Numerical Study of Meandering Effect on Confluence Channel Flow by openFoam

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Abstract Confluence channel flow is complex and it is important in river flow such as mixing and sediment transport. Confluence channel flow changes depending on geometry and hydraulic conditions. Through numerical simulations, effects of tributary channel location and discharge ratio (also, momentum ratio) on meandering confluence channel flow have been investigated. Depending on location of tributary channel, flow pattern in meandering channel is greatly influenced. Shear layer mode is examined through vorticity and Kelvin-Helmholtz mode is shown when velocity of tributary channel is high.

Keywords: Confluence channel flow, Meandering, Flow pattern, Separation, Shear layer

Methods

- Objective : Investigation on effects of geometry and discharge ratio on confluence channel flow
- There are total 72 confluence channel along natural river in South Korea and number of meandering channel is 32.
- It is necessary to understand meandering confluence channel flow pattern.

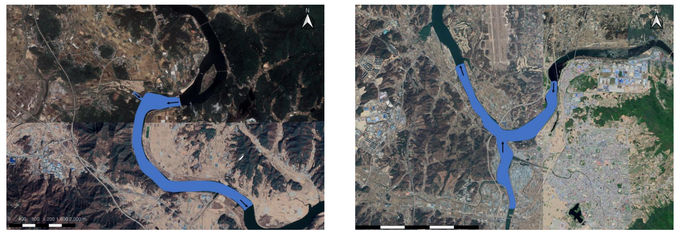

Figure 1: Meandering confluence channel in South Korea

- Computation domain

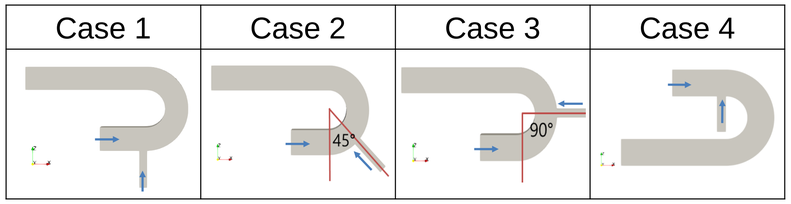

Figure 2: Schematic of computation domain

- Channel height : 15 cm (main) / 5 cm (tributary)
- Channel width : 30 cm (main) / 10 cm (tributary)
- Confluence angle : 90°
- Radius of curvature : 39 cm (1.3W)

- Discharge ratio ($Q_r = Q_b/Q_t$) : 0.125 / 0.3
- CFD tool : openFoam
- Turbulence model : LES with Smargorinsky subgrid model

Results

- Streamwise Velocity

- SPZ length
(a) 0.21 (b) 0.17
(c) 0.15 (d) 0.12
(e) 0.15 (f) 0.13

- SPZ height
(a) 0.093
(b) 0.16
(c) 0.092
(d) 0.155
(e) 0.092
(f) 0.09

- SL length
(a) 0.4 (b) 0.2
(c) 0.33 (d) 0.14
(e) 0.14 (f) 0.23

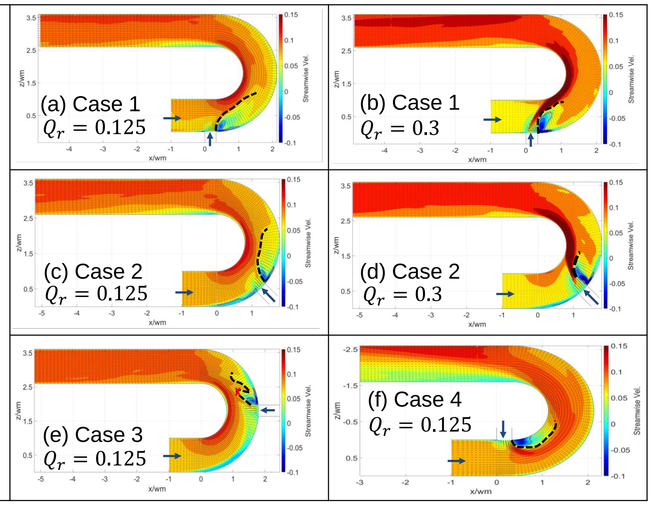

Figure 3: streamwise velocity contour and vector fields at y=0.14 m (0.9h) in each cases and shear layer and separation zone are marked by black dot line and red line respectively
*SPZ : Separation Zone, SL : Shear Layer

- Vorticity

Kelvin-Helmholtz mode for shear layer is showed under high discharge ratio condition.

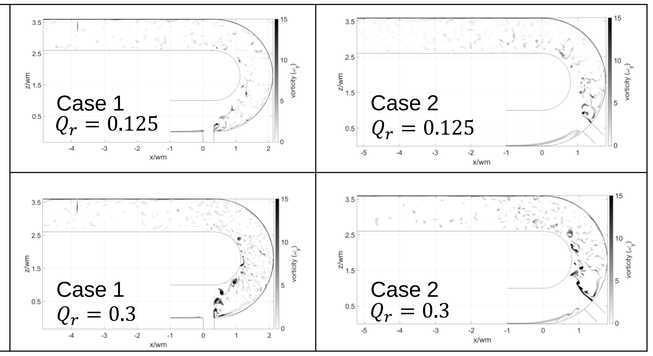

Figure 4: Distribution of vorticity at y=0.14 m (0.9h)

Conclusions

Effects of two parameters, namely (i) the radial location of the joint in half-circular channel and (ii) the discharge ratio (also, momentum ratio) have been investigated. The location of tributary channel and discharge ratio have greater influence on shear layer. On the other hand, separation zone is affected by discharge ratio rather than the branch location. Flow pattern along the meandering channel is affected by location and velocity of tributary channel since distribution of flow velocity in meandering channel is spatially varied. Shear layer mode in confluence channel is classified into wake mode and Kelvin-Helmholtz mode (Constantinescu et al., 2016) which can be decided according to vorticity fields. Shear layer tends to develop in Kelvin-Helmholtz mode when flow velocity of tributary channel is increased.

Acknowledgement

This study was funded by Korea Environment Industry & Technology Institute (KEITI) as Service Program for Demand-Responsive Water Supply, funded by Korea Ministry of Environment (MOE). (2020002650001)

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