MORPHOLOGICAL CHARACTERIZATION OF THE LOWER REACH OF THE TENRYU RIVER

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By scrutinizing cross-sectional data, aerial photos and flow discharge records, this study shed some new light on the causes of the morphological changes in the lower reach of the Tenryu River. The attention was placed on in-channel vegetation that is considered as a second order effect of dam construction. As a result, a vegetation-related erosion mechanism along the river course was identified.

Key Words : *Tenryu River, dam, cross-section, erosion, vegetation*

1. INTRODUCTION

The Tenryu River originates in the central Honshu mountains. From its source at Lake Suwa in Okaya, Nagano Prefecture, it extends 213 km, grazing Aichi Prefecture en route to its mouth at the boundary between the cities of Hamamatsu and Iwata in Shizuoka Prefecture. It drains 5,050 km² into the Enshū Sea (Fig.1). In length, it is Japan's 9th longest river.

Due to a series of dam construction in the upstream of the river, particularly after the completion of the Sakuma Dam, the sediment supply from the upstream was very much reduced, resulting in significant morphological change in the downstream and beach erosion in the Enshunada Coast as well.

The present study is aimed to characterize some major changes in the lower reach from Kashima site (RM 25km) to the river mouth. The particular objective of this paper is to present a holistic view on how the lower reach was affected by a second order impact of dam, which is the intrusion of vegetation into middle bars and floodplains. The analysis was based on the examinations of cross-sectional survey data, flow discharges, vegetation data and aerial photos as well.

2. APPEARANCE OF RIPARIAN FOREST ALONG THE RIVER COURSE

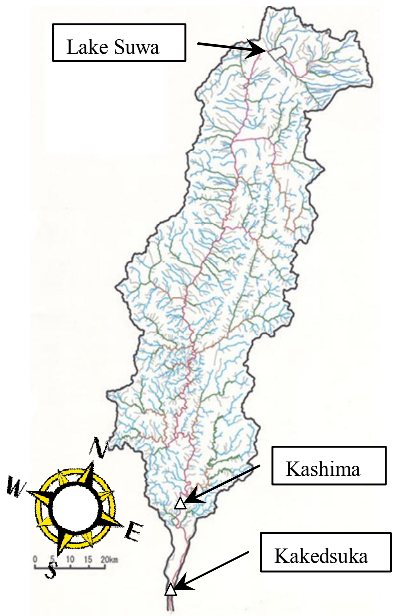

Fig.1 Tenryu River

Figure 2 shows the comparison of aerial photos taken in 1947 and 2004. It appears clear that the lower reach has been significantly transformed from non-vegetative to vegetated river channel. The species are mainly willow and Canada goldenrod and higher than 5m in many locations. Figure 3 shows that the vegetated area increased since 1950 and had a big jump from 1989. At present, the vegetated area accounts for about 20% of the total river channel area in the lower reach. Also shown in Fig.3 is the variation of 10-year moving averages of the annual maximum flow discharge. It declined steadily since the mid of 1970s. As a result of reduced flow disturbance, the in-channel vegetation have developed, which in turn, exerted significant impact upon the river morphology.

3. CROSS-SECTIONAL CHANGE

Figures 4-7 show the comparisons of cross-sections between 1989 and 2003 at 0.4km, 5km, 12km and 25km, respectively. At 0.4km, the deepest part was raised in 2003 as compared to 1989. At 5km, the elevation of middle sandbar was raised but the erosion occurred on the left-hand side of the bar. As shown in Fig.8, the middle bar at 5km was forested. Due to the presence of high vegetation, the sandbar has become stable and therefore caused large dead water zone. With constricted flow area, the main channel was incised. This may be considered as the mechanism for the cross-sectional change at 5km. At 12km, the change of cross-section was also characterized with both aggradation and degradation. By comparing the cross-section plot with the aerial photo, it was found that the aggradation occurred in the vegetated zone while the incision took place in the zone next to it. At 25km, however, the cross-section did not show any significant change over a decade. Based on the above comparison, it can be realized that the channel bottom was elevated around the exit, deepened in the middle and no-change at the entrance of the river course. And the channel deepening in the middle subreach was related to in-channel vegegtation growth. Figure 9 depicts the fluctuations in river bed in different sub-reaches over a longer period of time (70 yr). The general trend in the lower reach since 1960 was erosion, however, the subreach from 0.4km to 6.6km showed bottom-up in recent years. This long-term perspective support s the finding that the current river course has been flattened due to the shift from erosion to deposition in the subreach close to river mouth. Figure 10 depicts the relation between flood pulse and sandbar inundation frequency in the middle subreach. In recent years, the inundation frequency was greatly reduced even under the same flood intensity. This can be attributed to the aggradation of the bar.

