Impact of Flood to Residential Areas in Van Coc Lake, Hanoi Vietnam

Sai Hong Anh*, Toshinori Tabata**, Kazuaki Hiramatsu**, Masayoshi Harada**, Le Viet Son***

1. Introduction The Red river is the biggest river that runs through Hanoi capital. In 1971, a huge flood occurred in many provinces, including the capital in the Red River Delta, Vietnam. A total of 100,000 people died and damaged 450 million dollars from this disaster. Therefore, Vietnamese government considered an emergency solution that floodwaters will be discharged to the Van Coc Lake to protect Hanoi. Figure 1 shows the location of the Van Coc Lake which is a floodplain and a part of the Red River system. The Lake is located in the Dan Phuong and Phuc Tho districts of Hanoi city and plays an important role in the operation process of Day Weir to protect Hanoi city from floods. This study performed numerical simulations of the floodwaters from the Red River in the Van Coc Lake. A two-dimensional depth-integrated model was constructed to simulate three different discharge flows from the Red River (i.e., 2,500, 1,200, and 600 m^3/s). Moreover, the impact of the Manning's coefficient on the flood flow behavior was considered. The water level was calculated using the model for each residential area and in front of the Day Weir located at the end of the area. The model was also used to analyze a hazard map with the highest velocity, and the flooded area at each hour with three different discharge flows from the Van Coc Gate. The difference of the velocity, water level, and flooded area between the two cases of the Manning's coefficient was shown from the simulations.

2. Materials and methods The Lake is a floodplain, the floodwater flows have smaller horizontal variation than vertical one. Therefore, a two-dimensional depth-integrated model is applied herein to simulate the floodwater in the area. The shallow water equations used in this study are as follows:

Continuity equation:

$$\frac{\partial \eta}{\partial t}+\frac{\partial}{\partial x}\{U(h+\eta)\}+\frac{\partial}{\partial y}\{V(h+\eta)\}=0 \tag{1}$$

Momentum equation in the x and y directions:

$$\frac{\partial U}{\partial t}+U\frac{\partial U}{\partial x}+V\frac{\partial U}{\partial y}=fV-g\frac{\partial \eta}{\partial x}+v_h\left(\frac{\partial^2 U}{\partial x^2}+\frac{\partial^2 U}{\partial^2 y}\right)-\frac{gn^2U\sqrt{U^2+V^2}}{(h+\eta)^{4/3}} \tag{2}$$

$$\frac{\partial V}{\partial t}+U\frac{\partial V}{\partial x}+V\frac{\partial V}{\partial y}=-fU-g\frac{\partial \eta}{\partial y}+v_h\left(\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial^2 y}\right)-\frac{gn^2V\sqrt{U^2+V^2}}{(h+\eta)^{4/3}} \tag{3}$$

where U and V are the depth-averaged horizontal velocity components in the x and y directions; η is the water level; t is time; h is the water depth; f is the Coriolis parameters; g is the gravitational acceleration; n is the Manning's coefficient of roughness; and v_h is the coefficient of the eddy viscosity. In this study, in order to assess the effect of Manning's coefficients, the model simulated for two cases as follows: case 1: n=0.035 to 0.172 s/m$^{1/3}$ depending on the vegetation, obstructions, and house areas; and case 2: n=0.035 s/m$^{1/3}$ for all the mesh. A leapfrog finite difference method was applied for the numerical solution. In order to represent the phenomena of inundation, the wet and dry scheme (Uchiyama, 2004) is applied to treat each wetting and drying mesh. As written above, an emergency plan is considered to store the floodwaters from the Red River into the Van Coc Lake in order to

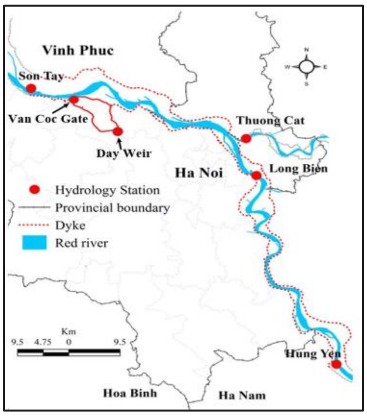

Fig.1 The research area

---

*Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University ** Faculty of Agriculture, Kyushu University
*** Division for Water Resources Planning for the North Region, IWRP

Keywords: Day river system, Day weir, Red river, Two-dimensional depth-integrated model, Van Coc Lake

protect Hanoi city from flooding. In this plan, floodwaters will discharge into the area from the Red River with 2,500 m^3/s. Therefore, the model simulated the discharge and the other discharges with Q = 1200 m^3/s and = 600 m^3/s to compare the results.

