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UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Optimisation of Stilling Basin Chute Blocks Using a Calibrated Multiphase RANS Model

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Air-water flows common in hydraulic structures.

2. Model description

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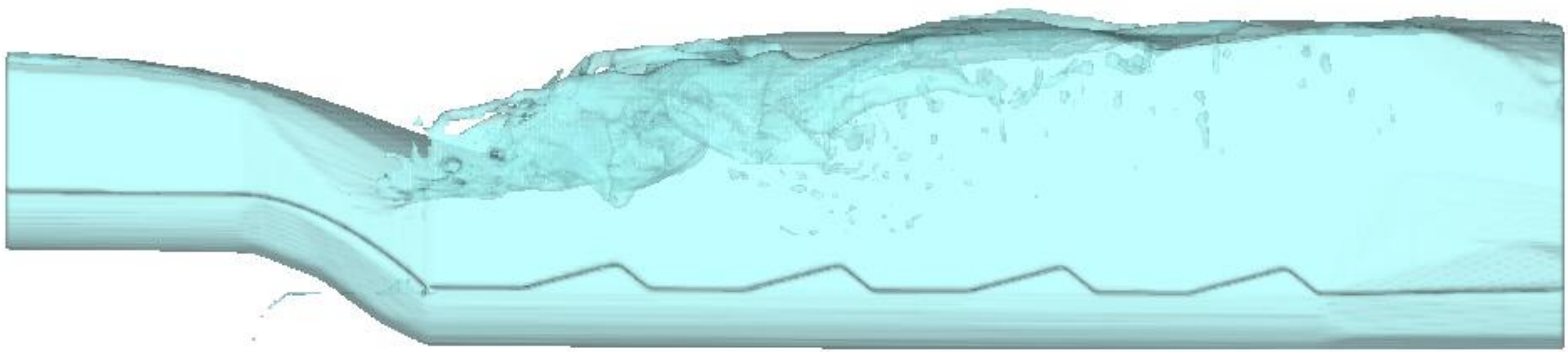
Main numerical options:

- VOF
- RNG $\kappa - \varepsilon$
- 2^{nd} order advection

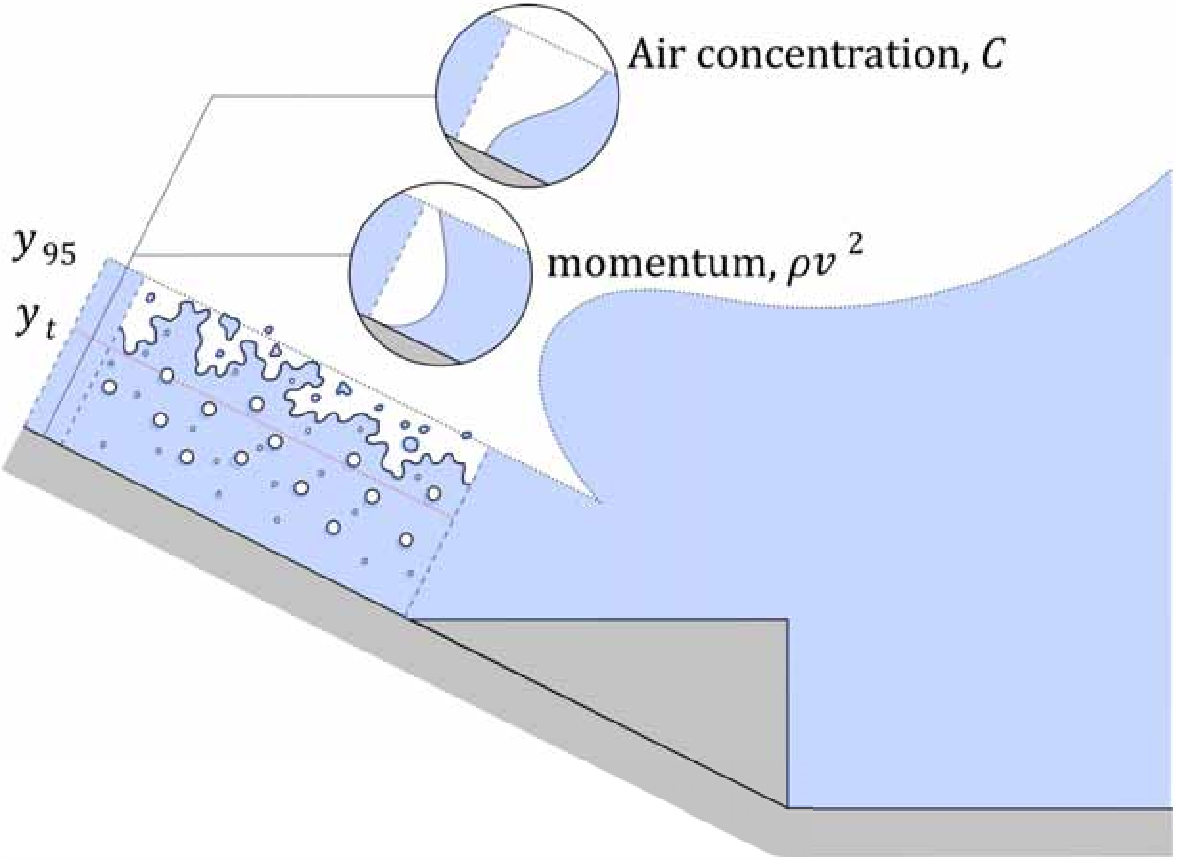


Air-water interactions

$$\bar{C}_{total} = \boxed{\bar{C}_{ent}} + \boxed{\bar{C}_{rough}}$$

$\bar{C}_{rough}$ → VOF, RNG $\kappa - \varepsilon$

$\bar{C}_{ent}$ → **Subscale** turbulent air entrainment model



2. Model description

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Air entrained (calibrated subscale model)

Stabilazing force: $P_d = \rho g_n L_T + \frac{K\sigma}{L_T}$; $L_T = C_\mu \sqrt{\frac{3}{2}\frac{\kappa^{3/2}}{\epsilon}}$

Perturbing force: $P_t = \rho\kappa$

When Pt > Pd:

$$\delta V = C_{air} A_s \sqrt{2\frac{P_t - P_d}{\rho}}$$

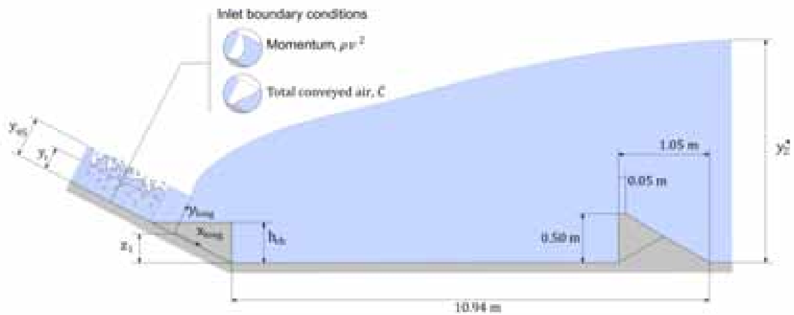
Implicitly coupled with:

- **RANS turbulence model (RNG)**
- **VOF**

3. Scenarios simulated

USBR Type II Stilling basin with 5 chute block heights:

- 0
- $1h_w$
- $3.1h_w$
- $7.1h_w$
- $10.7h_w$



Steady

Analysing the flow patterns within the stilling basin

Tail water = 1.05 conjugate depth

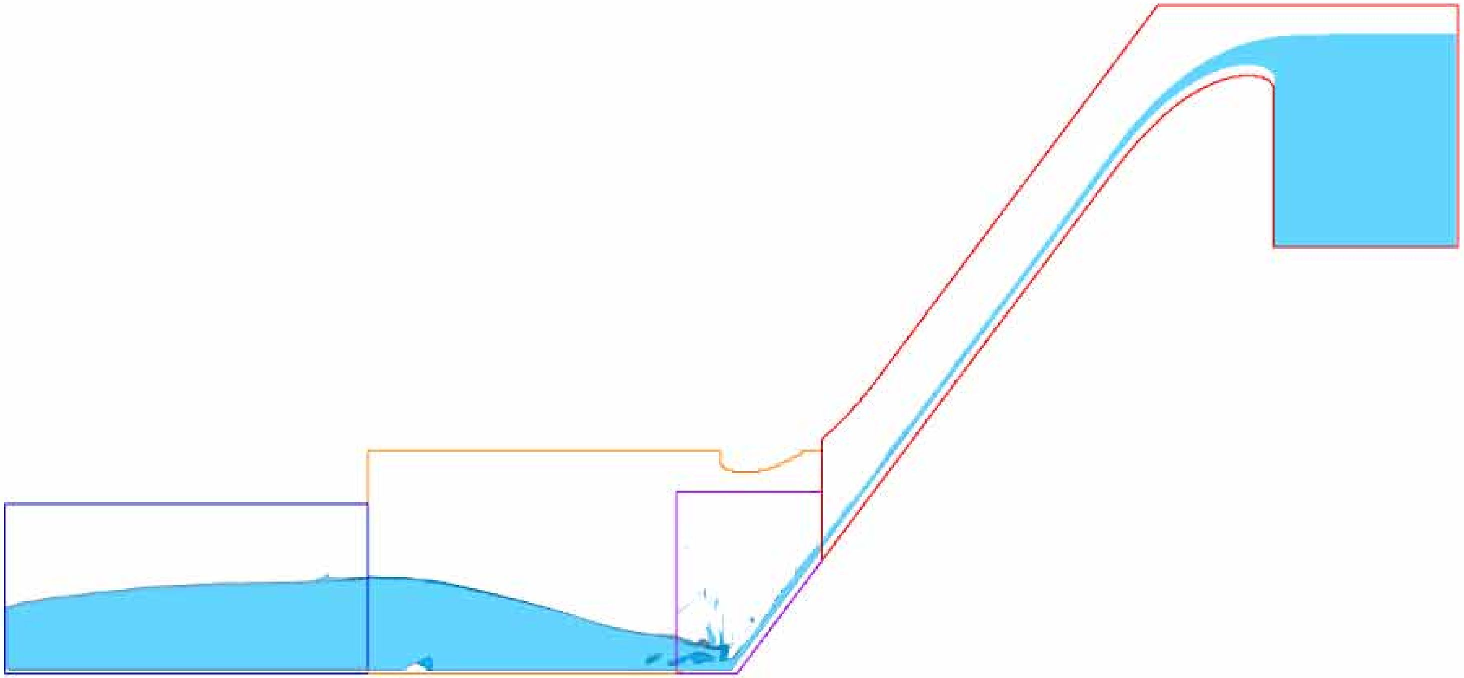
When steady: averaging the solution for 5 seconds

Transient

Analysing the stability of the HJ

Decreasing tail water level until HJ sweeps off.

3. Scenarios simulated



4. Results (steady time)

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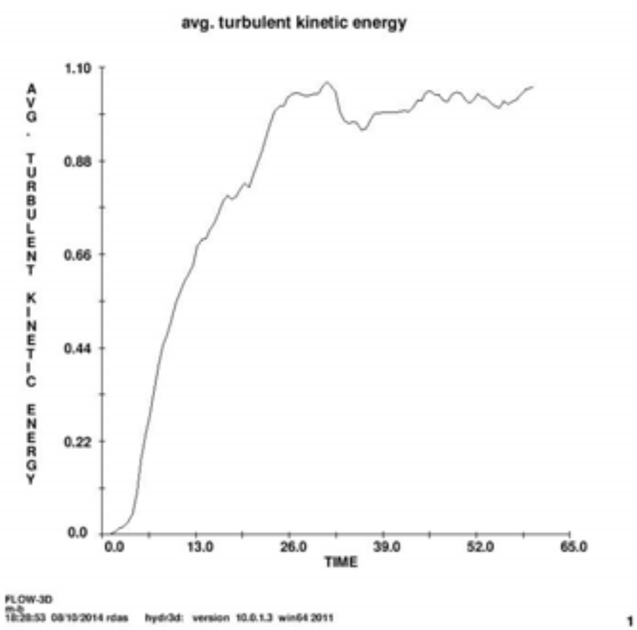

