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Applications in New River-meander Model

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ABSTRACT

If the sediment transport behaves as bed-load, the sediment surface at meandering channel will deform into transverse waves. This investigation is a new model for prediction of river-meander models in nature. The aim of this research is to give a precise method whose bed forms can have a variety of scales ranging from ripples through small dunes to fully developed dunes or sandwaves. Its mathematical model will be investigated.

1. Introduction

Using momentum equation and continuity equation in previous researches an important model for evaluation of meandering models was developed. From a stability criterion for sediment particles on the stream bed another mathematical model is used to predict the damped oscillating system at the meandering boundary layer. The stability of the system is predicted by forcing upon it a traveling, small-amplitude alignment wave. The changing rate of the amplitude is predicted by observing the bottom wave and the change in channel bottom through a bank-moving similarity. The depth and velocity distributions are determined for the change of migration in meandering width with a certain lag, which corresponds $\gamma L/2\pi$ for velocity and $\Phi L/2\pi$ for depth where γ and Φ are corresponding phase angles. It is assumed that the bank

sediment transport depends on the same phase like velocity where the wavelength in boundary layer formations λ has nearly the same value as the L . In new model it is predicted^[1]:

- (1) Channel migration direction and migration expenditure value,
- (2) Dominant meander wavelength and phase shift,
- (3) Depth and velocity distribution of discharge in meandering boundary layer.

Values for input corresponds^[2]:

- boundary layer slope S ,
- width b ,
- centerline depth d ,
- median grain size D ,
- friction factor f ,
- meander wave-length λ which was taken as twice the distance from crossover to crossover, and bank-erosion

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constants.

2. Model

There are some research for model verification of field data and of the formulas and graphs where the computing of dominant migration wavelength and phase shift enables^[3]. In this model the erosion rate and boundary layer accumulation is depending to the change in curvature with a certain shift, which gives $\gamma L / 2 \pi$ for erosion rate and $\Phi L / 2 \pi$ for boundary layer height where γ and Φ are the corresponding phase angles^[2]. In the new boundary layer model it is assumed that boundary layer erosion is given with the same overlapping as velocity where the ODG model gives that the bank sediment transport phenomena can be seen with the same lag as depth. In this model the meander wave-length λ is given twice the distance from crossover to crossover. It is given the suggested wave-length as^[2],

$$\Lambda = 2 \pi B \quad (1)$$

where Yalin (1971) proposed that channel migration could be given with the law of the spatial correlation among perturbations in mixing length of channel flow^[4]. There are also observed macroturbulent eddies, presumably secondary flow cells which produce some roughness frictions against the flow accumulation. In a normal curvature which means that the channel has a constant curvature radius and has the straight boundary layer, it is more simple to calculate the velocity and depth values^[6,7].

3. Verification

In the previous literature it is very difficult to verify field data for testing of the different relationships and graphs which enables to predict migration wavelength and phase shift. There are many data observations on river meandering phenomena, however, as was observed also by Blondeaux and Seminara (1985), most of the data are incomplete because of insufficient evaluation about migration phenomena conditions where there is no information about channel slope and discharge^[3]. Computed migration wavelengths λ are given against dominant wavelengths, λd ^[4]. Parameters are:

m = power law exponent,

$\kappa(8/f)^{0.5}$ = it is given as power law,

κ = von Karman's constant (= 0.4)

F_{Dc} = Froude number of particle densimetry, is given as $U_{mean_c} / (\Delta g D)^{0.5}$,

U_{mean_c} = centerline-depth averaged flow rate,

Δ = specific weight of submerged sediment = $(\rho_s - \rho) / \rho$,

ρ and ρ_s = density of fluid and sediment,

g = acceleration of gravity

The value of B approximated nearly to six unless a larger number is obtained by evaluating B using some parameters^[8,9]:

(1) A largest possible transverse bed slope of two times average boundary layer height which is divided by width

(2) Needs some evaluation about sinuosity, width, depth, flow rate, and grain size.

