ETH zürich

Two-phase flow on cascade spillways

Experimentation with the 50° cascade spillway flow was finalized in 1999 and compared with the results of the 30° spillway. The flow resistance and the capacity of energy dissipation over a stepped spillway depend significantly on the relative step height. The 30° spillway has a larger dissipation rate than the 50° spillway because the length of the shear layer along the so-called pseudo-bottom between two adjacent step corners is larger. The large vortices in the step niches permanently consume energy from the main skimming flow above the pseudo-bottom. Further, by increasing the relative step height $k = K/D_h$, the resistance parameter f decreases for 50° whereas f increases for 30° stepped spillways. In the experimental range of about $0.1<k<1$, $f=0.1$ is a typical value. Here K is the height of the step niches measured perpendicularly to the pseudo-bottom and $D_h = 4R_h$ is the hydraulic diameter.

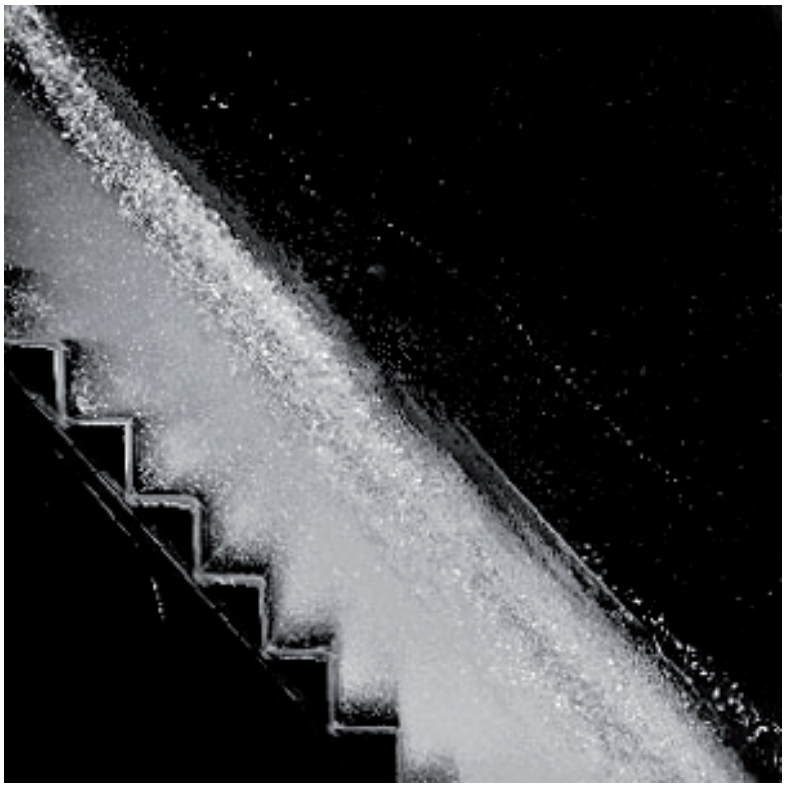

Fig. 1: Skimming flow over steps with K=20 mm, 50°, Fo=4.9, close to the inception point of air entrainment.

Fig. 1 shows a typical flow pattern slightly downstream of the inception point of air entrainment where the black or pure water flow changes to so-called white water. By using a stroboscope it was found that the air concentration along the bottom increases rather rapidly downstream of the inception point. Regarding the particle size, air bubbles are almost spherically shaped close to the pseudo bottom with a diameter of about 0.7 mm, and increase in size up to typically long air pockets of some 50 mm and more close to the free surface.

The results of this PhD Thesis were compared with similar studies and general agreement was noted. The particular feature of the present study was the experimental instrumentation (fiber-optical probe) used for two-phase flow that allowed detailed observation of air concentration and velocity distribution in the white water zone. Some limited observations were also conducted in the step niches.

Main goals

- general hydraulic behaviour of two-phase flow on stepped spillways.
- knowledge of the energy dissipation capacity of stepped chutes.
- provision of design guidelines for stepped spillways.

Keywords:	stepped spillways, cavitation protection, two-phase flow, energy dissipation
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Laboratory of Hydraulics, Hydrology and Glaziology
Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie