LABORATORY STUDY OF SAND BAR DEVELOPMENT AT A RIVER ENTRANCE

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River mouth topography changes continuously due to the actions of waves and river flow. Under the combination effect of waves, tide movement, long-shore and cross-shore current, and river flow, sediment is transported and deposited at the river mouth, forming sand bars at this area. Sand bars at river mouth influence extremely to river flow features in the river, obstruct navigation and flood discharge. However, they can prevent the river from salinity intrusion, and be flushed easily in flood season. Understanding sand bar development at river mouth and its characteristics are necessary for flooding and navigation control. This study focus on the formation of sand bar at river mouth due to wave actions and estimation the bar size through laboratory experiment and field observation.

The features of waves, river flow and bed layer material are the main factors that relate directly to the characteristics of sand bar. In the winter, the influence of river flow could be eliminated. Okazaki and Sunamura (1994) predicted the position and height of the berm on permeable beach due to waves. The wave run-up height that is response to the berm height was presented as follows

$$R' = 0.0877\left(gT^2\right)^{5/8} H_b^{1/8} d^{1/4} \phi \tag{1}$$

in which R' is the wave run-up height, g the acceleration of gravity, T the wave period, H_b the height of breaking wave, d the sediment diameter, ϕ the reduction factor due to the roughness and permeability of the slope.

$$\phi = \exp\left(-0.04 D_*^{0.55}\right) \tag{2}$$

$$D_* = \left[\frac{g}{\nu^2}\left(\frac{\rho_s}{\rho} - 1\right)\right]^{1/3} d \tag{3}$$

where D_* is the dimensionless grain diameter of sediment, ν the kinematics viscosity of water, ρ_s the mass density of sediment grain, ρ the mass density of water. The berm height, B_h, relates directly to the wave run-up height, R', it was assumed that there is a proportion between them. Applying the relationship between breaker height and deep water wave characteristics (Komar and Gaughan, 1972), the relationship between deep water wave length and the wave period, and assuming the approximation of the sand bar height H_R and B_h, relationship of H_R could be obtained as shown in Eq.(4)

$$\frac{H_R}{H_0} = 0.343\left(\frac{H_0}{L_0}\right)^{-13/20}\left(\frac{d}{H_0}\right)^{1/4}\phi \tag{4}$$

where, H_0 and L_0 are the height and length of deep water wave, respectively. Considering the proposal about asymmetry coefficient of bar profiles (Suga, 1985), and bar proportion, the relationship of sand bar length, L_R, can be obtained as in Eq.(5).

$$\frac{L_R}{H_0} \sim \left(\frac{H_0}{L_0}\right)^{-1/2}\phi \tag{5}$$

The sand bar profile area, A_R, is proportion of the product of sand bar height and width: $A_R \sim L_R H_R$. From the relationship of sand bar height in Eq.(4), and sand bar width in Eq.(5), the area can be given as

$$\frac{A_R}{H_0 L_0} \sim \left(\frac{H_0}{L_0}\right)^{-2/5}\left(\frac{d}{L_0}\right)^{1/4}\phi^2 \tag{6}$$

For predicting sand bar development at a river entrance, a series of experiments was carried out in a two-dimensional wave flume, with the difference of bottom material, water depth at river mouth. Under the action of waves, sediment at the bottom of the slope was agitated and transported into the river mouth and deposited there, and formed the bar. The changes of the bottom surface caused of the variation of wave breaking point.

The combined actions of breaking wave and the wave induced current have carried sediment into river mouth. Bottom layer at the slope was eroded on the time of wave action to the balance depth, and the sand bar was developed to equilibrium state. The experimental results of the relationship between equilibrium sand bar characteristics and their action factors are shown in Fig.1 and Fig.2. Those results were verified by the field observation on the development of sand bar at Natori river mouth after the flood in 1996. It can be seen the height of sand bar obtained the maximum at the bar side of seaward and its width developed along the mouth. The height of sand bar before flood seemed be invariable comparing with the one after the flood, however, the width and the area of sand bar was increased. The bar evolution at the field is similar as the ones in the experiment. Thus, the results of the experiment could be reasonable agreement.

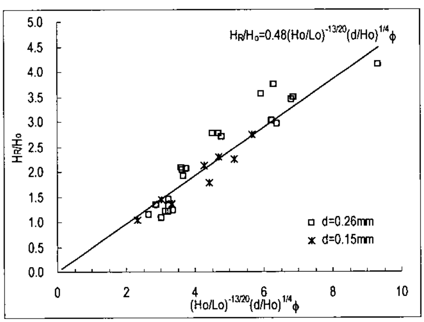

Fig.1 Relationship of dimensionless bar height and wave action factors

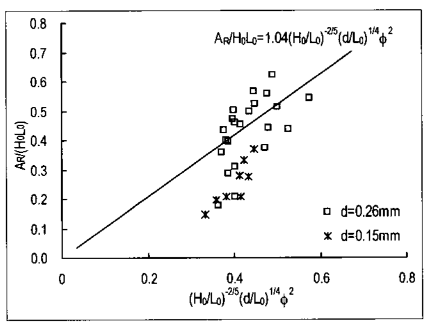

Fig.2 Relationship of dimensionless bar area and wave action factors

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