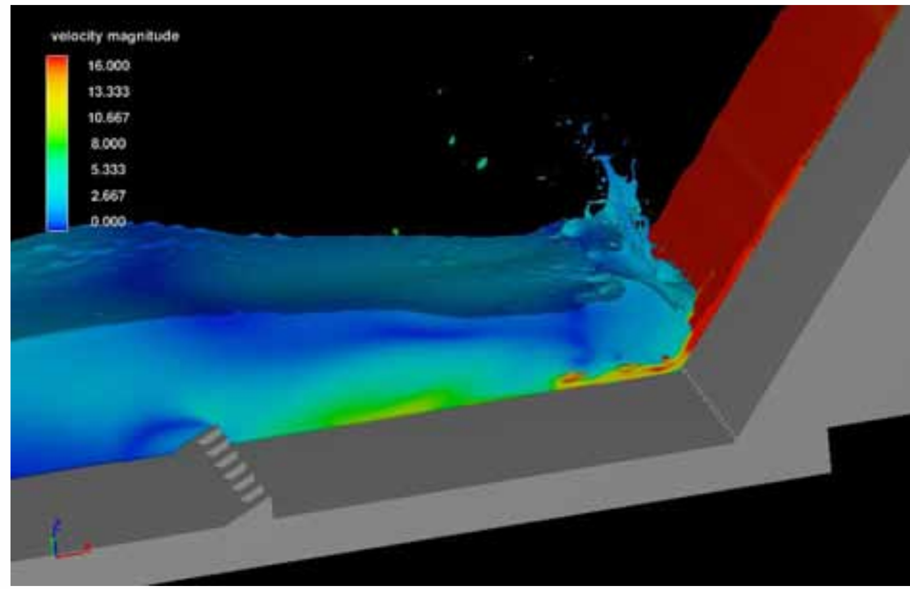

4. Results (common)

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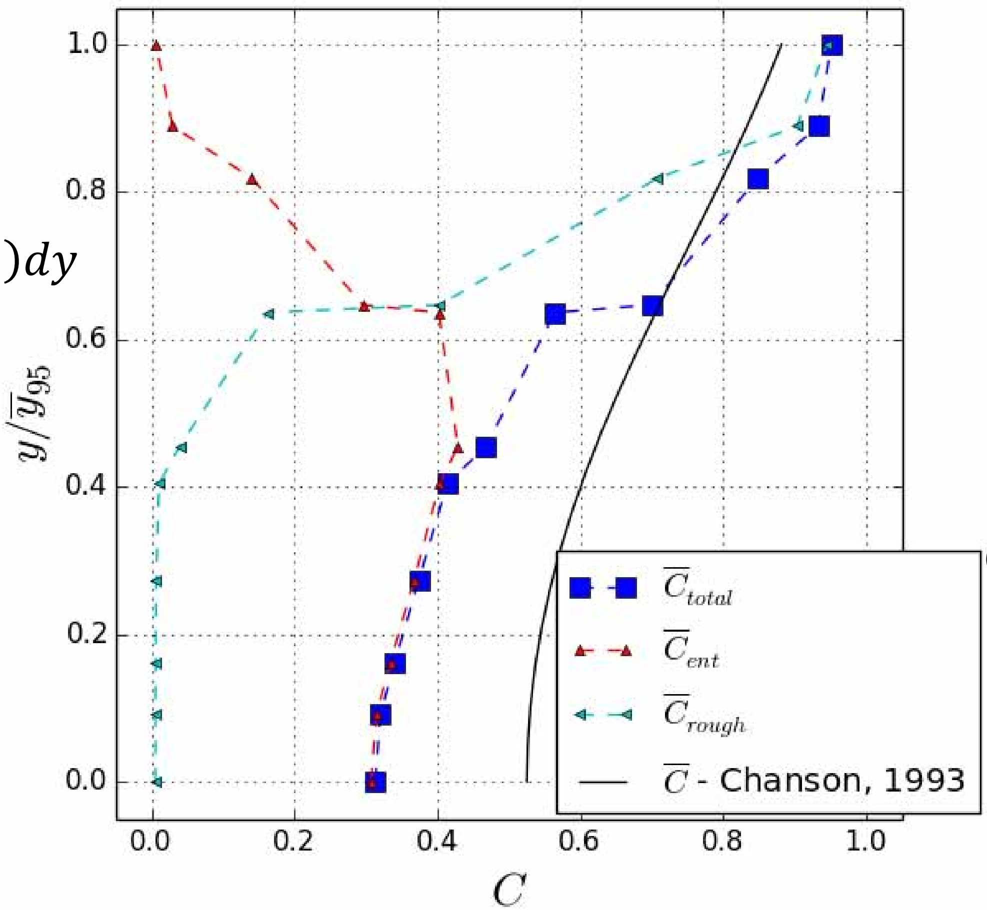
Spillway