By observing the graph for data plotting $\alpha = 0.4$ is noted which is given as transverse-mass flux constant. As a result the scatter of the data graphs gives agreement with the other evaluated data^[10,11]. It is given that the distribution of the evaluation observed points shown in the line of enabling agreement is approaching but less than that given by the observations of Ikeda et al. (1981) which shows good agreement^[12]. This approaching has only one reason which is given as in the earlier studies as observations that fixed values of B without considering whether the flow depth in the channel was enough to accommodate the corresponding transverse bed slope^[13]. The evaluated observations is taken in this research from prototypes in natural rivers. The data are complete in the condition that channel-forming flow conditions are chosen. Details of the data - evaluation conditions are proofed in an previous chapter^[14]. The distribution conditions of meander wavelength which is taken as twice the distance from crossover to crossover in plan-section, is observed to change from roughly six times the width to nearly 31 times the width, with a mean of the order of 13^[15]. By using transverse bed gradient and mixing length of $B = 6$ and $\alpha = 0.4$, and the overall-average bank-full discharge evaluation of $b/d = 20$, $F_{Dc} = 13$ and $m = 5$, the dominant and most seen wavelength which is observed by this assumption if the ODG bank-erosion model is given as proof^[16] where the IKEDA model conditions are also added^[16]. The group distribution of wavelengths of channel migrations are in changing from less than $6b$ to more than $31b$. By using $B = 7$, $\alpha = 0.4$, and the boundary layer's average discharge values of $b/d_c = 41$ and $F_{Dc} = 8$, and $m = 2.92$, the most predicted wavelength shows the same property as the observed average distance of wavelength in boundary layer^[17].

Different conditions in occurrence of migration rates is dependent by a comparable distribution in length from crossover at $s = 0.1$ to first outer - bank erosion condition s_e ^[17]. The distance in the migration bends ranges from about 0.10 to about 0.47 times the meander migration length. The model distance is shorter than the one-quarter of a wavelength. If bank sedimentation rate is dependent by different discharge rates and here the parameters should be in a close relationship between s_e and phase shift

between either curvature and boundary layer topography Φ and migration and discharge γ [17] which shows good agreement with the mechanism of controlling bank sedimentation. This bank erosion cannot be the same of s_e , the phase shift is a good proof for outer-bank sedimentation which can be observed firstly at the downstream from a given migration plan point. The distance s_e for the most observed meander migration rate would then be estimated by the Φ_d and γ_d distributions [16] as,

$$(s_e)_d = \gamma_d L_d / 2\pi \quad (\text{IKEDA MODEL}) \quad (2)$$

or

$$(s_e)_d = \Phi_d L_d / 2\pi \quad (\text{ODG MODEL}) \quad (3)$$

where the index d = a variable of the most observed migration rate [16]. By putting as before, $B = 7$, $\alpha = 0.4$, $b/d = 20$, $F_{De} = 14$, and $m = 13$, the evaluated $(s_e)_d$ is 0.13, $L_d \approx 0.15L_d$, which is smaller than the computed model distance of $0.3 L_d$. The given length is maybe correct [16].

4. Discussion

In observing the meander migration lengths the phase lag between the meander form and discharge rate is realistic that has small importance in the collection of data by meandering occurrences of individual meandering formation.

5. Conclusion

The outer-bank sedimentation rate can be plotted as a function of migration rate which is computed as twice the length from crossover to crossover of planform meander occurrences. Here the lengths are without dimension by dividing in plot through the migration distance L , which is computed along the boundary layer symmetry axis. It is observed that migration plan forms with a large λ/b ratio show length to first outer-bank sedimentation location phenomena of less than $0.27 L$.

The new equations for prediction of γ [16]:

$$\Gamma = \arctan \Gamma = \arctan \left(\frac{e1}{e2} \right) \quad (4)$$

and

$$\Phi = \Upsilon - \arctan \left(\frac{bk}{a1} \right) \quad (5)$$

where $k = 2\pi/\lambda$, $e1$ and $e2$, $a1$ are constants which are dependent on the boundary layer sediment material (Figure 1).

6. Result

The point of the bend migration locations gives the correct phase shift associated with boundary layer disturbances which is a proof for the outer boundary layer sedimentation in the prototype of a flume which shows a good agreement with the phase difference with discharge rate at least as long as a transverse boundary layer gradient factor of greater than 7 if it is used. A comparison is given between measured and computed discharge rates of meander bend. The computed discharge velocity are predicted as the mean amplitude growth velocity and the n-component of the wave distribution at crossover.

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