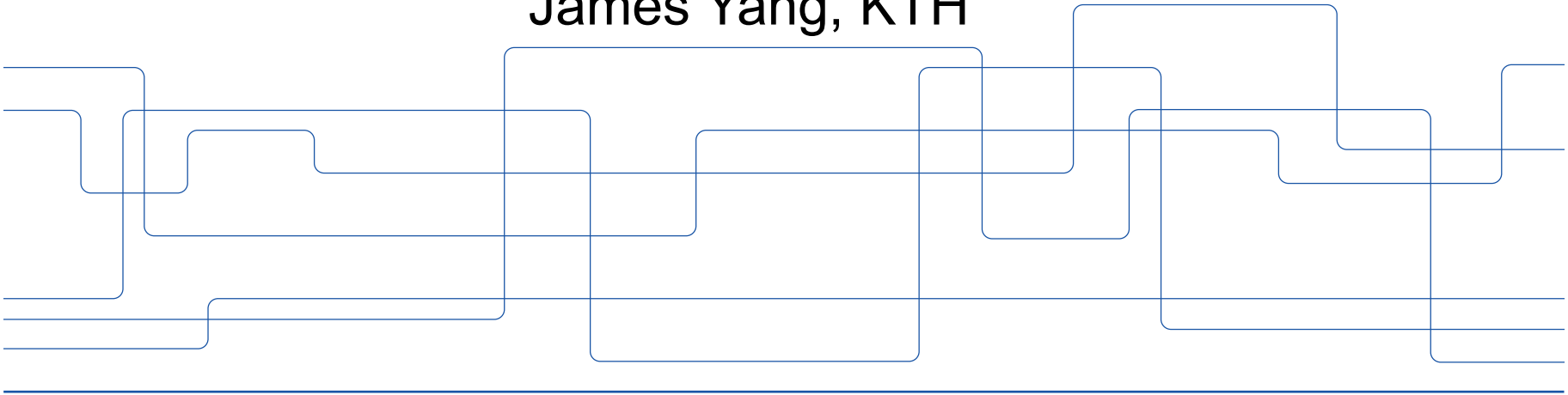
KTH ROYAL INSTITUTE OF TECHNOLOGY

SVC projects & research activities within hydraulic design at KTH

James Yang, KTH

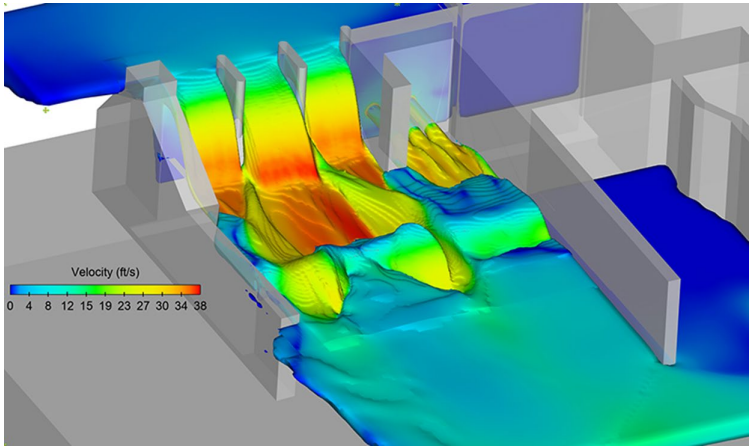


1. Project goals

- To adapt & develop CFD as a tool for analysis of hydraulic issues, incl. two-phase flows.
- To investigate hydraulic loads acting on hydraulic structures and rock foundations.
- To develop solutions/tools for energy dissipation.
- To illuminate current issues concerning discharge capacity & approaches for its enhancement.