$$\bar{C}_{total} = \bar{C}_{ent} + \bar{C}_{rough}$$

$$h_w = \int_{y=0}^{y=y_{95}} (1 - \bar{C}_{total})dy$$



y_t over $C = 0.50$

Literature values

$\bar{C}_0 = 0.52$

$\bar{C}_{total} = 0.63$

h_w = 0.141 m

Computational values

$\bar{C}_0 = 0.31$

$\bar{C}_{total} = 0.57$

h_w = 0.135 m

4. Results (steady solution)

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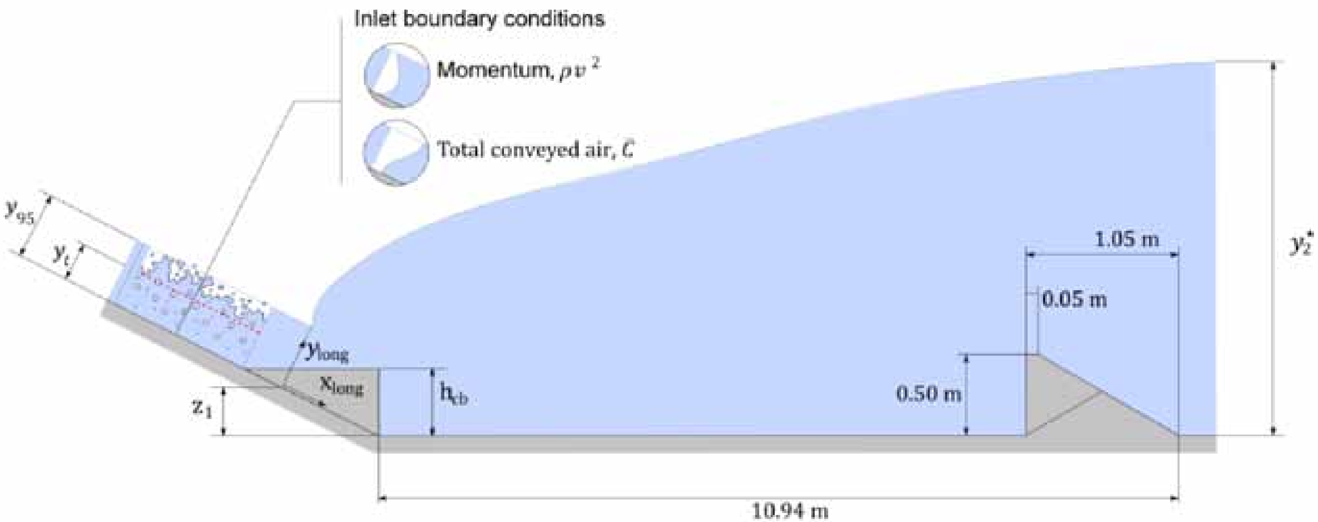

Submergence parameter:

$$E = \frac{{y_2}^* - z_1}{{y_2}^*}$$

h_{cb}	$z_1\ (m)$	${y_2}^*\ (m)$	E
0	2.558	2.672	0.043
$1h_w$	2.277	2.672	0.148
$3.1h_w$	2.533	2.672	0.052
$7.1h_w$	2.696	2.672	-0.009
$10.7h_w$	2.787	2.672	-0.043