4. DISCUSSION

By synthesizing all materials described above, a general picture can be drawn with regard to the

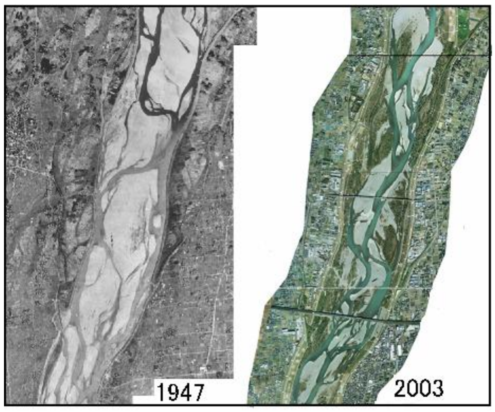

Fig.2 A plan view on the change in Lower Tenryu River

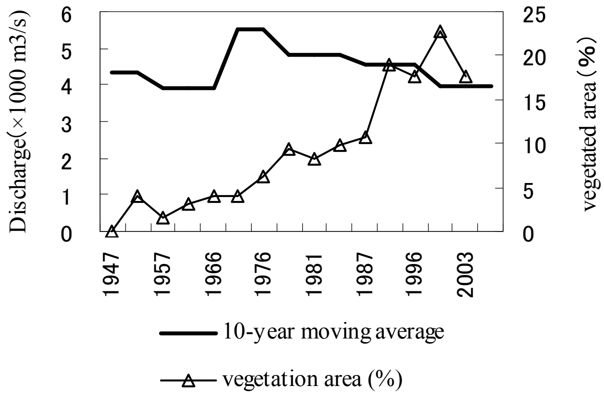

Fig.3 Changes in flow discharge and ratio of vegetated area to total channel area

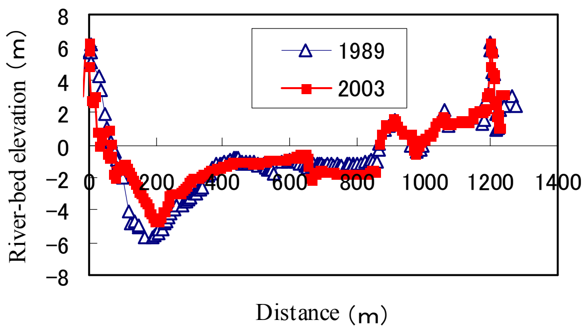

Fig.4 Comparison of cross-section at 0.4 km

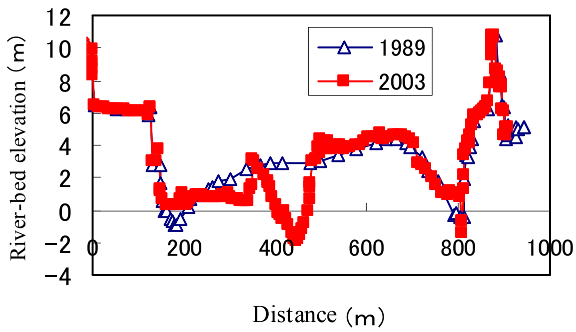

Fig.5 Comparison of cross-section at 5 km

two decades, however, in-channel vegetation developed in the lower reach due to the reduction of flow disturbance. With the presence of riparian forest, middle bars and floodplains trapped a large amount of sediment causing aggradation. In the meantime, the aggradated sandbars led to further incision in thalweg in the middle part of the lower reach because of the constriction of conveyance area. This vegetation growth-sandbar stabilization- thalweg erosin process is considered as an indirect effect of dam construction manifected in Lower Tenryu River. It should be mentioned here that riparian vegetation has been reported to potentially enhance stream bank stability (e.g. Thorne, 1990; Gregory,1992), and this study hypothesized that the same mechanism holds true for the middle sandbars.