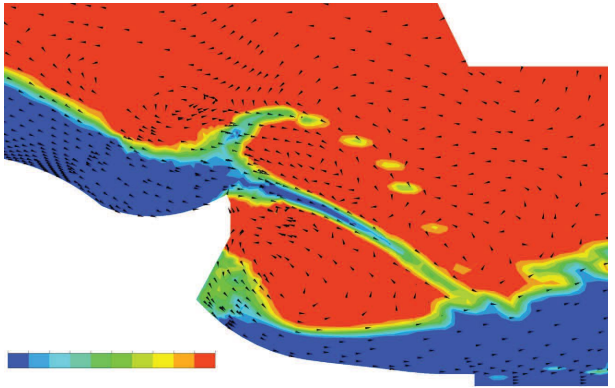
2. Free-surface flows

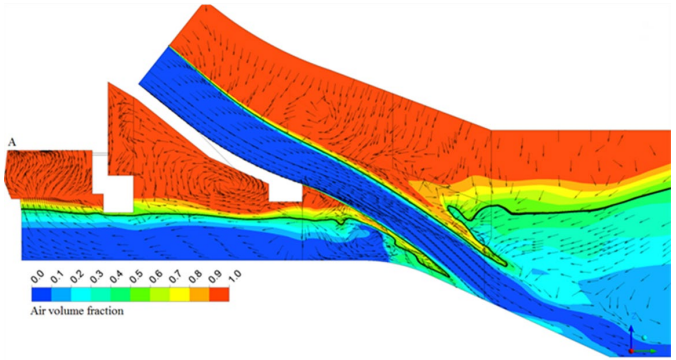
- CFD as a tool for analysis of two-phase flows.
- Quality and Trust



2. High-velocity two-phase air-water flows

- Velocity up to 30-45 m/s
- Turbulence models
- LES, DES (RANS+LES)
- Two-phase flow models
- Population balance model

