TREATMENT OF SUSPENDED SEDIMENT IN SIDE BANK REGIONS

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1. INTRODUCTION

Riverbed evolution takes place through erosion-deposition processes. In suspended sediment dominated rivers, erosion is the main source term for sediment within a flow body. The erosion depth is measured by the depth normal to the bed surface. On the other hand deposition rate is treated usually using fall velocity and sediment concentration at a reference level. Therefore, it is recommended to modify erosion-deposition terms in governing equations when we treat the river bed evolution in the reach with dominant suspended sediment. Present study is to investigate an influence of modified erosion term on erosion-deposition process using simplified flow field.

2. METHODOLOGY

Generally, the depth-integrated form for mass conservation of sediment in flow body and mass conservation equation of bed sediment without bed-load terms are described using Cartesian coordinate system, respectively as follows.

$$\frac{\partial \bar{c}h}{\partial t}+\frac{\partial r_1 \bar{u}\bar{c}h}{\partial x}+\frac{\partial r_1 \bar{v}\bar{c}h}{\partial y}=\frac{\partial}{\partial x}(h\in_x \frac{\partial \bar{c}}{\partial x})+\frac{\partial}{\partial y}(h\in_y \frac{\partial \bar{c}}{\partial y})+\frac{1}{1-\lambda}(E-D) \quad (1)$$

$$\frac{\partial z_b}{\partial t}+\frac{1}{1-\lambda}(E-D)=0 \quad (2)$$

Where, $\bar{c}, \bar{u}, \bar{v}$: depth averaged sediment concentration, x-component of velocity and y-component of velocity. $\in_x$, $\in_y$ are components of dispersion coefficient. h: flow depth, E: erosion rate of sediment, D: deposition rate, λ: porosity and r_1: is the correction factor.

Sediment erosion and deposition are defined usually as those shown in Fig. 1, which is explained in Introduction. Referring to definition shown in Fig. 1, the erosion term of equations (1) and (2) should be described as $E/(\cos\beta)$ instead of E in present coordinate system. Equations (1) and (2) are modified as follows.

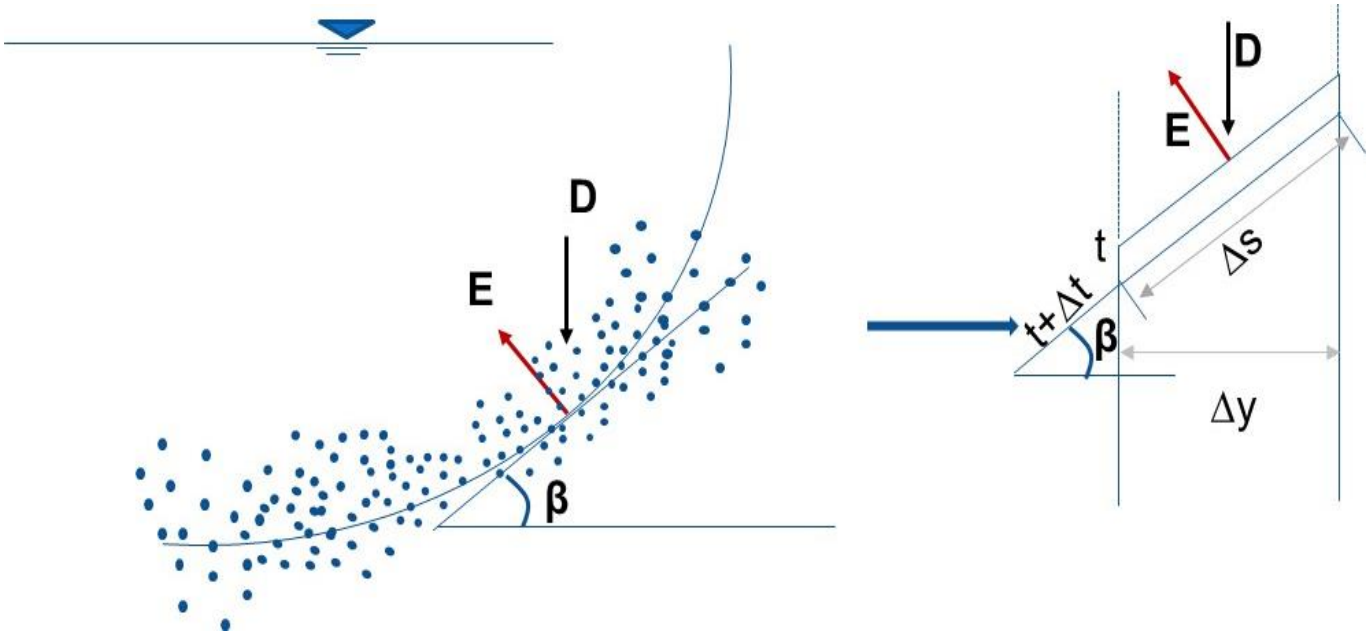


Fig. 1 Definition sketch for erosion-deposition process due to suspended sediment

$$\frac{\partial \bar{c}h}{\partial t}+\frac{\partial r_1 \bar{\bar{u}}\bar{\bar{c}}h}{\partial x}+\frac{\partial r_1 \bar{\bar{v}}\bar{\bar{c}}h}{\partial y}=\frac{\partial}{\partial x}(h\in_x \frac{\partial \bar{c}}{\partial x})+\frac{\partial}{\partial y}(h\in_y \frac{\partial \bar{c}}{\partial y})+\frac{1}{1-\lambda}(\frac{E}{\cos\beta}-D) \quad (3)$$

$$\frac{\partial z_b}{\partial t}+\frac{1}{1-\lambda}\left(\frac{E}{\cos\beta}-D\right)=0 \quad (4)$$