4. Results (steady solution)

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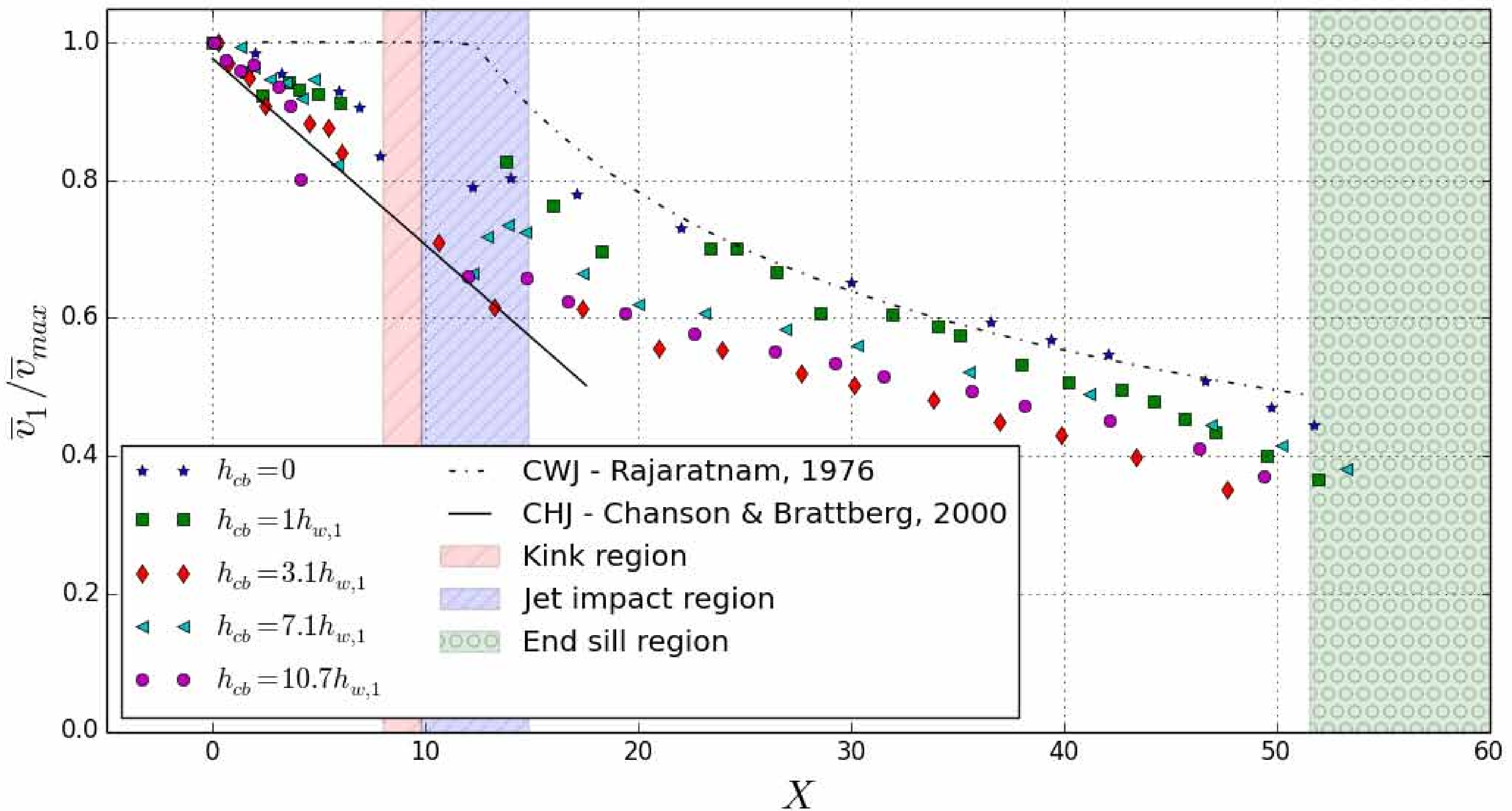

