# NUMERICAL CALCULATION FOR BEDLOAD DISTRIBUTION IN MEANDERING CHANNEL

Hokkaido University Student Member ○Chang-Lae JANG
Hokkaido University JSCE Member Yasuyuki SHIMIZU

## 1. INTRODUCTION

The changes in river morphology don't occur independently, because water flows, bottom topography, bank erosion, sediment characteristics, and the roughness are mutually interrelated. And understanding the processes and mechanisms of channel morphology induced by such influences and responses quantitatively is very important for river engineering purposes to manage rivers and prevent disasters from flood. Numerous attempts to estimate channel changes caused by aggradation or degradation of the riverbed with mixed grain size for fixed banks have been developed (Ashida et al.,1991; Sun et al.,2001). Numerical models to calculate temporal and special changes in the channel with uniform grain size considering the bank erosion were proposed(Shimizu et al.,1996; Nagata et al.,2000). However, the existing literature mostly concentrates on the mixed grain size with fixed bank or uniform sediment with bank erosion, while, on the contrary, the interaction of mixed sediment and bank erosion simultaneously is distinctive feature of natural rivers. In this paper, a numerical model is proposed to simulate the channel deformation and bed load distribution in time and space simultaneously in the meandering channel as a preliminary study to develop a computer model for calculating the sediment characteristics and bank erosion simultaneously in alluvial channel. And this model was verified with laboratory experiments by Ashida et al.(1990).

## 2. NUMERICAL CALCULATION

A generalized coordinate system was used to calculate water flows, and the riverbed changes. At first, continuity and momentum equations for a two-dimensional shallow water flow were employed to calculate water flows. Momentum equation was separated into two parts, advection phase and non-advection phase, using the operator splitting method. Advection phase was calculated by the CIP method, and non-advection phase was computed by the central difference method. The bed load transport rate was calculated by the Ashida-Michiue's(1971) formula, and the sediment size fraction is calculated by the sediment continuity equation per bed material size fraction in the generalized coordinate system proposed by Hirano(1971). To calculate bed load transport rate in the transversal direction to primary flow in the meandering channel, secondary flow due to centrifugal force and the slope in the transverse direction was considered.

## 3. CALCULATION RESULTS

This numerical model was applied to reproduce laboratory experiments of a meandering channel by Ashida et al.(1990) for the purpose of validation. The experiment was conducted in the initial sine-generated-meandering channel with the maximum angle of $35^o$ on the initial channel slope I of 0.009. The meandering length, L, was 220cm, and the channel width, B, was 20cm. Water discharge Q of 3.6(l/s) was maintained, and the channel bed consists of bed materials with mean diameter $D_m=1.7mm$, and $D_{90}=4mm$. Fig. 1(a) is the bed load distribution in mean diameter after experiment, and the bed materials are finer at the inside near the bend apex than at the outside. Fig. 1(b) shows the channel bed deformation, and the bed is degraded at the outside covered with coarse materials, and aggraded at the inside with fine bed materials. Fig. 2(a) is the calculation results of the sediment sorting. The bed changes are shown in Fig. 2(b). And these simulation results are quantitatively agreement with the experimental results. Fig. 3 is the calculation results of the bed changes in the natural shaped-channel with uniform bed materials. Fig. 4 is the results of the bed changes and the bed load sorting in the channel with non-uniform bed load. The calculation conditions are that the initial channel slope I is 1/161, the bed is composed of mean diameter, $D_m=1.1mm$, and $D_{90}=1.8mm$ . Water discharge Q is 1.5(l/s). This calculation results show that the bed with uniform bed load is deeper than with

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Address: 160-8628 Kita-13, Nishi-8, Kitaku, Sapporo, Hokkaido, TEL 011-706-6198

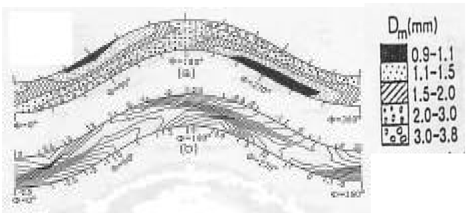


Fig. 1. Experimental results by Ashida et al. (1990).
; (a) bed load distribution ( mean diameter ),
(b) channel bed deformation in equilibrium state.

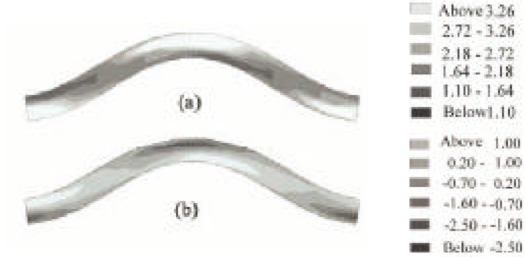


Fig. 2. Calculation results
; (a) bed load distribution ( mean diameter ),
(b) channel bed deformation in equilibrium state.

non-uniform bed load. The bed is scoured deeply in the outside of concave part and narrow width (Fig. 3(b)), and also flow velocity is large (Fig. 3(a)). Fig. 4(a) is flow velocity, Fig.4(b) is bed load distribution, and Fig. 4(c) is bed deformation. The bed with uniform grain size (Fig. 3(b)) is scoured deeper than with non- uniform grain size (Fig. 4(c)), and this is relatively similar to the experimental results by Ashida et al. (1990). As time progresses, the point bar shows up in the inside near the bend, and the bed materials are finer. Although there is no available data to compare the bed deformation and bed load distribution in space and time, the simulation results show relatively good trends.

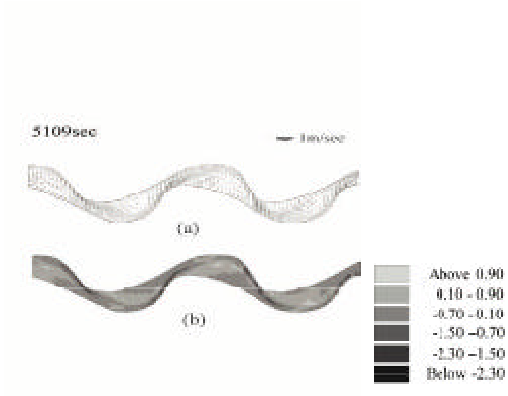


Fig. 3. Calculation results in the natural shaped-channel with uniform bed load ;(a)flow velocity distribution (b) bed load distribution

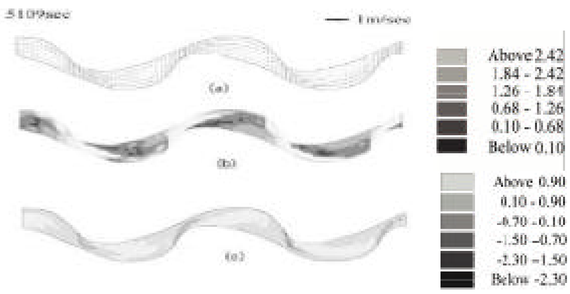


Fig. 4. Calculation results in the natural shaped-channel with non-uniform bed load; (a) flow velocity distribution (b)bed load distribution, (c) channel bed deformation

## 4. CONCLUSIONS

In this paper, a numerical model is proposed to simulate the channel deformation and the spatial and temporal distribution of bed load simultaneously. The simulation results are compared with laboratory experiments of a meandering channel by Ashida et al. (1990) and are quantitatively agreement with the experimental results. In the natural shaped-channel, the results of the bed changes and the bed load sorting in the channel with non-uniform bed load show the characteristics of natural river with non-uniformity materials, although their applicability was not verified. In the future a numerical model has to be developed considering the sediment characteristics and bank erosion simultaneously in the meandering channel.

## 5. REFERENCES

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