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SECTION DE GÉNIE CIVIL

Plunging circular jets :

Experimental characterization of dynamic pressures near the stagnation zone

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Motivation and research performed :

Spillways are a requirement for dams' safety, mainly preventing dam over-topping in flooding events. A common spillway solution involves plunging jets which dissipate a considerable energy flow in the plunge pool. Dissipation has to occur in a controlled manner to avoid endangering dam's foundations and the river valley slopes. Indeed, a **scouring process** in the downstream riverbed will inevitably develop until an equilibrium is reached, or else, a pre-excavated or concrete lined plunge pool has to be provided. The master thesis explored general actions due to high-velocity jets focusing on **experimental studies carried out at LNEC, Lisbon**.
Special attention was given to the **dynamic pressures** in the plunge pool floor at the vicinity of the jet **stagnation zone**. Tests involved a **circular plunging jet** with velocity V ranging from 5 m/s to 18 m/s and plunge pool depth Y ranging from 4,2 to 12,5 times the jet diameter D. Differences in dynamic pressure measurements were highlighted between transducers located in the inner and in the outer regions of the jet diameter. Results were analysed, discussed, and compared to previous authors.
Several parameters characterizing the dynamic pressures evidenced trends tied with the jet velocity that, to the author's knowledge, were not found in previous researches. These can possibly be explained by the recirculating currents in the plunge pool, which intensity increases with jet velocity, and are an inevitable consequence of the fixed and limited size of the experimental facility. This aspect deserves further investigation to achieve a better understanding and more complete characterization.

Figure 1 : Kariba dam between Zambia and Zimbabwe in Africa : 6 orifices of the spillway under operation (≈12 000 m³/s)

Figure 2 : Experimental facility at LNEC, Lisbon

Pertinence and main outputs of the experimental work :

- 5 high-precision pressure transducers used near the stagnation point (cf. Figure 3 and 4).
- Through a combination of **analytical** and **experimental work**, the project enabled new insights on stagnation pressures, which are key dynamics loads to the design of spillways and dissipation basins.
- Experimental work achieved for future comparison with Computational Fluid Dynamics (CFD) for the evaluation of jet's power related to scour process → António Muralha's (LNEC/IST) PhD work under development.

> «***One main issue is the challenge of energy dissipation and scour control downstream high-head spillways***»
> - ICOLD Bulletin 2016 -

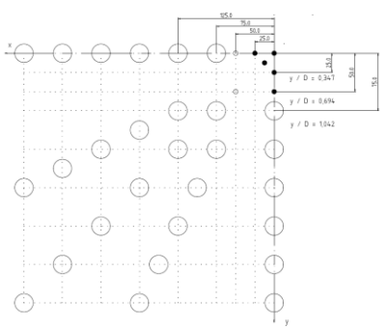

Figure 3 : Top view of locations' choice of the 5 pressure transducers' near the stagnation point (in black shade)

Figure 4 : Pressure transducers and piezometers installed in the facility. After, observing preliminary tests, the research focused on the more central part (stagnation zone)

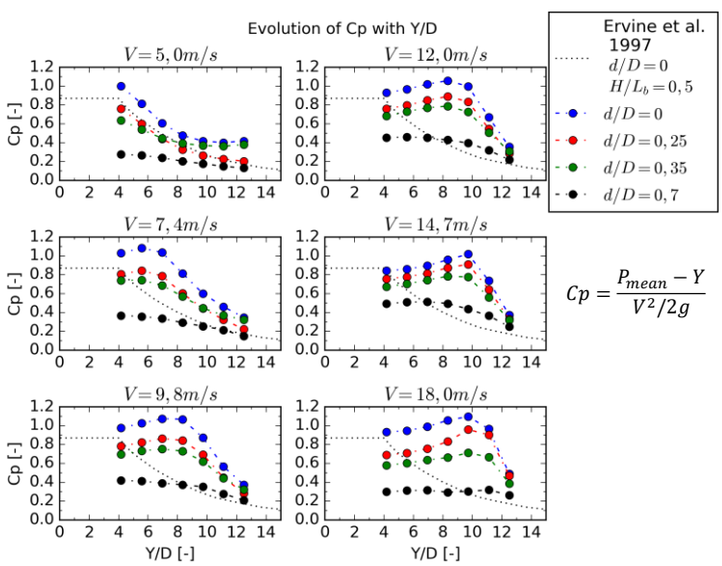

Figure 5 : **Mean dynamic pressure coefficient *Cp*** as a function of the pool depth ratio Y/D**,** a key parameter in the scouring process (*Cf. Report for results in fluctuating coefficient Cp', Skewness, Kurtosis, Power Spectrums).*

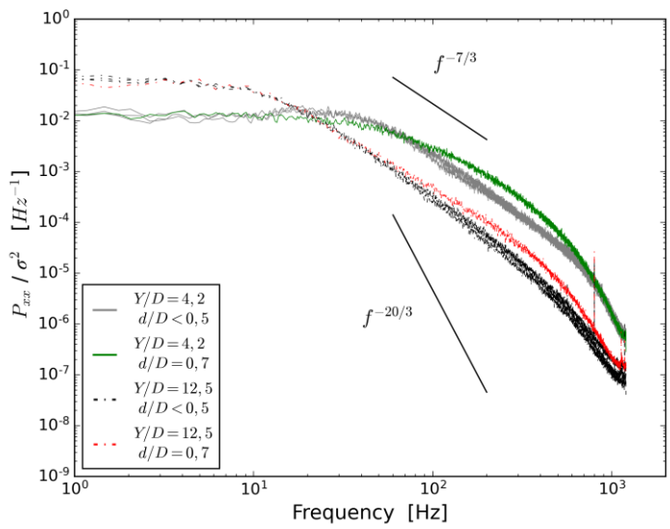

Figure 6 : Influence of pool depth Y/D and radial distance d/D on **non-dimensional spectral content** of jets' impact pressures.
(Graph for V = 9,8 m/s).

Key words : *Scour, spillways, plunging jets, energy dissipation, experimental work, dynamic pressures, stagnation zone.*