4. Results (steady solution)

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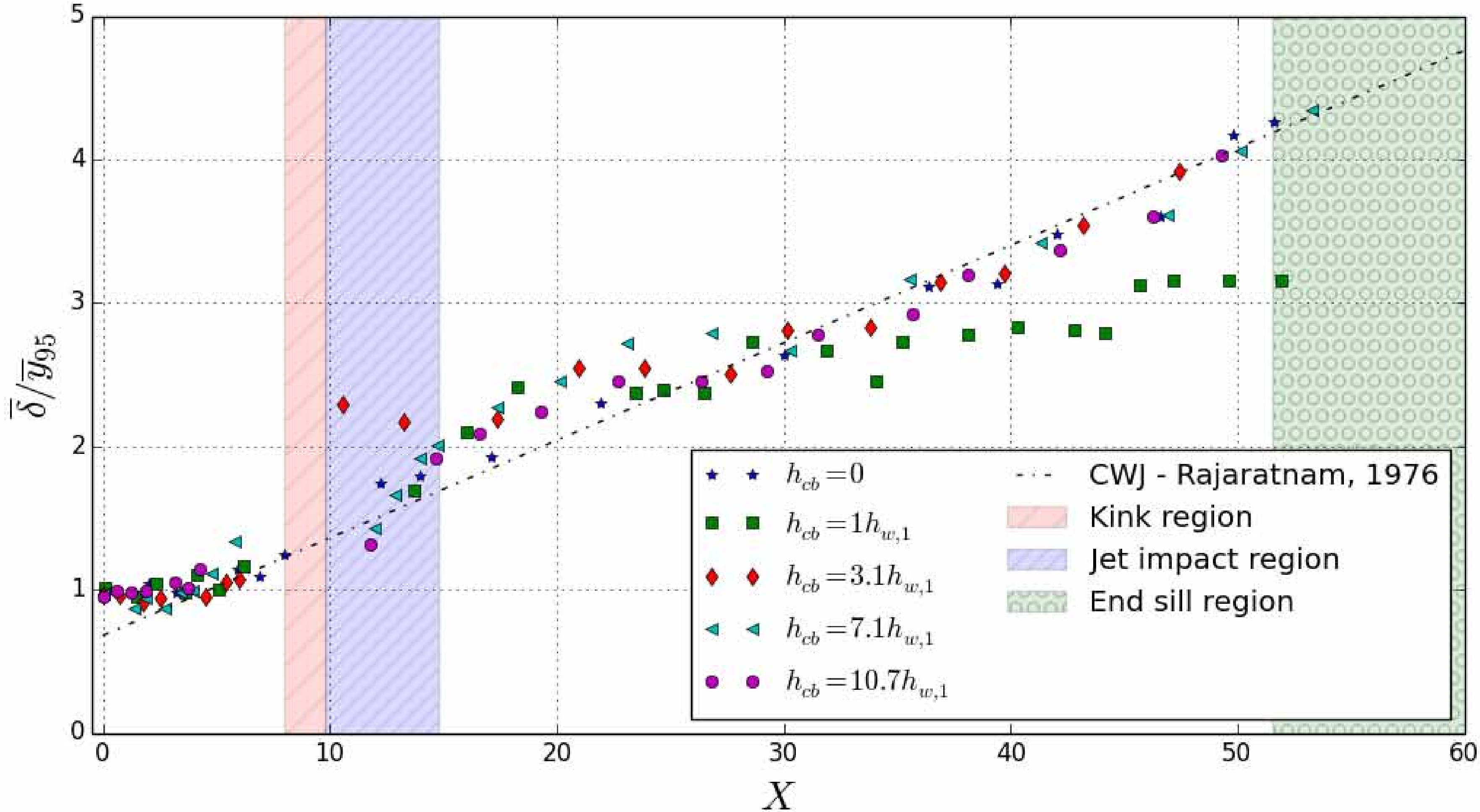

