A MORPHOLOGICAL NUMERICAL MODEL FOR AN WARPING AREA IN THE YELLOW RIVER BASIN

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ABSTRACT

In the period from 26th July to 26th August 2004, the Yellow River Conservancy Commission conducted a field experiment of warping on the floodplain of Libotan in the Middle Yellow River. Six experimental runs were conducted and monitored and so lots of data were acquired. With the data and the knowledge of flow and sediment transport in the warping area, the authors set up a numerical model for sediment transport in the warping area and investigated the critical problems involved in the modeling. With the data obtained in the first three runs, the model was calibrated and with the data obtained in the last three runs the model was validated. The validation results show a good harmony between the calculated values and the field data, and show its robust capacity in modeling sediment transport in the warping area. The established model provides a scientific support for large-scale warping experiments of the kind to be conducted in the near future.

1. 2004 FIELD EXPERIMENT OF WARPING IN THE MIDDLE YELLOW RIVER

In the period from 26th July to 26th August 2004, the Yellow River Conservancy Commission conducted a field experiment of warping on the floodplain of Libotan in the Middle Yellow River. Six experimental runs were conducted and monitored and so lots of data were acquired. The data helps to investigate flow and sediment transport, sedimentation, to improve the numerical model for the warping area, and to calibrate and validate the model.

2. IMPROVING AND CALIBRATING THE NUMERICAL MODEL FOR WARPING

The numerical model was an improved 1-D morphological model[1]by considering the features of flow and sediment transport in the warping area .

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2.1 Cross-sectional Hydraulic Geometrical Relationship in the Warping Area

The ground of initial warping area was flat and broad, and did not have any apparent channels on it. With sedimentation going on in the warping area, the cross sections in the warping area began to take steady geometrical relationships. With the data measured in the area, a hydraulic relationship between channel geometry cross-sectional geometrical index (width-depth ratio) and flow discharge was established in order to facilitate the simulating of the changing in geometry in the warping area as shown in Fig.1 .Correlation coefficient between the two factors is found more than 0.9, which indicates a good relationship between them, i.e.,

$$\frac{\sqrt{B}}{h} = 28.5Q^{0.45} \tag{1}$$

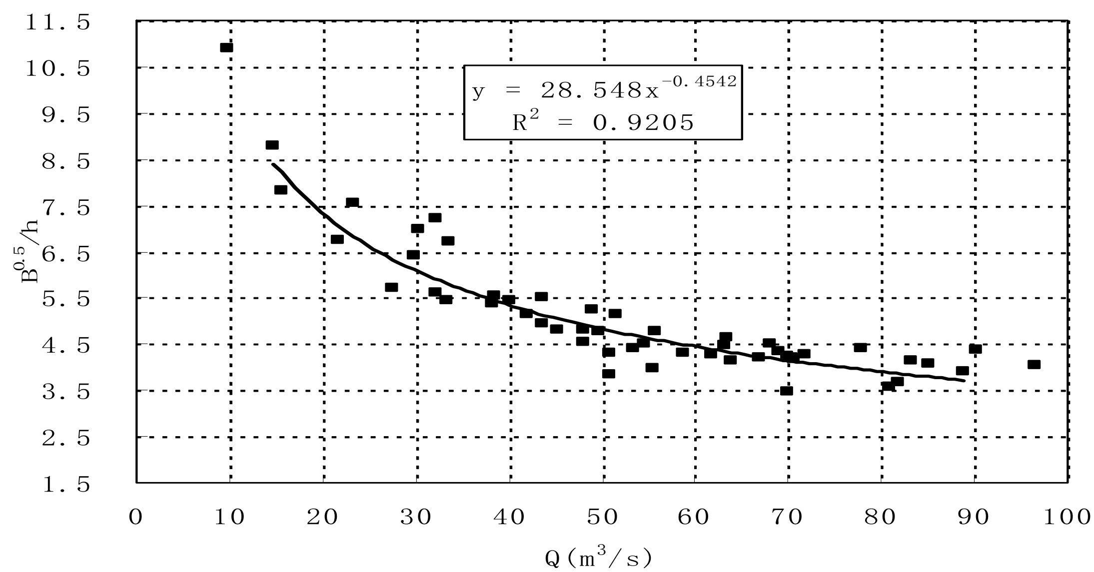

Fig.1 Cross-sectional geometrical index Vs flow discharge

2.2 Methodology for Calculating Sediment Particle Grading

Change in particle grading of the bed materials in the warping area affects directly sediment carrying capacity and sediment content down the flow course, so it is an important factor in reflecting the sediment transport in the warping area[2], for which the formula by Academician Han Qi Wei[3] is used.

$$P_{h,l} = \frac{P_{s,l}}{\lambda}\left[1-(1-\lambda)^{(\frac{\omega_l}{\omega_m})^{\theta}}\right] \tag{2}$$

Where θ is an empirical coefficient, l the number for the fractional grading of the suspended materials. $P_{h,l}$ average grading of the deposits, which depends on the grading of the suspended sediment at the entrance section, setting velocity (ω_l) of the fractional sediment, depositional effective falling velocity (ω_m) and deposition percentage λ .

