ENERGY DISSIPATION AND ECOLOGICAL PASSABILITY AT THE FLOOD RETENTION BASIN NEUWÜRSCHNITZ

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Abstract

During the period September 2010 – April 2011 the Institute of Hydraulic Engineering and Technical Hydromechanics (IWD), Technische Universität Dresden, performed a model test series to investigate the planned flood retention basin Neuwürschnitz by order of the State Reservoir Administration of Saxony. The structure consists of a rockfill dam with a combined corridor structure in the middle of the dam including two outlets and a spillway. The energy dissipation takes place in a depression shaped plunge pool. Central issues of the investigation were the performance of the outlets and the spillway as well as the effected energy dissipation in the depression basin considering three scenarios. The paper reports about the main observations and findings of the model tests.

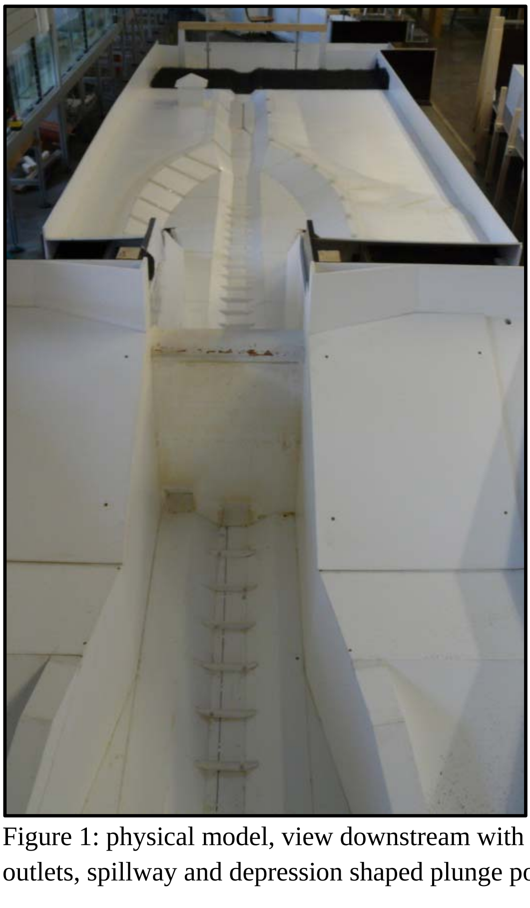

Figure 1: physical model, view downstream with corridor, outlets, spillway and depression shaped plunge pool

Introduction

In response to the extreme floods in Saxony in August 2002 flood management concepts had to be revised. Based on feasibility studies a number of reasonable locations for flood retention basins were detected. To meet the requirements of the EU Water Framework Directive (WFD) conventional hydraulically optimized structures have to be modified to ensure the migration of aquatic organisms.

The planned flood retention basin Neuwürschnitz is located in Saxony, about 30 km south of the city of Chemnitz. With a crest height of 14 m above ground and a crest length of about 500 m, the rockfill dam provides a flood retention volume of 923 000 m³.

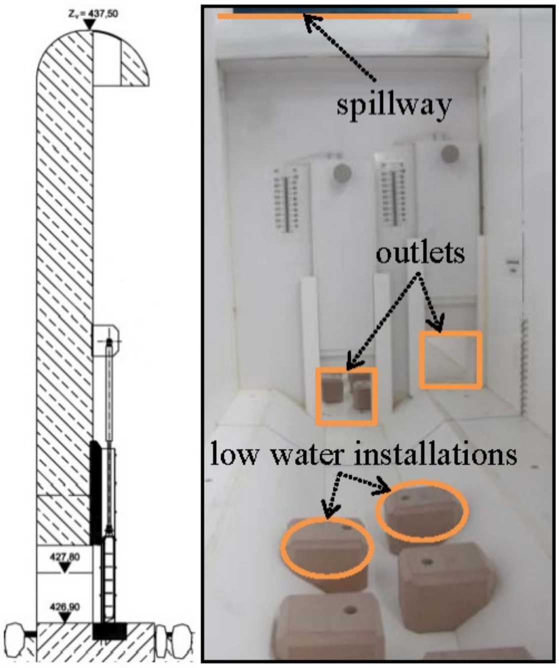

Figure 2: cross section flood retaining structure; physical model, view upstream with spillway, outlets and low water installations

Combined in one corridor structure in the middle of the dam two outlets with the dimensions width x height 1,4 x 1,4 m and a 6,6 m wide spillway are installed (Figure 2). During low water periods the outlet at the river bed is permanently open and ensures the ecological passability. Due to installations on the river bed the flow is forced into an alternating course, while a minimum water depth is provided. In flood conditions both outlets are in operation to regulate a specific outflow.

