ESTIMATION OF SEDIMENT BYPASSING AROUND THE NANAKITA RIVER MOUTH

Tohoku University Student Member ○ Eko PRADJOKO
Tohoku University Fellow Member Hitoshi TANAKA

1. INTRODUCTION

The river mouth is the meeting place between river streams; tide and wave which make the morphological response always vary in time. Basically, if we see the river stream flow in perpendicular direction with shoreline, it may interrupt the long-shore sediment transport which working along the shoreline. The development of sand spit and moving of river mouth axis are the morphologic responses toward that interruption in the natural river mouth. However, in semi constraint river mouth (the jetty structure exists in one side) or low energy beach type, the equilibrium condition of river mouth can be reach and the sediment bypassing of river mouth might be present. The existence of sediment bypassing will affect the influence level of river mouth to the surrounding beach.

The sediment budget provide the conceptual and quantitative model of sediment-transport magnitudes and pathways for a given time period (Rosati and Kraus, 1999). This method has been applied to analyze the coastal inlets condition along the U.S. shoreline in purpose to manage the safe navigation condition.

This study is attempted to apply the sediment budget method in order to estimate the sediment bypassing of the Nanakita River mouth. The Nanakita river mouth is located at east side of Japan Coast, facing to the Pacific Ocean. The two jetties constrain the river mouth direction but don’t have so much effect because the shoreline position is more forward than the tip of structures. The shoreline near the port breakwater has curve shape and the rest is relatively straight. All shoreline consist of sandy beach with average slope is about 0.11 (Kurosawa and Tanaka, 2001).

2. METHODOLOGY AND DATA COLLECTION

The sediment budget is the calculation of sediment gains and losses, or sources and sinks, within the specified control volume (or cell) over a given time period. The differences between the sediment sources and the sinks must equal the sediment volume change occurring within the cell (Rosati and Kraus, 1999). The sediment source or sinks components can be expressed as long-shore transport, cross-shore transport, and river sediment supply. The volume change can be defined as shoreline change and sand spit change.

The long-shore sediment transport component is calculated from 2 hourly wave data of Sendai Port station since 1991 until 2002. The CERC formula is used in the calculation with the empirical coefficient K=0.05 from Tanaka and Shuto (1991). The river sediment supply is calculated by using bed load transport equation from Meyer-Peter formula. The daily river discharge data of Nanakita River is collected from 1991 until 2002.

The shoreline and sand spit change is extracted from the bimonthly aerial photograph since 1991 until 2002. The rectification, tide and wave run-up correction is applied in order to reduce the error of measurement.

The sediment budget method used to estimate the lesser-known component from the best-known component (Rosati, 2005). The calculation of long-shore sediment transport and the extraction data of volume change give a best estimation of known component. Then, the method can be used to solve the lesser-known component i.e. the sediment bypassing over the river mouth.

3. RESULTS AND DISCUSSIONS

Prior the detailed calculation, the conceptual sediment budget (Figure 1) is developed to give an overview of source, sinks and transport pathway of sediments in the study area. Three cells are setup in the area which cover the left side (Cell A, Ls=1,800m), the area in front of river mouth (Cell B, Lrv=200m) and the right side (Cell C, Lr=900m). It is assumed there is no long-shore sediment transport component on the left

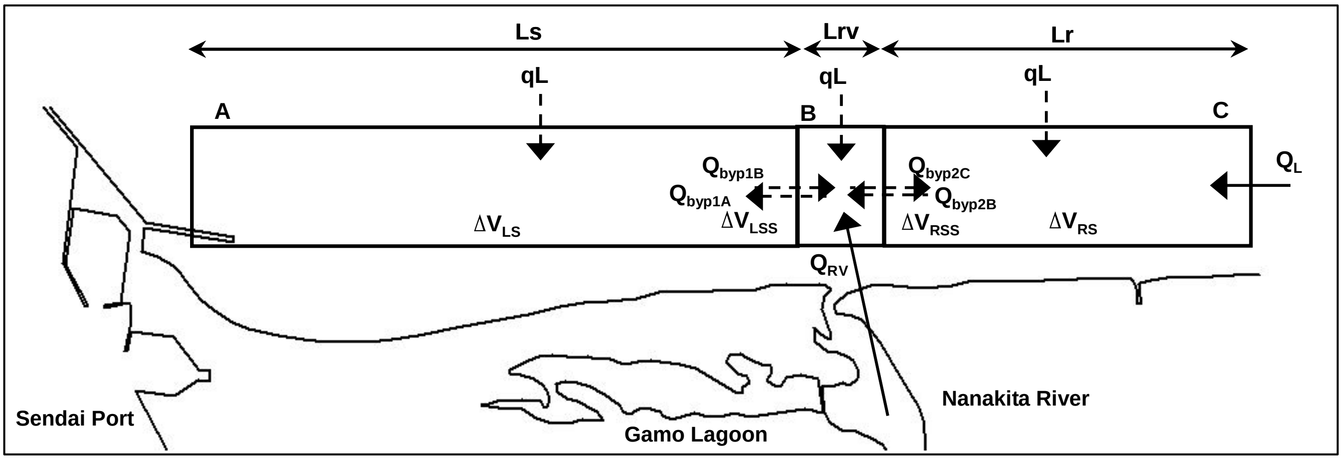

Fig.1 The conceptual sediment budget

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Tohoku University, 6-6-06 Aoba, Sendai 980-8579, Japan. Tel & Fax: 022-795-7451

boundary of model due to the existence of Sendai Port Breakwater. The wave induced long-shore sediment transport is considered working on the right side boundary. Based on this conceptual budget, the Equation 1 until Equation 4 can be setup. The cross-shore sediment transport (qL), which is the less-known component, is solved first by using Equation 1.

