thereby the regional current flow on the bottom land from the left to the right, and tend to the bank levee.

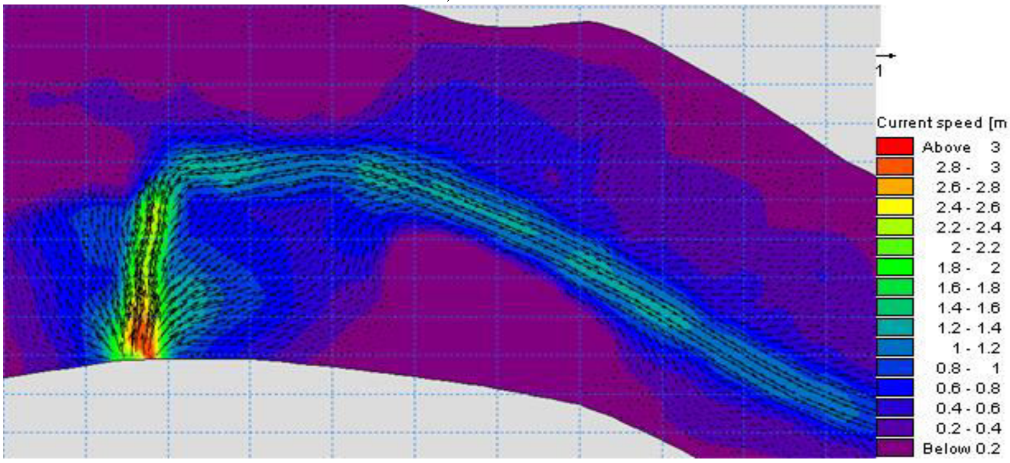

Figure 6: *Flow field of Maobula flood peak*

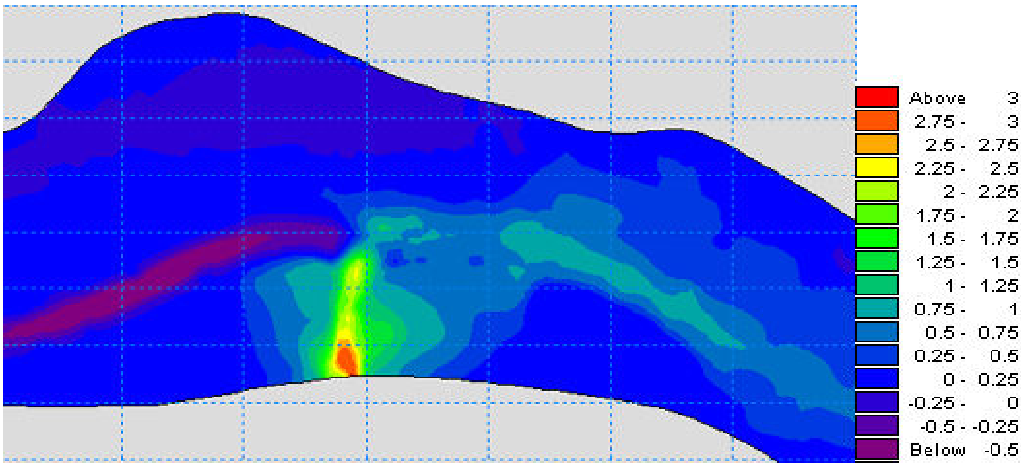

Figure 7: *Current speed changes after inflow flood of Maobula*

To reflect the flow field area changes of tributary inflow, with incremental velocity changes of which as an index. Draw out the distribution of the velocity change increment, as shown in Figure 7. Change areas from blue to red represent velocity increase (positive), blue area to purple area represent velocity reduction (negative) in the Figure. From the follow picture can clearly see that the inflow of tributaries make downstream flow velocity increased generally, the maximum value of velocity increased is 1.67 m/s; Upstream current speed decreased due to effects of floods from tributaries upon backwater in the main-stream, the maximum value of flow velocity decreased is 1.05 m/s.

5. Conclusion and Discussion

In this paper, the Mathematical Flow Model of the Inner Mongolia reach in the Yellow River is established by using the MIKE21 software.

Through the verification of the model and inflow of tributaries calculation results of the analysis show that, the model can reflect flow regime and changes in hydraulic factors relatively of inflow of the Inner Mongolia reach tributaries, which can be as one of the research methods of the river planning and construction.

Inner Mongolia reach tributaries flow into the stem will make the mainstream flow and water level change obviously, changes in the direction of flow, water flow on the floodplain, backwater level is the direct result , so regional flood control planning and river regulation should be paid attention to in this situation.

Due to the lack of the measured data and complexity of practical problems, calibration of model parameters also need large quantities of measured data; meanwhile, the inflow of the Inner Mongolia reach not only affect water flow state of the main stream, but also sediment deposition is a key problem in the evolution of river channel, and use the model simulated the process of high sediment concentration in a short time is difficult. This paper is only a preliminary attempt to study the river management of the Inner Mongolia reach, further work is needed in the practical aspects of the model.

6. Acknowledgements:

The study was partially supported by Open fund of Key Laboratory of Yellow River Sediment Research of Ministry of Water Resources (2015006) and the Support Plan for Young Talented Person with Scientific and Technological Innovation (70453).

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