DYNAMIC PRESSURES GENERATED BY PLUNGING JETS IN CONFINED POOLS UNDER EXTREME FLOOD DISCHARGES

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The direct impact of falling jets on the riverbed downstream of high dams is often used for dissipation of water energy from floods. Systematic research to investigate the physical processes involved in rock scour is carried out at the Laboratory of Hydraulic Constructions (LCH-EPFL) since 1998 (Bollaert, 2002 and 2004, Manso et al. 2004, Bollaert and Schleiss 2003 and 2005, Manso 2005). Rock scour is a three-dimensional complex process. Natural prototype pools evolve due to operation of dam's water releasing structures and their shape may influence the turbulent flow pattern at the liquid-solid interface. Pressures propagating inside rock joints are directly dependent on those acting at the water-rock interface. Up to present, pool bottom pressures generated by aerated turbulent water jets have only been described for flat pool bottoms.

This paper present experimental evidence of the influence of the pool geometry on plunging jet diffusion, based on direct measurements of the dynamic pressures transmitted to the pool bottom. Systematic model tests were performed with circular jets at prototype velocities impacting on flat and non-flat plunge pools. Lateral confinements with confinement diameter to jet diameter ratios of 5.5, 11 and 16.5 and heights of 2.7, 5.4 and 8.1 times the diameter of the falling jet, were tested (Figure 2). Dynamic pressures were measured at the pool bottom and inside a closed-end underlying fissure at frequencies of 1 kHz. Their accuracy is discussed. Dynamic pressure coefficients and density power spectra are presented. to compare jet impact conditions in flat and non-flat plunge pools. Preliminary results indicate that mean dynamic loads transmitted to the rocky riverbed are reduced when jet diffusion is disturbed by the lateral pool boundaries in comparison to flat wide pools (e.g. Figure 3). Fluctuating pressures seem also to be reduced but a detailed analysis is still ongoing. For shallow pools, jet development is enhanced and resulting fluctuating pressures have more energy at frequencies able of stimulate fissures to resonance. Inside underlying fissures, resonance was observed for a dimensionless pool depth ($Y/D = 4.2$), normally associated to core jet impact. Transient flow regimes relevant for pool bottom slab failure or unlined pools' scour propagation depend therefore on the degree of jet confinement regarding pool dimensions. Knowledge on the interaction between pool geometry and jet diffusion is expected to improve scour predictions and design of protection works.

Keywords: high-velocity jet, plunge pool, dynamic pressures, confinement

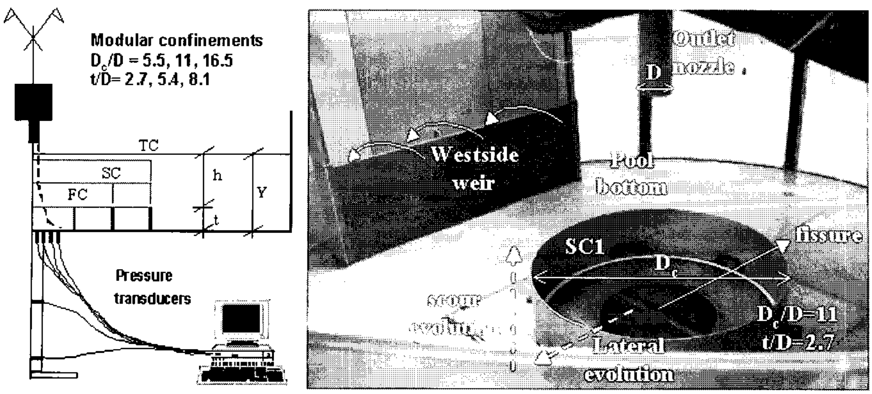

Fig. 2 Detailed cross-section and photo of the experimental set-up. Pressure transducers were alternatively set in the pool bottom at radial distances of y/D = 0.35, 0.69, 1.04, 1.32, 2.08 and 2.78, and along the closed-end fissure (y=0) at axial distances from the fissure's entry of x/D = 5.56 (middle) and x/D = 11.04 (end). The confinements were composed by fixing modular cylinders of diameter D_c and height t.

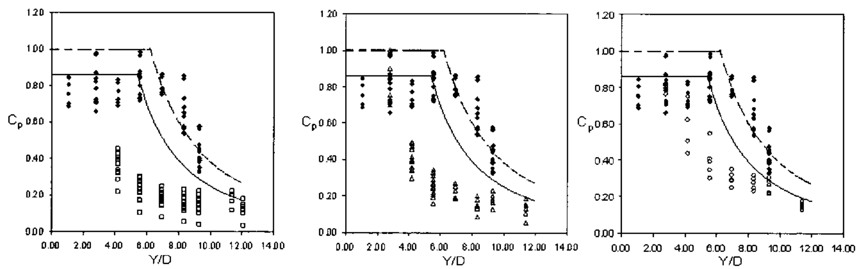

Fig. 3 Dimensionless mean pressure coefficient C_p as a function of the relative pool depth ratio, for flat pools (symbol ◆) and plunge pools with D_c/D=5.5 (FC, symbol □), with D_c/D=11 (SC, symbol Δ) and with D_c/D=16.5 (TC, symbol ○). Comparison with Ervine et al. (1997)'s best fit of data (continuous line) and submerged jet data (dotted line). All FC, SC and TC data are for t/D=2.7 ("lateral evolution") and tests with V >17 m/s.