Level Set Simulation of Free Surface Flow in Spillway for Fishway Design

IIHR- Hydroscience and Engineering

Haegyun Lee[1], Ching-Long Lin[2], Larry J. Weber[3]

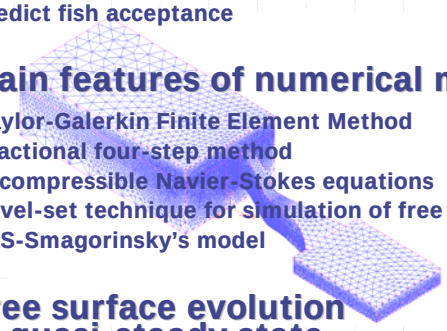
[1]Graduate Research Assistant, Dept. of Civil & Environmental Engrg.
[2]Associate Professor, Dept. of Mechanical & Industrial Engrg.
[3]Associate Professor, Dept. of Civil & Environmental Engrg.

1. Objective of study

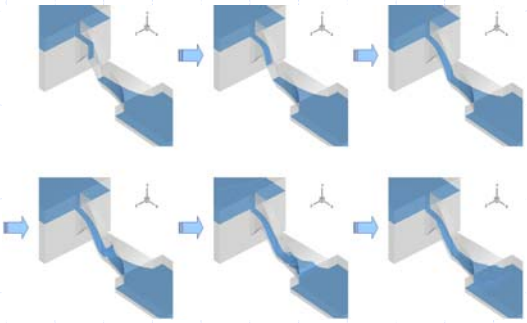
- Develop a state-of-the-art computational fluid dynamics (CFD) model for two-phase flow in complex geometry, based on level-set method,
  (a) to study turbulence structures and free-surface dynamics,
  (b) to determine the discharge and the low pressure regions which may lead to cavitation and
  (c) to investigate the stress and strain distributions on fishway structure
- Validate the CFD model by a physical experiment
- Suggest an optimal design for spillway
- Link simulation results to behavioral models to predict fish acceptance

2. Main features of numerical model

- Taylor-Galerkin Finite Element Method
- Fractional four-step method
- Incompressible Navier-Stokes equations
- Level-set technique for simulation of free surface
- LES-Smagorinsky's model

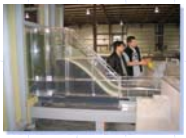


3. Free surface evolution to quasi-steady state



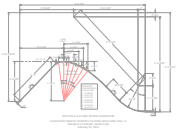
4. Physical experiment

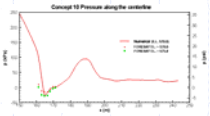
- Juvenile fish passage facility at the Wanapum Dam
- Design Concept-10 (Courtesy of Troy Lyons)
- Discharge of 20,000 cfs
- Laboratory model scale 1:24



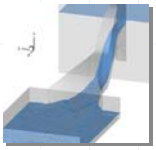
5. Validation of CFD model

- Pressure distribution along the bottom center line

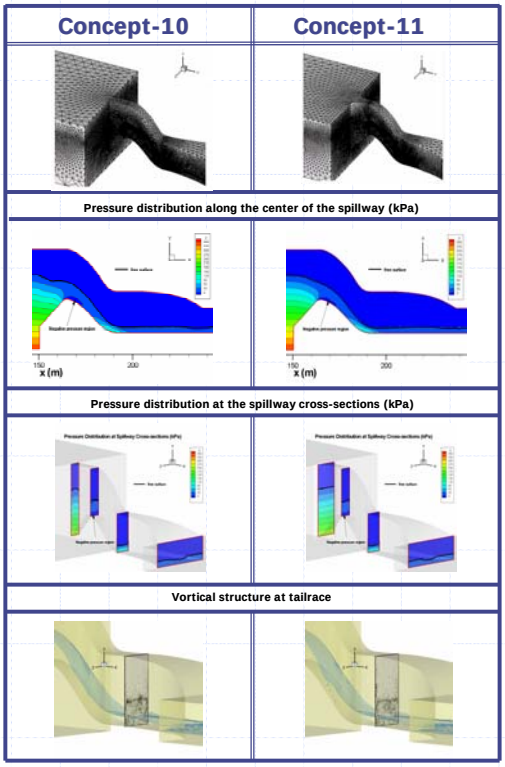




- Hydraulic jump



6. Analysis of two design concepts



7. Conclusions and future study

- The developed numerical code can simulate several flow characteristics observed in the physical experiment.
- More refined experimental techniques are needed to confirm the detailed flow structures found in this study.