Considering aspects of landscape aesthetics and the migration of benthic invertebrates a depression shaped plunge pool is chosen to dissipate the energy (Figure 3). While the corridor features a longitudinal slope of 1 % the depression shaped plunge can be divided into three sections distinguished by the longitudinal slopes 5 %, 0 % and -5 %. In total the plunge pool offers a length of about 35 m, a width of 21 m and forms a pool with 0,8 m depth.

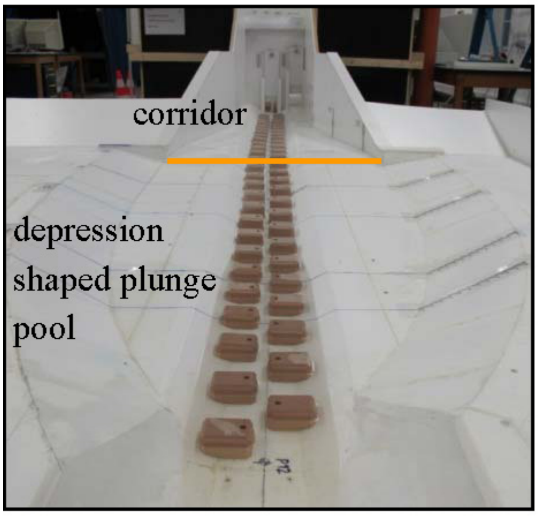

Figure 3: physical model, view upstream with plunge pool and corridor

Method

In order to test the design and the operation of the outlet structure a Froude equivalent model of the Neuwürschnitz dam scaled 1:15 was installed at the Hubert-Engels-Laboratory.

The original design of the dam outlet structures was investigated in a first test series. Following from the findings of this series the IWD offered proposals to enhance the structure. After discussing these with the designer and the awarding authority, the designer proposed a second design. The optimized structure was finally tested in a second test series.

Each test series followed two main objectives:

- to ascertain the hydraulic capacity of each operational structure in single operation and in different combinations
- to investigate the achievable energy dissipation in the depression basin considering the three scenarios shown in Table 1

In the model tests a magneto-inductive flowmeter, three ultrasonic sensors as well as additional benchmarks and a hydrometric vane were used to measure discharge, flow velocities and water depth. The performance was documented by photos and video recordings.

Table 1: operation scenarios

	BHQ_1	BHQ_2	HQ_{max}
total discharge [m³/s]	14,4	29,8	44,3
water depth above spillway crest [m]	0,3	0,4	1,2
operating structures:			
outlet, river bed		x	x
outlet, embankment	x	x	x
spillway	x	x	x

Results

Original design

The hydraulic capacity of the outlets showed to be higher than expected. This led to the regulation to open just 65 % under flood conditions described by the three scenarios. An additional safety buffer is offered this way.

Likewise the spillway's capacity also was sufficient but due to the rounded profile forming 180 ° the overflow was directed to the outlets, Figure 4. To prevent vibrations at the gates the profile had to be changed.

Figure 4: physical model, original design, overflow impacting the outlets

The jet produced by the outlets impinged on the low water installations and resulted in a high diffuse extrusion, Figure 5. This flow pattern had to be changed by modifying the shape of the low water installations.

Figure 5: physical model, original design, jet diffusion at the low water installations

Figure 6 shows the position of the hydraulic jump at scenario BHQ_2, which is 5-7 m behind the entrance of the plunge pool. Thus 14-20 % of the plunge pool length were not used to dissipate energy. High flow velocities in the lower part of the plunge pool led to a massive overflow at the embankments. A higher effectiveness of the plunge pool had to be exceeded by the modifications.