$$Q_L + Q_{RV} + qL = \Delta V_{LS} + \Delta V_{LSS} + \Delta V_{RS} + \Delta V_{RSS} \quad (1)$$

where Q_L is long-shore sediment transport; Q_{RV} is river sediment discharge; qL is cross-shore sediment transport; ΔV_{LS} and ΔV_{RS} are left and right side shoreline change respectively; ΔV_{LSS} and ΔV_{RSS} are left and right sand spit change respectively; and $L=Ls+Lrv+Lr$ is the total length.

$$Q_L + Q_{byp2C} + qLr = \Delta V_{RS} + \Delta V_{RSS} \quad (2)$$
$$Q_{RV} + Q_{byp1B} + Q_{byp2B} + qLrv = 0 \quad (3)$$
where $Q_{byp2B} = -Q_{byp2C}$
$$Q_{byp1A} + qLs = \Delta V_{LS} + \Delta V_{LSS} \quad (4)$$
where $Q_{byp1A} = -Q_{byp1B}$

As shown in Figure 1, the long-shore transport component also act between cell A - cell B and cell B - cell C. This sediment transport flow through the river mouth area (cell B) and is considered as sediment bypassing (Q_{byp}). This component can be estimated from solving the sediment budget equation in one cell starting from cell C by using Equation 2, cell B by using Equation 3, and cell A by using Equation 4. The calculations were performing in yearly basis and some correlation is plotted in Figure 2 and 3.

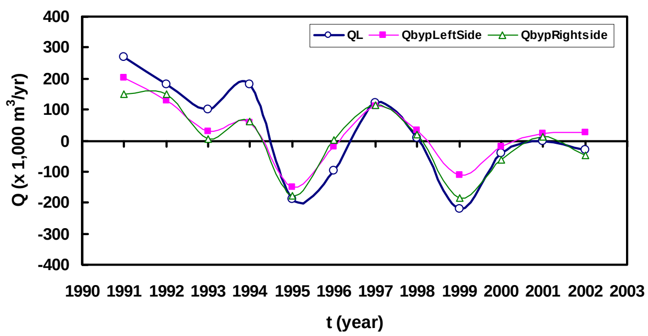

Fig.2 The long-shore transport and sediment bypassing.

Figure 2 shows the agreement between the long-shore sediment transport (Q_L) directions with the sediment bypassing directions. The $Q_{bypLeftSide}$ and $Q_{bypRightSide}$ are the sediment bypassing on left and right side of cell B respectively. This relationship means the excess of long-shore sediment transport in cell C bypass the river mouth to go to cell A. Conversely, the cell C gets supply from the excess of long-shore transport in cell A when the cell C is in sediment shortage condition. The sediment bypassing occurs in cell B (river mouth area) and has different value between left and right side of cell B due to the influence of river sediment discharge (Q_{RV}).

The magnitude of sediment bypassing is lower than the long-shore sediment transport. It is consistent with the natural condition that the sediment bypassing come from the excess of long-shore sediment transport after satisfy the sediment balance in beginning cell. The order of sediment bypassing is about 0.6 of long-shore sediment transport as shown in Figure 3.

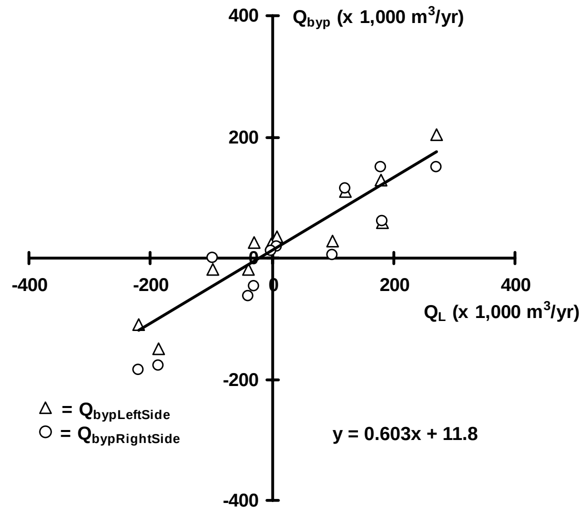

Fig.3 The correlation between long-shore transport and sediment bypassing.

4. CONCLUSION

The sediment bypassing has been estimated by applying the sediment budget method in the Nanakita River mouth. The results show that the sediment bypassing has lower value than long-shore sediment transport with order about 0.6 in this area. However, actually the hydrodynamic condition in front of river mouth is complex and influences the pattern of sediment transport in big extent.

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