2.3 Calibration of Parameters

With the above metioned formulas, a previous numerical model was modified. Then with the data obtained in the first three experimental runs, the parameters of the model were calibrated. The calculating time step was taken as 6 hours and the flow was taken as a steady flow. After the calibration, the coefficient for non-equilibrium transport recovery to saturation was found to be 0.14, θ =0.65, roughness for channel and floodplains 0.016 and 0.025 respectively

3. VALIDATION OF THE MODEL

With the data obtained in the last three runs in the 2004'warping experiment, the model was validated. The calculating time step was taken as 6 hours and the flow was taken steady.

Table 1 shows the values of calculated and measured sediment contents down the flow course in each experiment run. It shows that the calculated sediment contents change down the course in a similar way as the measured ones. And the twos are close to each other in values. Fig.2 shows a good agreement between the calculated and measured suspended sediment grading at the cross section (CS) Q12.

Table 1 Calculated and measured sediment content at various sites.

Run	Object	Hour	Flow (m^3/s)	Concentration (kg/m^3)						
				Q10	Q11	Q12	S4	Q13	Q14	Q15
4	Measured	110.5	49.4	126.1	151.6	90.7	53.8	79.8	59.2	24.0
	Calculated	110.5	49.4	126.1	114.1	96.7	62.4	86.0	58.6	22.0
5	Measured	100.6	67.9	44.5				34.2	27.8	15.1
	Calculated	100.6	67.9	44.5	41.9	39.3	36.3	33.5	30.5	14.7
6	Measured	20.9	69.3	37.0				29.5	19.2	19.8
	Calculated	20.9	69.3	37.0	35.8	34.8	32.9	29.5	22.4	19.0

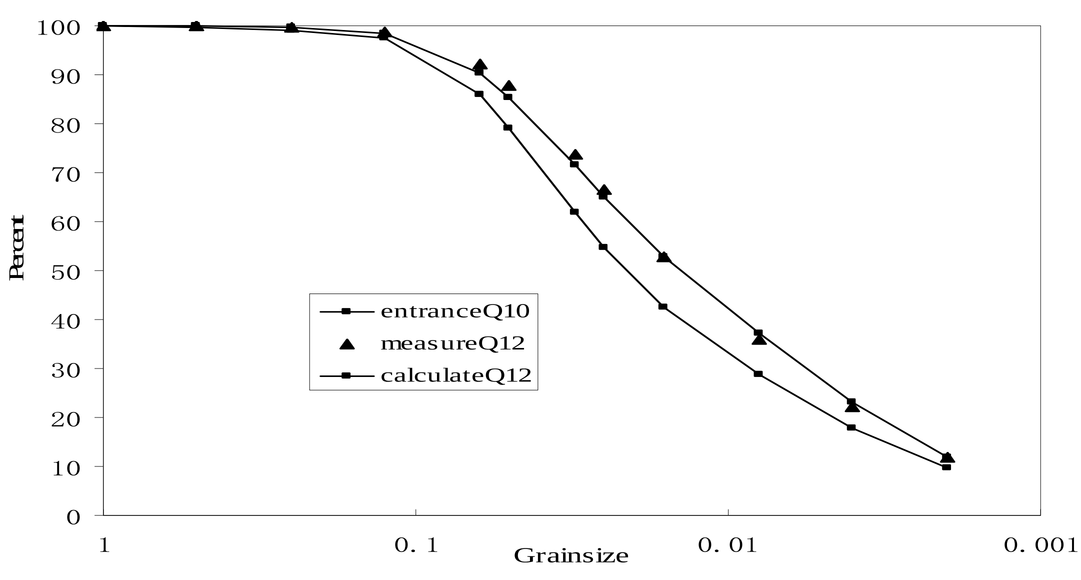

Fig.2 Calculated and measured suspended sediment grading

With the measured data of the suspended sediment grading, sediment content, and deposits grading at the neighboring cross sections, a comparison between the measured mean particle size (D_{50}) of the deposits at a cross section and the calculated value (Fig.3), which shows the points are distributed around the 45-degree line despite a little disperse .

