II－24 Response of River Mouth Morphology to Wave, Tide and River Flow

Tohoku University Student member ○ Patchanok SRIVIHOK
Tohoku University Fellow Member Hitoshi TANAKA

1. Introduction

River mouth morphology changes are the result from the interaction between fluvial and marine forces to bring the sediment to or to carry the sediment away from the river mouth. Naturally, sediment transport in the vicinity of the river mouth or tidal inlet is complicated and sensitive to the natural balancing change. In this study, the Nanakita River mouth behavior responding to the external forces will be examined since the gradual disappearance of sand spit has been noticed in the last decade by the local people. In fact, the sand spit at the river mouth can be classified to sub aqueous and sub aerial parts but the available data in the interesting periods is only aerial photographs. The changing behavior during 1990-2002, longshore sediment transport by wave and flushing ability by tidal and river discharge through the river mouth are examined and correlated each other in this study.

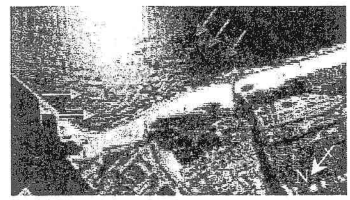

Fig.1 Location of the Nanakita River Mouth

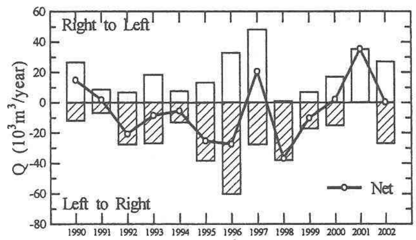

Fig.2 Computed Yearly Longshore Sediment Transport

2. Changing Behavior of Sand Spit

The high frequency taking aerial photographs at the Nanakita River mouth were used to find the river mouth geometry and temporal changing pattern including with yearly average sand spit characteristic. The long-term behavior of the river mouth since 1990-2002 can be noticed that the left and right sand spits comparably developed during 1990-1995 but since 1996 the left sand spit has gradually disappeared with the widening of the river mouth width and become stable since 2000 (Srivihok and Tanaka, 2004).

3. Effect of Wave and Tidal and River Flow

The location of the Nanakita River mouth is influenced by the incident wave and reflected wave from the breakwater at Sendai port situated at 2-km in the north of river mouth as shown in Fig.1. The dominant longshore transport direction from incident wave is normally from the south following the dominant wave from ESE or SE direction. In this study, longshore sediment transport from both incident and reflected wave were appraised by using CERC formula when the wave properties (wave height and wave direction) at breaking line were computed by wave ray method. The yearly shallow bathymetry up to 18-m depth was changed and applied in the computation. The computed yearly sediment transport is shown in Fig.2, which, net sediment transport direction regularly corresponds to the prolonging sand spit side in that year. Once the measured wave properties at 20-m depth were examined, wave period and wave direction measured from north show the increasing trend with the constant trend of wave height since 1990-2002. However, the changing direction of wave shows greater magnitude than the change of shoreline direction, which means more predominant sediment transport from south and relates to the dominancy of right sand spit that can be observed in the recent year (Srivihok and Tanaka, 2004). For the riverside, the river channel was continuously dredged since 1988-1999 by river authority. This activity causes the 42% increasing of tidal compartment area in the riverside (Tanaka and Yamamoto, 2000) and also results in an increasing of discharge passing through the river mouth section which, is supposed to enlarge the river mouth and impede the sediment bypass from right side to left side of the river mouth. Consequently the left sand spit has gradually disappeared according to the increasing of discharge with time. The computed river mouth discharge in Fig.3 was computed from the continuity equation of the tidal compartment in the river and the difference between observed water level inside the mouth and tidal level in the ocean.

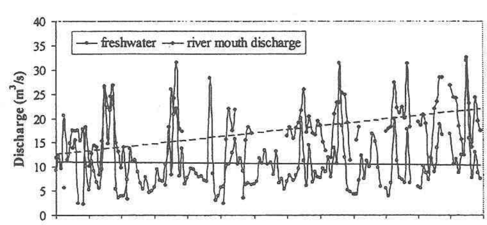

Fig.3 Freshwater and River Mouth Discharge

4. River Mouth Migration Model

The migration of the river mouth is then simulated by the use of numerical model (Tanaka, et al, 1995) to evaluate the effect of external forces.