3. Results and discussion Before simulating the flood in Van Coc Lake, the model was validated with the observed data in the Red River from 19:00 on 2nd February to 4:00 on 10th February, 2013 at Long Bien Station. Figure 2 shows that the computed water level profiles has good result in comparison with the observed water level profiles. Figure 3 shows that the area will be quickly covered by floodwaters after 5 hours (roundly 90% of the total area with two cases of the Manning's coefficients), with the highest discharge flow at the Van Coc Gate. A significantly different trend of the flooded area was found during the first 2 h between cases 1 and 2 with the discharge flows of 2,500 m^3/s and 1,200 m^3/s. However, the trend did not occur with the smaller discharge flow of 600 m^3/s. After 2 h, the difference trend with the two bigger flows decreased and reached zero in the last hours. In the case of 600 m^3/s, a fluctuation period from the 4th to the 18th hour was observed before decreasing to a steady state and reaching zero in some of the last hours. Figure 4 shows the floodwater behaviors, flooded area in the study area in the most dangerous discharge flow and case 1 for the Manning's coefficient. The floodwaters covered 26% of the area after 1 h. The floodwaters accounted for 48%, 66%, and 81% in the next 3 h. Meanwhile, 90% of the area was flooded only on the first 5 h. The total flooded area was 27 km^2 during the 5th hour. Flooding accounted for only10% of the remaining area of the study area from the 6th to the 12th hour. A flood map for each residential areas will be built in the next step of this research.

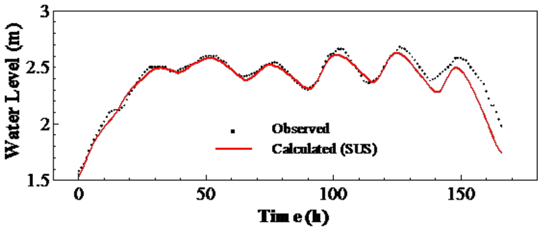

Fig. 2 Comparison of calculated and observed water level

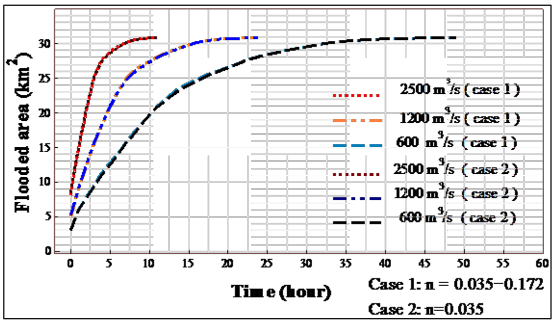

Fig. 3 Period of time until the area is covered by floodwater

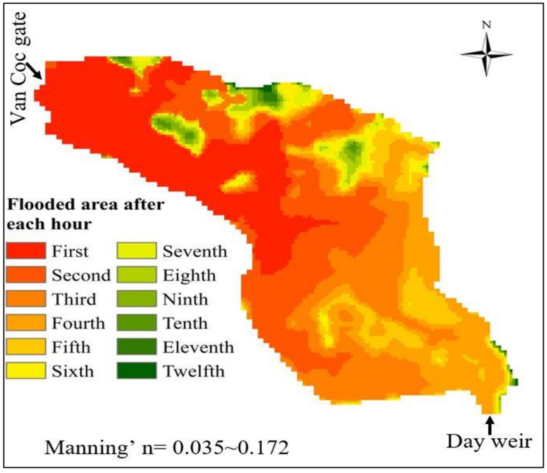

Fig. 4 Flooded areas after each hour in the case of a discharge flow of 2,500 m^3/s at the

4. Conclusion In this study, the area was considered as a buffer zone to receive floodwaters before they can be discharged through the Day Weir if necessary. Three flow scenarios at the Van Coc Gate were considered, that is, 2,500, 1,200, and 600 m^3/s, with two cases of the Manning's coefficient of roughness (case 1: n = 0.035 to 0.172 s/m$^{1/3}$ and case 2: n = 0.035 s/m$^{1/3}$). The results were compared by identifying the two hazard maps of the highest velocity for each cell in the area with the biggest flow (i.e., 2,500 m^3/s) in cases 1 and 2. The locations with high velocity were determined based on these maps. The map of the flooded area at each hour was provided and indicated the visual changes of the floodwaters in the area.

References

Uchiyama, Y., Dec., 2004: Rep. Port and Airport Res. Inst., Yokosuka, Japan, pp.3-21.