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主　論　文　の　要　旨

論文題目　**Effects of Riparian Vegetation on Transitional and Equilibrium River Morphology**

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論　文　内　容　の　要　旨

This thesis has studied the effect of riparian vegetation on transitional and equilibrium river morphology and discusses potential engineering countermeasures to mitigate the risks brought by vegetation expansion in a gravel-bed river.

The interaction between riparian vegetation, water flow, and geomorphology has created diverse fluvial landforms on Earth. Investigating the interaction between these elements also has significant engineering value. The interaction has been studied extensively in the last decades. By using numerical models that developed rapidly in the last decade, vegetation effects, i.e., vegetation distribution and flexibility, are discussed in this study. The results have compensated for the bio-hydro-geomorphology interaction triangle and deepened the understanding of the interaction.

In Chapter 1, the research backgrounds are introduced, and research problems are identified. The major focus of the thesis is the effect of riparian vegetation. The thesis aims to investigate the effect of uniformly distributed floodplain vegetation on transitional river morphology, the effect of vegetation distribution along river transect on equilibrium river morphology, and vegetation flexibility effect on the river morphology. By investigating these three focuses, the understanding of vegetation’s role in a fluvial system can be deepened. In addition, early research has implied the importance of water edge vegetation on a fluvial system. By investigating these three problems, the question regarding the role of water edge vegetation can be answered.

In Chapter 2, a numerical experiment is performed to investigate the effects of floodplain vegetation combined with various low water channel planforms on the meandering development in a gravel-bedded river. Three different low water channels, whose wavelengths are determined by an empirical criterion of the mobility of alternate bars through river bends, are studied. Two different floodplain covers are considered: a bare floodplain and a vegetated floodplain. The simulation configurations are based on the Otofuke River at Hokkaido. Results show that with suitable initial low water channel planform and floodplain vegetation, meandering develops in a gravel-bed river without periodic vegetation establishment on bare bars. The sinuosity in the simulation is close to the river in the field. Meandering develops from two processes in gravel-bed rivers, (1) alternate bar growth with an erodible bank and (2) growth from the initial low water channel bend. The wavelength and amplitude of developed meandering are similar. The results suggest that appropriate initial low water channel and floodplain vegetation is sufficient condition for meandering initiation in a gravel-bed river. Furthermore, vegetation establishment on the floodplain is not a necessary condition for meandering development in short-term river morphology development. This chapter demonstrated vegetation on the floodplain can bring serious damage to river embankment in a vegetated river, and implies the important role of water edge vegetation in the formation of channel meandering. A countermeasure to this problem is discussed in Chapter 3.

In Chapter 3, a river management measure aiming to reduce embankment failure risk and remove riparian vegetation in the Satsunai river is investigated by numerical simulation and field survey. The measure is artificially reopening a closed channel on a vegetated floodplain to redirect the flow. Field surveys performed before and after an artificial flush flood demonstrate that such measure is not efficient in achieving its engineering goals. A method to improve the efficiency of the reopened channel is proposed in this chapter. This measure closes an upstream side channel to concentrate flow into the reopened channel to improve its efficiency. Numerical simulation shows that by reopening and narrowing side channels in the braiding network, the erosion in the old main channel is reduced, and the morphological change in the reopened channel can be promoted. Combined with Chapter 2, appropriately modifying the floodplain, e.g., artificially creating a new watercourse on the floodplain, can reduce the risks brought by vegetation expansion.

In Chapter 4, the effect of vegetation distribution on river morphology in a braided river is studied. Vegetation distribution along river transects is controlled by hydrological conditions and flow disturbance, and it can also be affected by human activities. As one of the most dynamic river patterns, braided river can be significantly influenced by vegetation encroachment, while the effect of vegetation distribution along river transects on braided river characteristics is still unknown. A depth-averaged hydro-morphodynamic model is employed to study the potential influence of vegetation transect distribution as the development of numerical model in the last decade has proved its efficiency in studying the interaction between vegetation and river morphology. Rather than discussing a specific reason that induces different vegetation distribution and their effects on river morphology, the problem is generalized and studied by varying the vegetation habitat extension. Two patterns of transect distribution of vegetation have been investigated: (1) Vegetation establishment near the low water channel; and (2) Vegetation establishment on bar tops and keeps distance from the low water channel. The model has successfully reproduced the reduction in braiding index of a vegetated braided river. The results show that the transect distribution of vegetation significantly influences the statistical properties of braiding river bed elevation. Bed variance increases with the increase of vegetation habitat area in both distribution patterns. Skewness and kurtosis decrease and increase with the increase of vegetation habitat area in case of type (1) distribution, respectively. With a distribution type (2), the relationships between skewness, kurtosis, and vegetation habitat area are opposite. Our results have provided an extra explanation for the discrepancy in the skewness between field observation and laboratory experiment and also show implications for the management of vegetated braided rivers with a gravel bed. For a restoration project in a vegetated braided river, vegetation near the water edge should be removed rather than vegetation on the bar top. Compared to Chapter 2, this chapter shows that only with a vegetation belt that is close to the water edge, the river morphology can be significantly influenced. The results further prove the importance of water edge vegetation in the fluvial system.

In Chapter 5, the effect of vegetation flexibility on river morphology is investigated. Flexible vegetation, e.g., reedy grass, may play an important role in vegetation expansion in rivers. However, the flexibility influence on river morphology development is generally ignored in early research. To investigate the effects of vegetation flexibility in a fluvial bio-hydro-morphodynamic simulation, a model to predict flexible vegetation reconfiguration is incorporated into a bio-hydro-morphodynamic model based on Delft3D. The effects of vegetation flexibility in a gravel bed river with alternate bars have been studied. *Phragmites japonica*, which is an extensively existing reedy grass in a riparian environment, is the target vegetation. Results show that vegetation flexibility impacts river hydrodynamics and morphology development processes. With flexibility accounted for, the water depth decreases, averaged Shields stress in vegetation patch increases, and active channel width widens. Erosion and deposition in the channel are reduced. The significance of flexibility depends on multiple factors, i.e., stem density growth rate, rigidity, and sediment size. With a fast stem density growth rate or large gravel size, the difference between flexible and rigid cases can be neglected. Compared to Chapter 2 and Chapter 4, the effect of flexible water edge vegetation is demonstrated in this chapter.

Based on the results, conclusions are summarized in Chapter 6, and future research is recommended.