$$(1-\lambda)Lh\frac{dX_R}{dt}=e_r q_r(1-f)B-e_w(1-\lambda)Q_R \quad (1)$$

$$(1-\lambda)Lh\frac{dX_L}{dt}=-e_r q_r fB-e_w(1-\lambda)Q_L \quad (2)$$

where X_R and X_L are the coordinates of the tip of right and left sand spit. L is width of sand spit (using 61m.), h is the water depth (using 1.01m.), λ is the sand porosity, q_r is the bedload transport rate by tide and river discharge, Q is the longshore transport rate, f is the weight function for sediment flushing on right or left sand spit follow the estimation criteria from Tanaka, 1995. e_r and e_w are efficiency of sediment outflow by discharge and sediment inflow by wave respectively. The model computation was carried out to minimize the error of sand spit location by comparing to measured data from aerial photographs (shown by dotted plots in the figure). e_r and e_w were varied through the combination from 0.1 to1.0 with 0.1 interval. Location of spit and river mouth width with optimum e_r and e_w for 1990, 1997 and 2000 are shown in Fig.4-6. Left sand spit was limited at 290 m during computation because of jetty on the left bank.

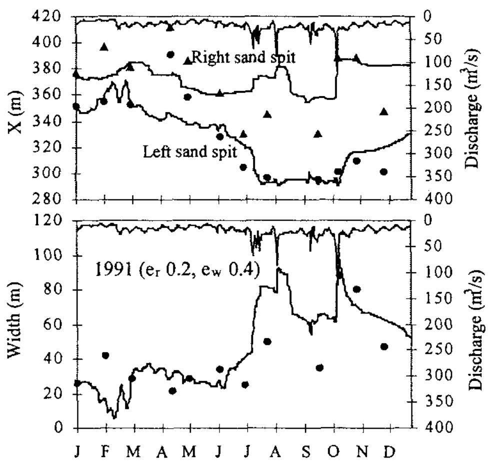

Fig.4 Spit Location and River Mouth Width in 1991

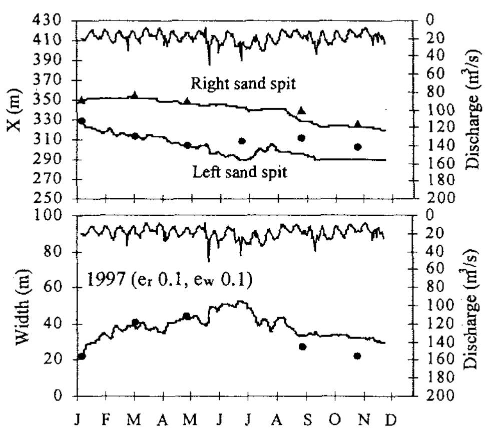

Fig.5 Spit Location and River Mouth Width in 1997

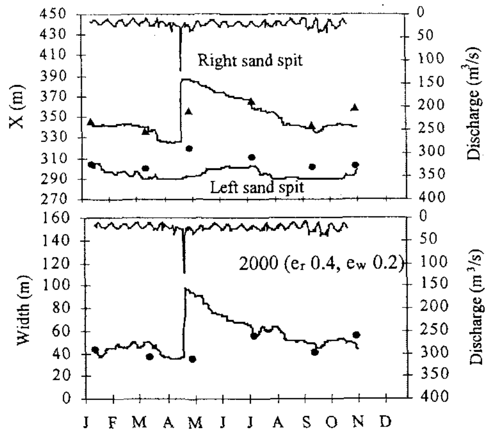

Fig.6 Spit Location and River Mouth Width in 2000

5. Conclusion

The efficiencies of wave, e_w and discharge, e_r influent to the river mouth behavior. The strong wave efficiency in 1991 (e_r=0.2, e_w=0.4) causes high fluctuation and complicated feature of the river mouth. The comparative efficiency of wave and discharge in 1997 (e_r and e_w = 0.1) due to the effect of river dredging causes less fluctuation of spit development and widening of river mouth width. In 2000, the river mouth becomes further wide because of the significant flushing ability from high discharge efficiency compared to wave efficiency (e_r=0.4, e_w =0.2). Moreover, the river channel flows along the left jetty with the less longshore sediment supply from left side. Therefore, water depth becomes deeper from scouring and aggravates the disappearance of left spit. However, this model cannot be well simulated during high discharge with the overestimation of X and width. The reason is the assumption of a constant water depth, though the water depth can be deeper with less change of width in the actual condition. Hence, the model might be improved by the adjustment of depth and f function.

Acknowledgements
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