It is considered that the modified erosion term influences significantly the river bed evolution in bank areas. To investigate the influence of lateral slope on bed evolution, we need formulas of erosion and deposition rates. The deposition rate is evaluated:

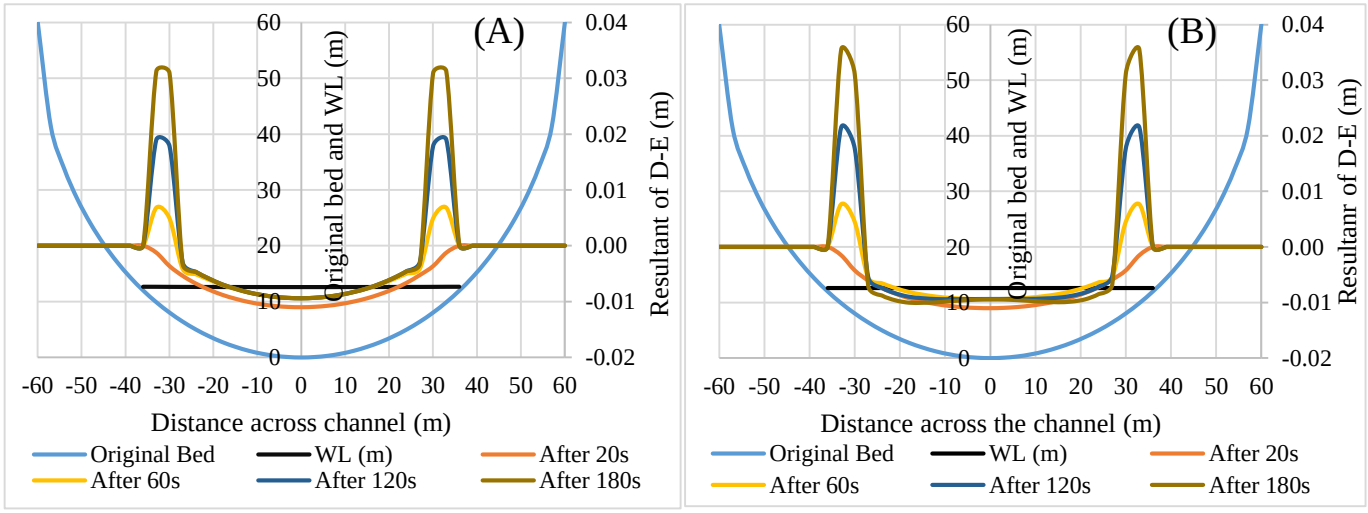
$$D=c_b w_0 \quad (5)$$

In which c_b is the sediment concentration at reference level. Present computation employs Itakura and Kishi's (1980) formula for erosion rate.

$$E=Kw_0\left(\alpha_* \frac{\sigma-\rho}{\sigma}\frac{gd}{u_* w_0}\Omega-1\right) \quad (6)$$

3. RESULTS AND DISCUSSION

Channel changes were computed using a set of Eqs. (1) and (2) as well as Eqs. (3) and (4), assuming uniform flows in open channel with circular cross-section. Computational conditions were specified as w_0/u_* =0.22 at the center of the channel and w_0 = 2.52 cm/s. The computed results are shown in Figs. 2(A) and 2(B). In both figures, temporally accumulated value $\int_0^t (E-D)dt$ are shown for 20, 60, 120 and 180 seconds.



(A) Without cosβ (B) With cosβ

Fig. 2 Effect of side bank on the erosion and deposition process

In the resultant of D-E axis, positive value indicates deposition dominated and negative indicates erosion dominated. It is observed from the experimental results that introduction of side bank slope influences the erosion pattern. In the case of condition without cosβ maximum erosion takes place in the center of the channel whereas with cosβ causes widening of the channel with increased erosion in both side of the center of the channel.

4. CONCLUSION

From the results it is revealed that introduction of lateral slope influences the erosion-deposition processes for channel dominated by suspended sediment. It should be included in the governing equations. However in order to evaluate such effect more comprehensively in the erosion-deposition process a dimensionless unified diagram is to be prepared.

REFERENCES

Itakura, T. and Kishi, T.: Open channel flow with suspended sediment, Journal of Hydraulic Division, 106(8), 1980, pp. 1325-1343.