Fig.4 shows changes in the calculated and the measured D_{50}s down the flow course, which demonstrates nearly same spatial change patterns, and the calculated and the measured values are close to each other. It indicates the modification to the methodology for bed material grading has improved the model performance in modeling the grading of the deposits in the warping area.

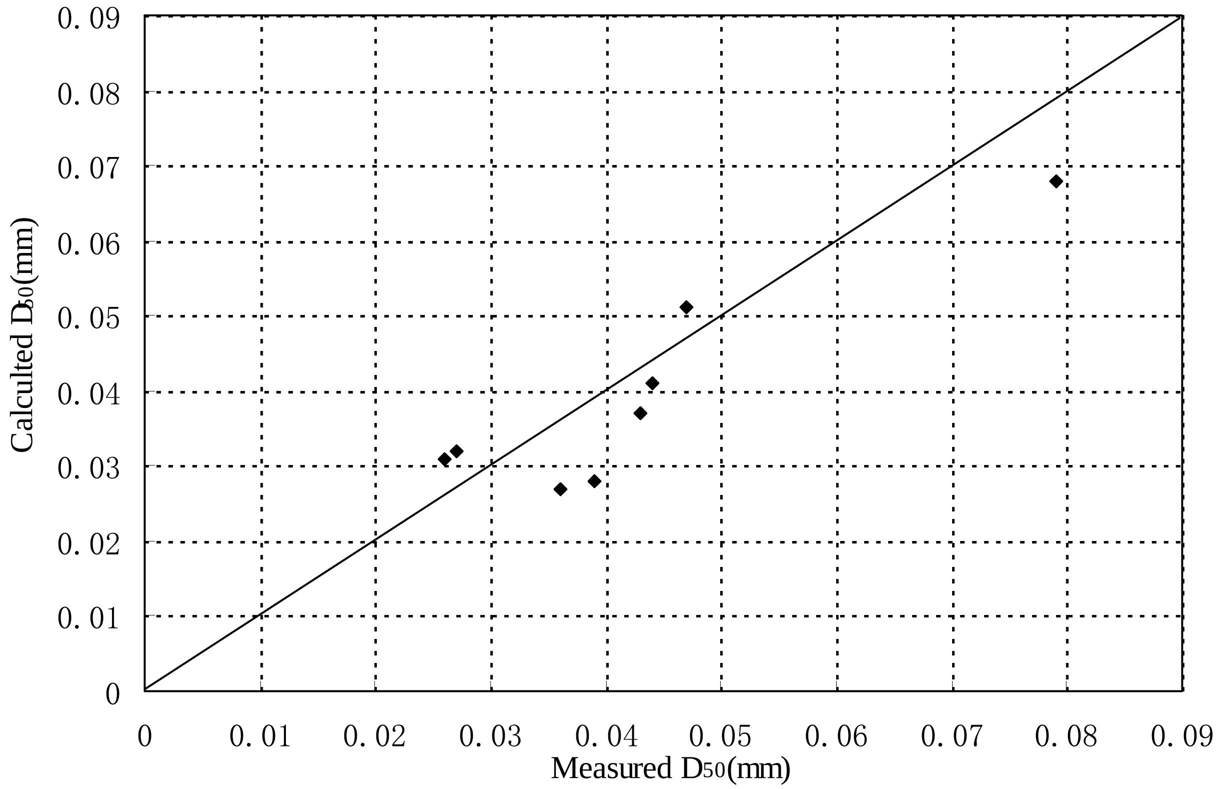

Fig.3 Comparison of calculated and measured D_{50} of the deposits

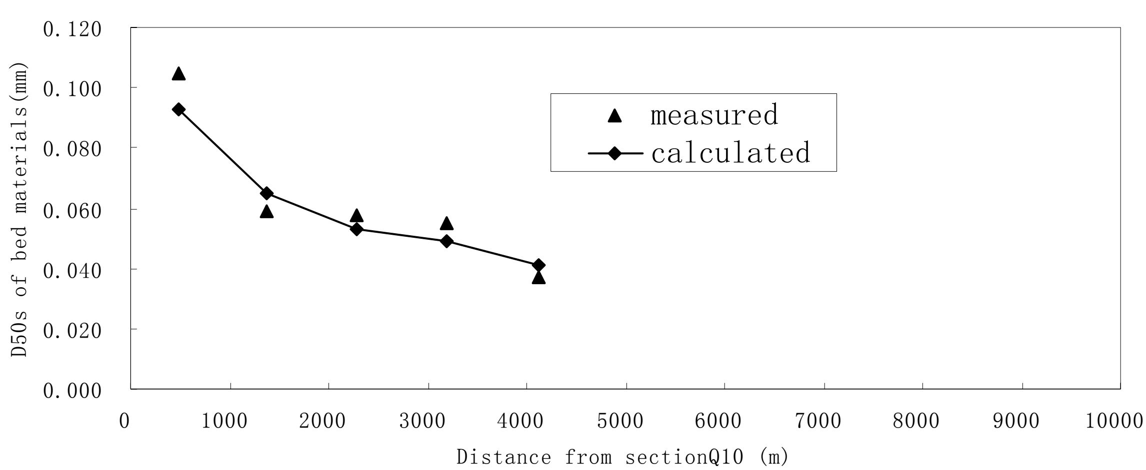

Fig.4 Calculated and measured D_{50} of bed materials down the course (Run No.3)

Fig.5 shows the calculated and the measured longitudinal profiles after warping. It shows a good agreement between the twos, and that the calculated and measured cross-section adjusting processes are close to each other. It justifies that the methodology for simulating the cross section forms is reasonable and that the model is able to do a better job of modeling the cross-section adjusting processes.

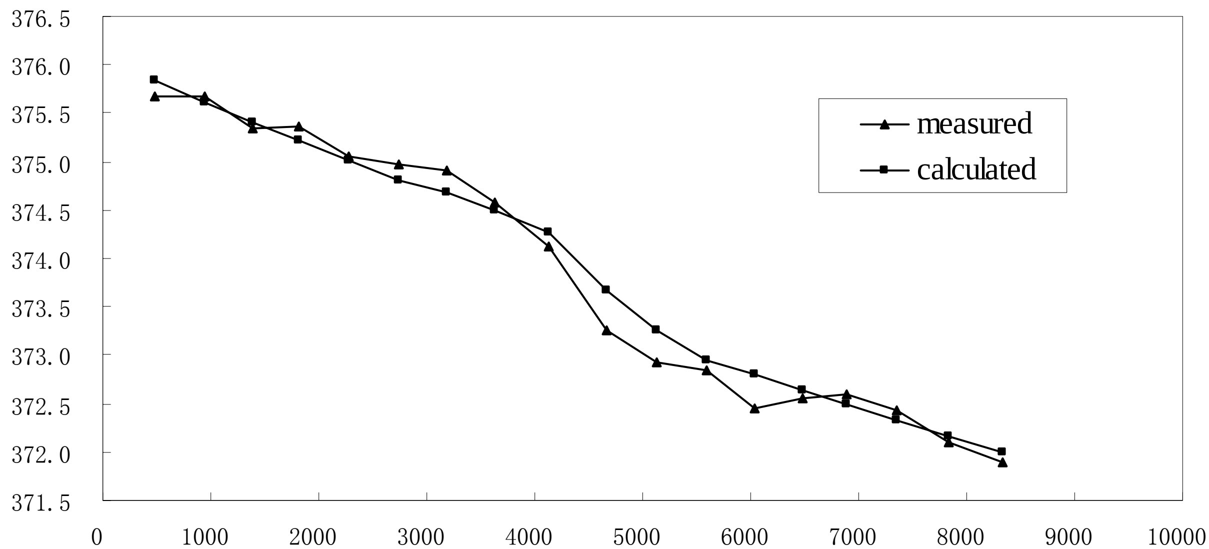

Fig.5 Calculated and measured longitudinal profiles after warping

4. CONCLUSIONS

(1) The data, measured in the field warping experiment in the Middle Yellow River, provide a systematic and complete data set, which help to improve the numerical model for the warping area and calibrate the parameters, and serve as a fundamental data source for improving numerical models.
(2) With the improved methodology for calculating the cross-section forms in the warping area, the model can do a better job in modeling the cross-section adjusting processes.
(3) With the improved methodology for calculating the grading of the bed materials in the warping area, the model can do a better job in modeling the changes in grading of the deposited materials in the warping area.
(4) The improved numerical model can do a better job in modeling both the changes in sediment content down the flow course and the law governing the deposition distribution in the warping area. All indicate that a numerical model has been established for the warping area in the Yellow River.

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