PHYSICAL AND 2-D MODELING OF A CURVED AND STEPPED SPILLWAY

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Nowadays, according to the current state of the art, 2-D flow models are often used in the field of hydraulic engineering to investigate multidimensional flow conditions, such as flood run-off in floodplains. Nevertheless, physical models are still built to reproduce highly complex flow conditions and to answer questions of dimensioning. Physical models provide the opportunity to investigate complex flow situations under well-defined and reproducible boundary conditions. For a physical model, it means considerable efforts to modify the model geometry, whereas these variations and, thus, also the investigation of effects of different measures on flow conditions can be done rather easily in a numerical model. This means an important advantage for numerical models compared to physical models. Thus, the question arises, if a numerical 2-D flow model, which currently represents the state of the art in the field of hydraulic engineering, can replace a physical model also for investigating complex flow conditions, since a generated mesh and calibrated numerical model can easily be modified to investigate the effects of various measures on different flow parameters compared to a physical model.

To address this issue, the 2-D flow model HYDRO_AS-2D was applied to a complex geometry with strong variations in bottom topography. The Wienerwald Reservoir with a curved an stepped spillway behind a weir for flood runoff should be adapted to the state to the art. The current weir was planned be replaced by two weirs, situated right-angled, which would lead to rather complex flow conditions requiring a physical model. Hence, a physical model scaled 1:25 was built (Fig. 1) (Wibmer, 2000) consisting of a part of the reservoir, two weirs, the curved and stepped spillway and a part of the river Wien at the downstream end of the model.

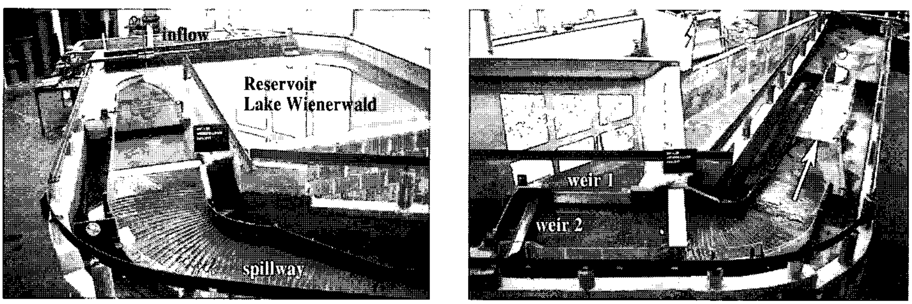

Fig. 1 The physical model consisting of a part of the reservoir, the weirs and the stepped spillway

The 2-D flow model HYDRO_AS-2D was mainly developed for dam-break analysis and flood modeling, but can also be applied to general 2-D flow situations. The model solves shallow water equations in a conservative form by using a finite volume method (Nujic, 1995). Due to its high accuracy and stability it can be effectively applied to complex flow conditions, such as the combination of sub-critical and super-critical flow regimes, as well as to computation of free-surface flows with strong variations in bottom topography (Nujic, 2003). The model HYDRO_AS-2D is widely used in Austria, Germany and Switzerland mostly for modeling flood-propagation problems. It is capable to model different kinds of structures as well as to model flow with steep gradients and therefore well-matched for comparison with the physical model.

The numerical model was calibrated by means of the measured water levels in the reservoir for different discharges ranging from 120 to 270 m^3/s. A careful modeling of the weir overfalls turned out to be the key for calibrating the numerical model. Depending on the discharge, the overfalls over the weirs were submerged or free and, thus, different methods to simulate the weir overfalls had to be applied. Summarizing the results of the model calibration, the best results were gained for free overfall over the weirs with tailwater elevations being lower than the weir heights. These cases were reproduced with high accuracy by the numerical model.

The results of both the physical and the numerical model were compared by means of cross sectional and longitudinal profiles of the water levels for three different discharges. The comparison of the cross sectional measurements and simulations exhibits that the main characteristics of the water level in the curve of the spillway - the increasing water level at the outer wall of the curve which is important for the capacity and safety of the construction - can be reproduced by the numerical model. The longitudinal profile of the water levels along the outer wall also mirrors the essential features. Both the calculated elevation of the water level and the location of the maximum water level agree with the results of the measurements. The results of the measurements as well as of the simulations prove the missing discharge capacity of the spillway for the design discharge since the water levels exceed the height of the outer wall by almost 2.0 m.

It has been shown, that 2-D numerical models are nowadays capable to cope with different and very complex hydraulic situations. The difficulties or inaccuracies may however arise due to shallow water assumptions when trying to model some kinds of structures. Experience shows that for example a broad-crested weir could be successfully modeled by depth averaged equations, but greater inaccuracies may arise in a case of short crested weirs. Such situations should be preferably modeled by using a weir type of equations. Accurate values of weir coefficients should be however provided in this case which are sometimes difficult to estimate accurately. One possible way to solve such kind of problems effectively would be to model only structures in a physical model and use the gained experimental data to calibrate a numerical model (hybrid type of model).

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