Revitalisation of the Limmat - Instream structures and 2D simulation of the flow-structure interaction

The 1 km residual flow section of the hydropower plant Letten in Zürich (operated by ewz) is situated in an urban area between the parc of Platzspitz and the river bath Unterer Letten. The straight river section has a limited and uniform flow pattern and the riverbed is poorly structured with little depth variability. The ecomorphological level is classified as strongly restricted (AWEL, GIS ZH). The revitalisation should provide habitats for rheophile fish species such as grayling, nase and spirlin, and facilitate the migration of the lake trout. The river section is delimited by a main street and the levee towards the headrace channel of the Letten power plant, thus the restoration is strictly restricted to the riverbed.

The pre-project (SIA phase 31) of the flow section restoration includes permanent instream river training structures supplied with local organic measures like rootstock. Instream river training structures, so-called micro groynes, are inclined structures consisting of stones, which are directly built into the riverbed with almost no intrusion in the levee. The micro groynes are submerged structures typically protruding about 10 to 20 cm from the riverbed, providing a bank protection and a diversification of the bed morphology. Micro groynes guide the flow energy towards the centre of the channel, where the riverbed sediment is mobilized and thus create ecologically valuable scour pools and deposition areas.

In this project, two-dimensional numerical simulations of the river reach were used to design and model the micro groynes and to study the flow-structure interaction in case of low flow and for a major flood. Two computational meshes were generated using QGIS v3.12 and BASEmesh v1.4.5 and four hydraulic simulations were performed with BASEMENT v3.0.1. For the low flow condition, the result of the numerical simulation displays the influence of the micro groynes on the flow path, which creates a low flow channel. For a major flood event, the result of the numerical simulation demonstrates that the micro groynes are not increasing the flow depth in the channel.

One of the main challenges was the implementation of the micro groyne structures into the computational mesh. Numerical simulations with BASEMENT v3.0.1 seemed appropriate to accurately display the edges of small structures like micro groynes using the cell-based elevation attribute of the computational mesh. In order to maximize the impact of the micro groynes on the flow, the interpolation method “maximum” was assigned to the micro groynes, while the interpolation method “minimum” was assigned to the riverbed.

Another challenge was the accurate representation the flow-structure interaction, i.e. the resulting helicoidal secondary flows, which influence the sediment transport, the flow velocity and the shear stress. The flow-structure interaction during low flow was assessed by comparing the resulting velocity distribution before and after the implementation of the micro groynes. Inclined micro groynes locally increase the flow velocity at the tip and between the groynes, while de velocity in the micro groyne area near the levee is reduced. The formation of a low flow channel is reinforced. In case of a major flood event, the resulting water surface elevation distribution before and after the implementation of the micro groynes were compared to assess the effect of the instream structures on the flood safety. As a result, the micro groynes do not influence the flood safety of the reach but generally lead to lower flow depths as without the micro groynes.

In addition, one hydraulic simulation was performed with BASEMENT v3.1 using the tracer feature to test its ability to display the helicoidal secondary flows at high submergence.