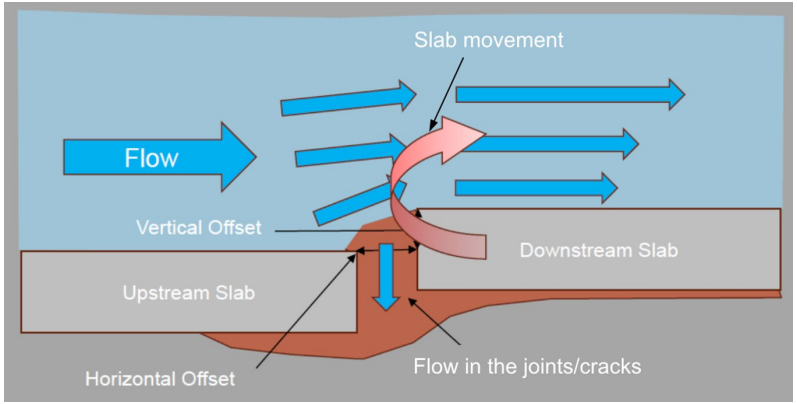


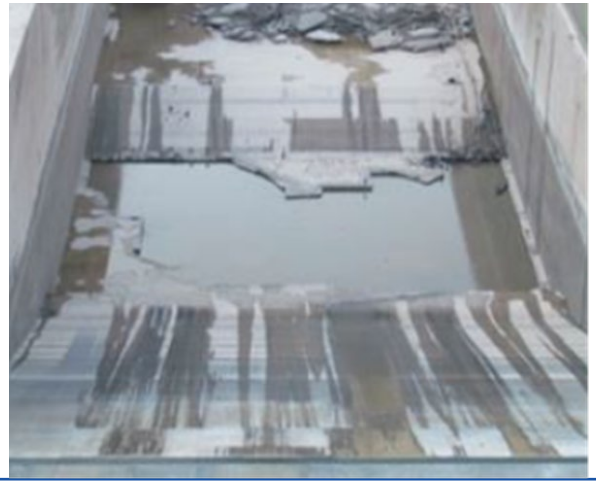


3. Stilling basin damages

- Höljes, Stenkullafors, Långströmmen, Bergeforsen, etc
- New post-doc project

Oroville

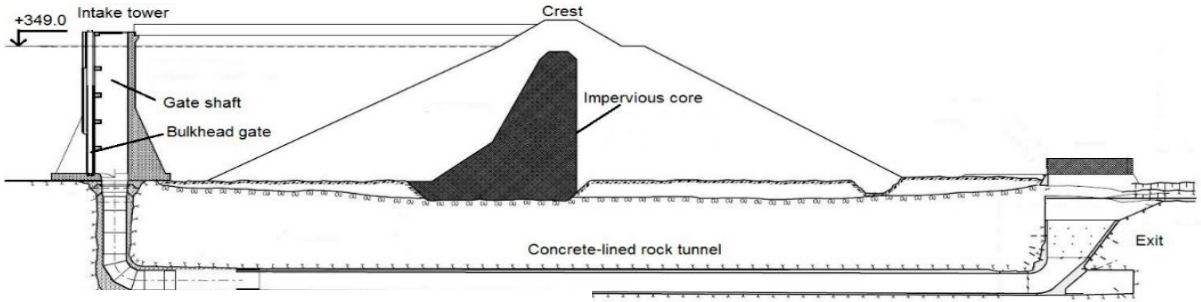


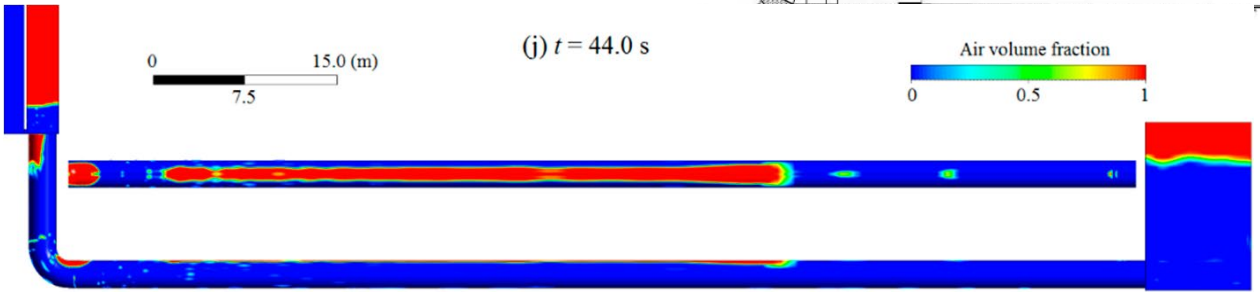


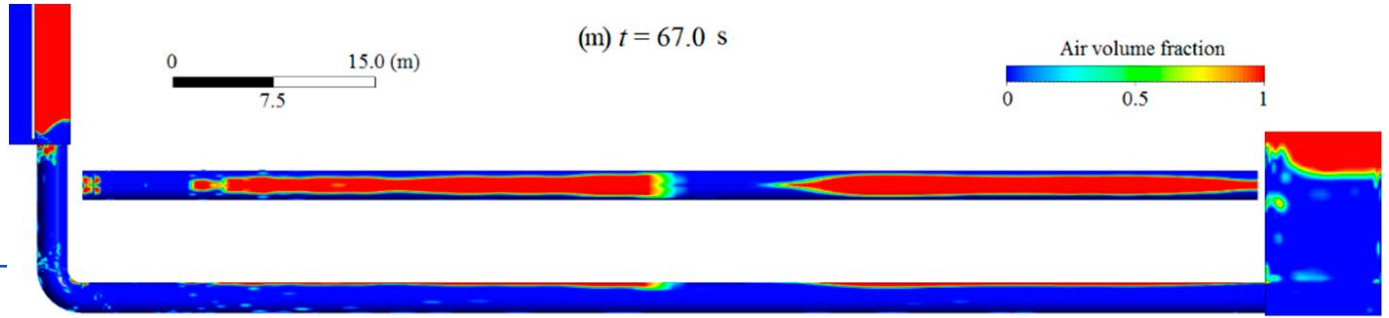
4. Bottom outlets

- 8 out of 9 bottom outlets have operations issues.
- Major concern is attributed to air entrainment.
- Unacceptable flow fluctuations in the system
- Formation of geysers (often blow outs downstream)

