Simulation of Flow Characteristics in the Junction of Laishe River and Neishe River in Southern Taiwan Using the Flow-3D Software

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Abstract

In 2009, Typhoon Morakot hit Taiwan, intensive rainfall led to multi-area of landslides in Laishe River and Neishe River watershed (Total landslide area about 340 ha), bringing tons of sediment into the rivers. The bed level of the rivers rose rapidly. Seriously topography changed impacted the flow condition and the ability of channel sediment transport in Laishe River and Neishe River. This study takes the junction of Laishe River and Neishe River as research subject and utilizes numerical simulation software to discuss the flow characteristics in the junction as well as nearby reach at the circumstance of bed level changed. This study utilized Digital Elevation Model (DEM) to analyze the geomorphologic factors in the watershed by ArcGIS software. Moreover, we use numerical simulation software (HEC-HMS and FLOW-3D) to analyze the hydrology of the catchment and the flow condition in the channel. We set the boundary flood discharge with 100 years return period in 24 hours duration. The three-dimensional numerical simulation results show that the flow condition emerges more turbulent in the junction due to the fluid interaction between Laishe River and Neishe River, causing flow characteristics more complex. Through vertical velocity and turbulence parameter analysis, we could estimate the erosion area in the meandering zone. According to the analysis results above, we can realize the downstream flow characteristics effected by the interaction of Laishe River and Neishe River, which could be the basic employment reference of the bank protective works in the future.

Study Area

Laishe River watershed located in the mountain side of Pingtung County. The watershed area is around 4,424 ha, and the mean elevation is approximately 970 m. The average annual precipitation is about 3,265 mm.

River Elevation Analysis

- A. Channel Horizontal Cross Sections Elevation Analysis
- B. Channel Vertical Cross Sections Elevation Analysis

Catchment Hydrology Analysis

- A. Frequency Analysis
  - Intensity-Duration-Frequency Analysis in Laishe Watershed
    - Return Period (year)
    - Lognormal Distribution II (median)

1D River Analysis System

- Parameter Setting in HEC-RAS
  - Manning’s n (W): 0.025
  - Bed Material (C): 0.75
  - Vertical Elevation (T): 0.0265
  - Horizontal Elevation (H): 0.025

3D River Analysis System

- Parameter Setting in FLOW-3D
  - Model Size (m): 500
  - Initial Condition
    - Boundary Condition
      - Flow Change Location
    - Parameter Setting
      - Shape
        - Shape of 3D River Analysis System

Study Procedure & Method

- River Elevation Analysis
  - A. Horizontal Cross sections elevation analysis
  - B. Vertical Cross sections elevation analysis

- Catchment Hydrology Analysis
  - A. Frequency Analysis

1D River Analysis System

- HEC-RAS software

3D River Analysis System

- FLOW-3D software

Results Discussion

- The bed level rose about 10 to 20 m after Typhoon Morakot (200908). However, the channel in our study area shows erosion status in both horizontal and vertical analysis.
- In 1D River analysis, we can observe that the flow nearly inundate all the cross section, which shows the characteristic of braiding. Therefore, it is hard to control flow path in the main channel.
- In 3D numerical simulation, the flow become obviously turbulent due to the interaction between Laishe River and Neishe River. Some complex flow conditions such as vortices, backwater effect may happen in the meandering zone where turbulent energy value is higher than other. It poses a serious threat to the embankment near the meandering zone.

Conclusion

- The flow condition and the ability of channel sediment transport have been still unbalanced in Laishe River and Neishe River since typhoon Morakot in 200908.
- We can analyze the flow characteristics of the junction based on series numerical simulation and reliable parameter settings. The results show that the embankment near the meandering zone might be threatened by the interaction of the flow.
- Although the simulation is in rigid boundary condition, we can analyze the erosion part depended on z-velocity variation and turbulent number difference obtained from 3D numerical simulation.