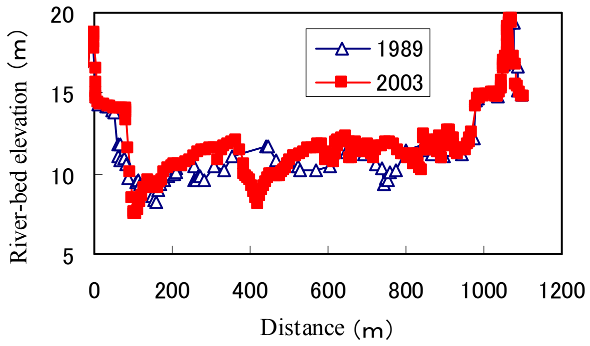

Fig.6 Comparison of cross-section at 12 km

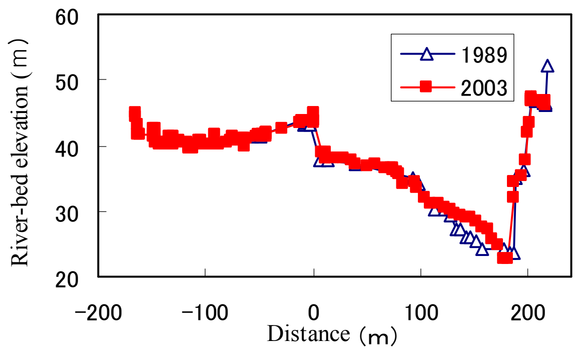

Fig.7 Comparison of cross-section at 25 km

5. CONCLUDING REMARKS

A major morphological change in the lower reach of the Tenryu River was the development of riparian vegetation. An in-channel vegetation-related erosion mechanism was identified in the middle sub-reach of the Lower Tenryu River. This channel erosion together with the deposition process in vegetated zones may have further hindered the sediment supply from the river to the coast as a second order impact of dam construction. It should also be mentioned that the riverbed excavation for sand mining was conducted extensively in the Lower Tenryu River before 1968, and is still going on in the upper sub-reach of the Lower Tenryu River although the volume is now very much controlled. The impact of sand mining on the erosion-deposition processes in the Lower Tenryu River will be a subject for further study.

Fig.8 Aerial photo for the site of 5 km

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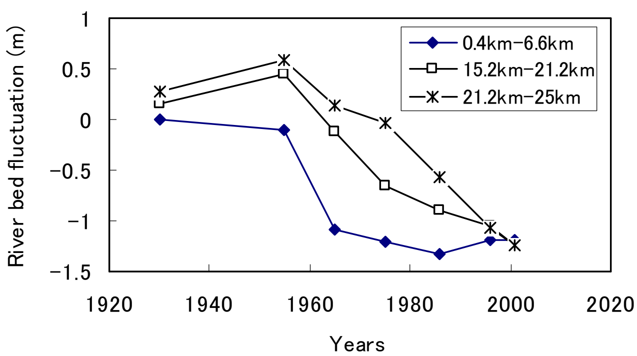

Fig.9 River bed variations in different sub-reaches

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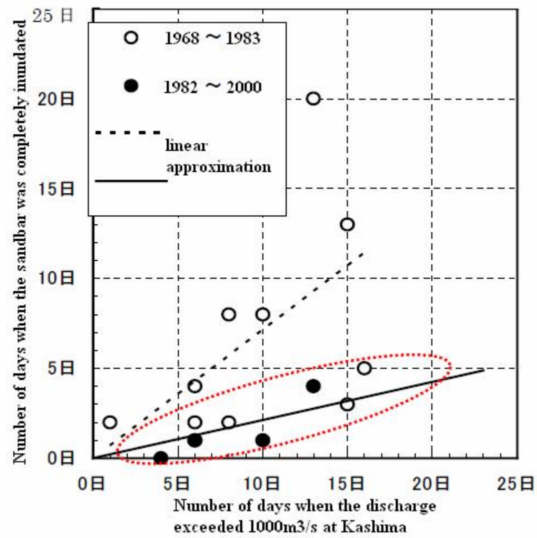

Fig.10 Reduction of inundation frequency over forested bar