4. Results (transient solution)

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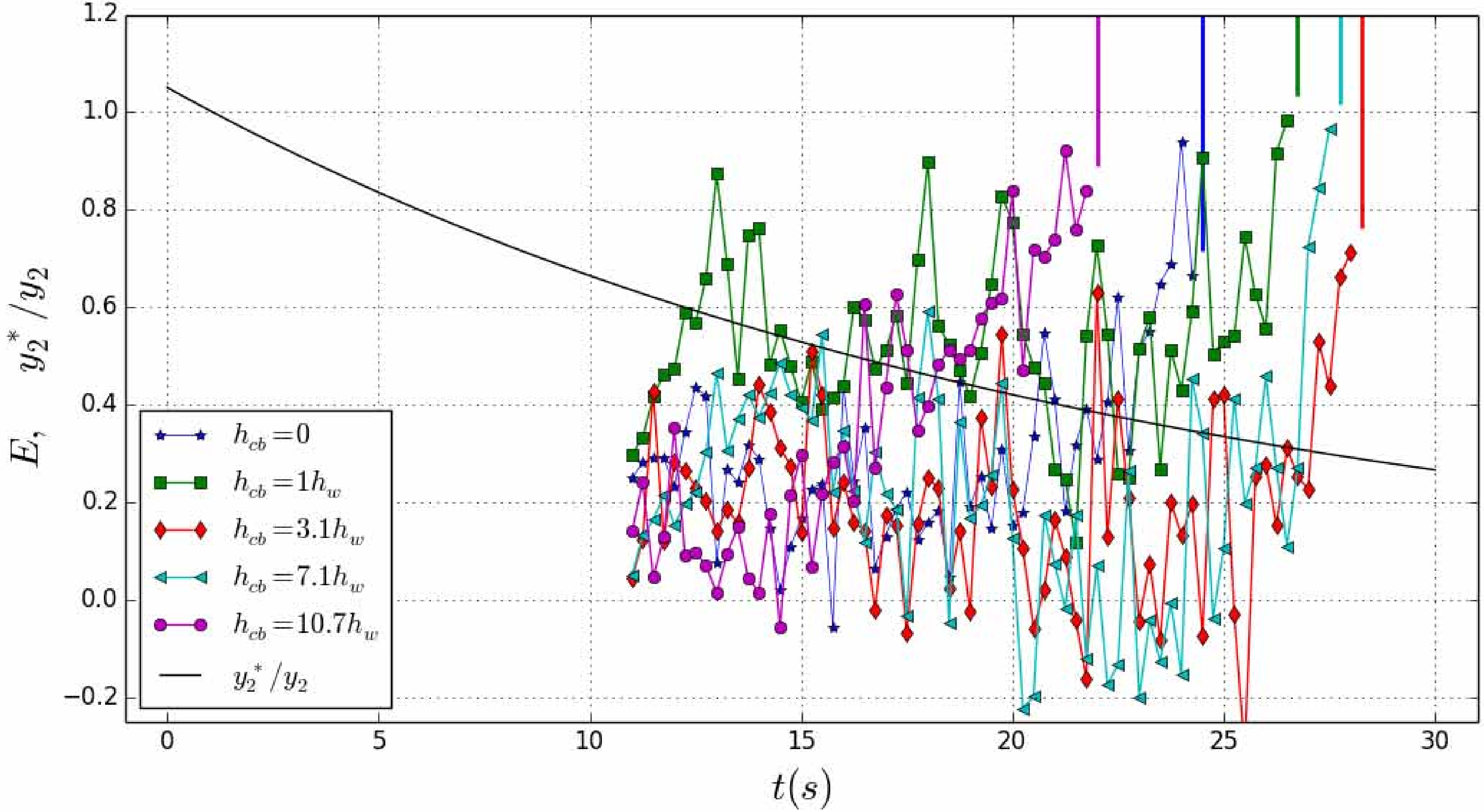

5. Conclusions

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- Multiphase simulation with just one fluid (fast simulation).
- Good agreement with the spillway flow features (entrained-entrapped conc. profiles, equivalent water depth, …).
- Good agreement for B-jump flow patterns.
- Transient analysis in order to study stability of the HJ as time cost efficiently simulation.
- Model limitations (not to forget).

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Thank you for your attention,

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