論 文 の 内 容 の 要 旨

論文題目　　The Impact of Interaction Between Sediment Size and Channel Aspect Ratio on River Planform Dynamics
（河床材料の粒度と川幅水深比の相互作用が河道の平面形状の動態に及ぼす影響）

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Flood disaster often causes serious problems for cities which located around a meandering river. Maintaining stability of meandering rivers remains as the most challenging task for river management. Some studies propose various approaches to understand meandering characteristics. One of the most common approaches is the classification of meandering pattern. Based on the past studies, there are three types of meandering channel by focusing on sediment characteristics, aspect ratio and sinuosity. These parameters can represent the characteristics of meandering rivers well, but the mechanism of meandering river is diverse and complex. Detailed investigation on each parameter can contribute to better understandings of such mechanism. In this study, the relationship of bank and bed materials and their impacts on meandering characteristics are examined especially focusing on aspect ratio of river channel. Besides, bank erosion process is also one of important factors which determine the characteristics of channel migration on small scale (reach scale) and channel planform change on large scale (segment scale). Some target rivers in Indonesia, Japan and Cambodia are introduced to evaluate those parameters through field measurement and numerical simulation.

The bed material of the target rivers could be classified into 3 types, based on the grain size distribution: coarse sand (0.5-2mm) with occasional gravel (2mm-), fine sand (0.075-0.5mm), and silt and clay (mainly -0.075mm cohesive material). It was clarified that the difference of the bed material is caused by basin geology. On the other side, the grain size distribution of sand is almost same in all river banks, while the ratio of cohesive material is different especially between Japan and South Asia. Hence the bank material could be classified into 2 types: cohesive and non-cohesive materials. In terms of aspect ratio and sinuosity, aspect ratio of 12 and 25 as well as sinuosity of 1.5 were found to be important criteria to classify target rivers based on meandering characteristics. By using these parameters, previous classification with three meandering types were modified because the meandering rivers with low-moderate (12-25) aspect ratio (Type 2) shows diverse sinuosity. Then Type 2 was divided into Type 2a which has lower sinuosity than 1.5 and Type 2b that has higher sinuosity than 1.5. Other meander parameters such as meander wavelength and radius of curvature also showed individual characteristics in each type similar to the results of aspect ratio and sinuosity. Especially there is clear relationship between aspect ratio and meander wavelength or radius of curvature in Type2 and it was implied that scroll bar formation affects the meander process. This study also investigated how the weighted mean of silt-clay percentage (M value) affect the channel migration and channel planform as well as aspect ratio. Basically, M value more than 20 is considered to be cohesive.

The relationship of sediment size and aspect ratio was investigated by several approaches and it was found that sediment size has important role to maintain channel stability. While sediment movement is considered to be active in rivers with high sinuosity, low aspect ratio and cohesive sediment (Type 1), the extent of bank erosion is governed by high silt-clay percentage (that means M value is more than 20). In Type 1 which has cohesive bed and bank, bed deformation was found to be active but channel migration was quite limited because of high silt-clay percentage in the bank. In Type 3 which has low sinuosity, high aspect ratio and erodible bank with fine sand materials, both bed and bank are not so stable. Usually, braided channels are created on the river bed. Type 2 is the intermediate condition between Type 1 and 3, but both sinuosity and M value are quite divers. Therefore, there are no clear relationship between M value and aspect ratio or sinuosity. However, the bed and bank material have some unique characteristics. Some Type 2 rivers have similar material with Type1, but some rivers have coarser bed material than that of Type3 and others have lower silt-clay percentage in the bank than that of Type1. As these results show, it was clarified that the bed and bank material of Type2 tends to be different. Moreover, analysis of old maps clarified that some Type2a rivers with lower silt-clay percentage on the bank used to be Type2b before straitening.

In order to understand the mechanism to make difference between Type2a and Type2b, numerical simulation (ICHARM Bank Erosion Model) was carried out in addition to the analysis of field data. By comparing the results of several cases in the simulation, forming mechanism of Type 2a and 2b could be clarified. The target river is the Cimanuk River where steeper channel is Type2b and milder channel is Type2a. Several parameters were set based on the actual condition of the Cimanuk River, but bank or bed material was changed in order to understand the effect of sediment size on river channel. Through the simulation following patterns were clarified. In the milder channel, Type 1 may become Type 2a when the cohesive material on the riverbed is less and it cannot form the bank. Bank cohesion is also essential factor because riverbed material is supplied from less cohesive bank and it is transported well. Then wider and shallower channel is formed because the bank is usually stabilized by the cohesion in milder river. That means lower silt-clay ratio on bank or bed may change Type1 channel to Type2 channel, but still high silt-clay ratio stabilizes the channel and Type2a is formed. However, the silt-clay percentage of the Sangkae River is as high as other Type1 rivers. It is the future task to clarify the mechanism. In the steeper channel, Type 3 may become Type 2b by increasing depth when coarser material is contained in riverbed. It might be caused by coarser material at bank-toe stabilizes the riverbank and suspended sand forms bank. Moreover, if the silt-clay percentage of the bank of Type3 is increased, scroll bar is formed in a narrow channel and Type2b is formed. In both cases, such a narrow and deep channel with high stream power has higher sinuosity.

Proposed meandering characteristics is important to understand meandering river characteristics. Parameters of this classification could distinguish the type of meandering rivers. Detailed investigation of each parameters gives comprehensive perspectives about each meandering type. Each type needs different approaches to maintain stable cross-sectional shape in terms of river management. Type 1 and Type 2a have relatively stable river shapes, and thus a river manager may spend less effort to maintain the river compared to the other types. Of course, some parts might have small scale characteristics such as local bank erosion due to human activities or impact of river crossing structures that still need to be considered. For Type 3, river managers need to understand bar formation mechanism and give more attention to check the bar in every flood events. Rivers in type 2b tend to be unstable and are typically located in upper part of lower reach. Active erosion and deposition must be monitored through periodic and frequent cross-sectional surveys. One important message is that the sediment size change causes the change of channel dynamics as well as cross-sectional shape. A river manager needs to identify several active zones, at which stability of the cross-sectional shape needs to be maintained. Therefore, suitable river works plans to maintain the stability of cross-sectional shape could be selected to carry out based on design and budget optimization.