5. Bottom outlets







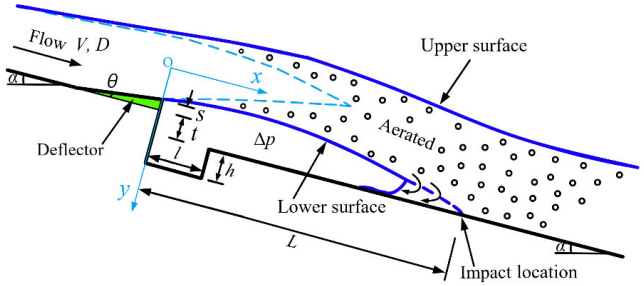
6. Models versus prototypes

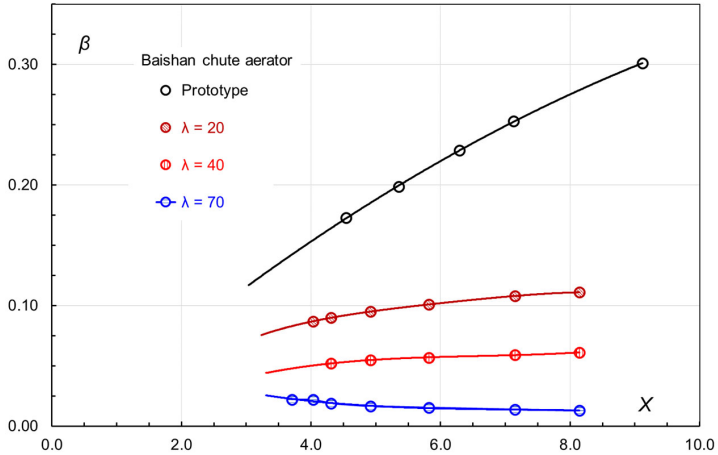
- Air flow in a Froude model is not reproduced.
- Air pressure is not scaled
- Air flow affects water flow (pressure, air concentration in water etc)

Yang, Li, et al. (2022). Plausible differences between the laboratory & prototype behaviors of spillway aerator flows. *Water*, 14(20), 3264.

6. Models versus prototypes

- Based on lab & prototype data, water flow velocity should **exceed 7 m/s** to scale air supply.
- Below this limit, any attempt to upscale is theoretically wrong.
- Still, air concentration and streamwise development can **not** be scaled.





7. Smart solution:
Effective energy dissipation

- To improve energy dissipation in existing spillway
- To mitigate scour risks downstream

7. Smart solution: Effective energy dissipation

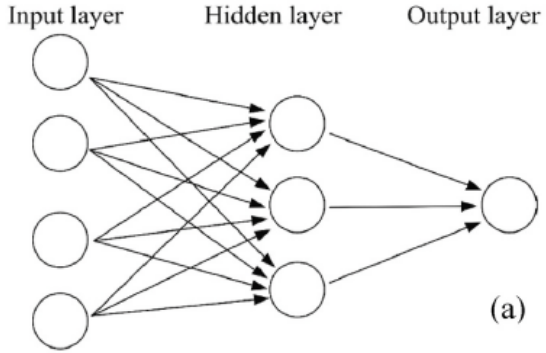
- Dissipate energy
- Air entrainment
- Re-distribute the flow in cross-section
- Models + CFD

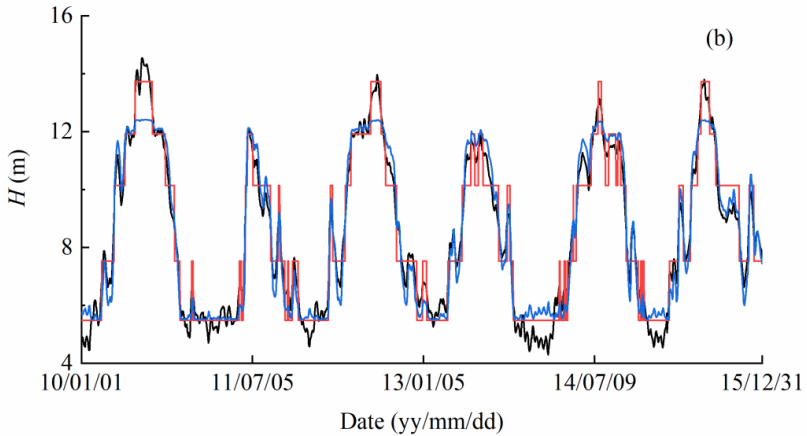
8. Innovation:
Enhanced discharge capacity

- Most dams features an increase in Q by 20-50%.
- Effective discharge structure reduces costs significantly.
- Project going on now.

9. Machine Learning (ML) technique

- Different methods & their combinations
- Useful approach in data mining
- To check historical data quality (water stage, uplift, seepage etc)
- Steady-state & Time series prediction
- Flow, sediment, discharge, energy dissipation, etc





Li, SC & Yang, J (2022). Improvement in river water-stage forecasts by ensemble learning. *Engineering with computers*, https://doi.org/10.1007/s00366-022-01751-1.

10. International collaboration

- Many other countries are more “Hydraulic” than we are.
- Cost effective to use each others’ laboratory resources
- More productive researchers

Reflections?