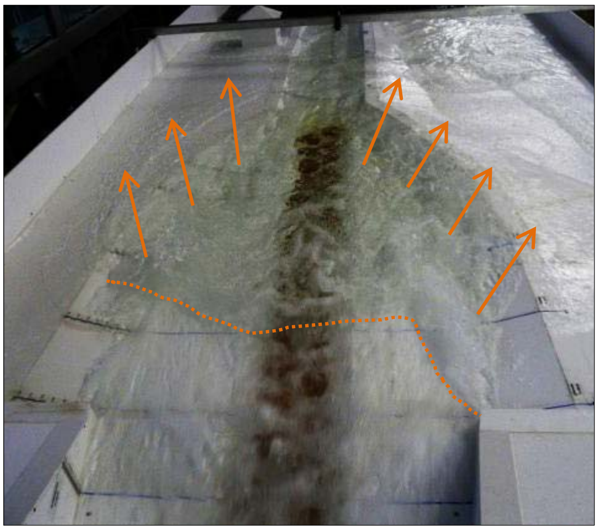

Figure 6: physical model, original design, flow pattern in the plunge pool at scenario BHQ_2

Modifications

The installations in the main water course were changed in order to form the low water corridor with a specific minimum water level. Instead of alternately placed big single stones a pool- and boulder-type pass with crossbars and vertical slots, Figure 7, was installed. The changing of the general construction type implied the limitation of the maximum longitudinal slope to 3 %. To equal the same maximum depth in the plunge pool, the depression was forced to begin directly at the level of the first installed crossbars. The lower parts of the plunge pool remained unchanged.

In order to achieve a jet detachment from the spillways profile and slide the line of impact of the water curtain to tailwater the profile was shortened by 30 °, Figure 7.

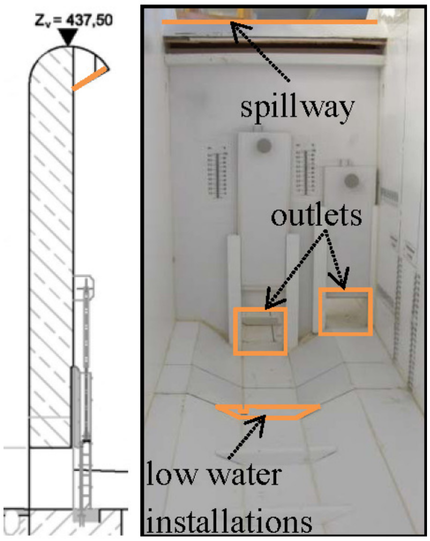

Figure 7: physical model, modified spillway and low water installations

Modified design

The diffuse extrusion at the low water installation was reduced by using the alternative construction.

As intended the shortening of the spillway profile directed the water curtain towards the tailwater, Figure 8, and prevented the impact on the gates. Additionally the hydraulic capacity of the outlets was further increased. This finding was explained by the reduced backwater effect, which occurred while the curtain struck the jet out of the outlets.

Figure 8: physical model, modified design, water curtain directed more to tailwater

The modification of the depression shape shifted the location of the hydraulic jump towards the entrance section of the plunge pool (Figure 9). The more effective utilization of the whole plunge pool resulted in a lower oncoming flow to the embankment of the plunge pool.

Finally, the overflow at the embankment was reduced to a smaller area and a smaller total volume. Especially the left embankment, where the gauging station is located, the accessibility is ensured.

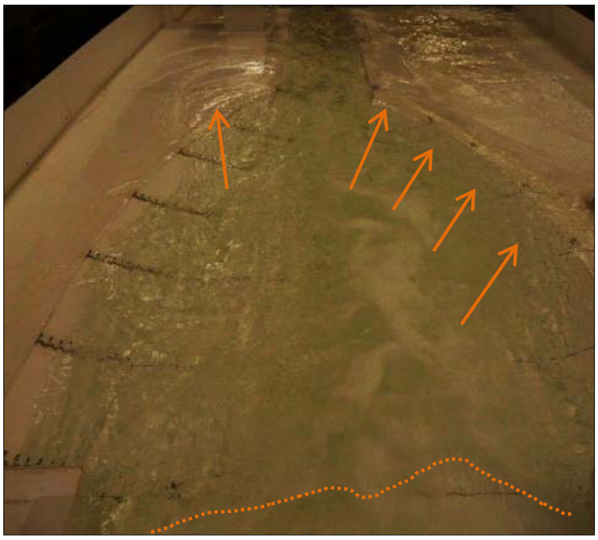

Figure 9: physical model, modified design, flow pattern in the plunge pool at scenario BHQ_2

Conclusion

A Froude equivalent model scaled 1:15 of the planned flood retention basin Neuwürschnitz was investigated at the Institute of Hydraulic Engineering and Technical Hydromechanics (IWD), Technische Universität Dresden. The model tests were aiming for the investigation of the performance of the outlets and the spillway as well as the achieved energy dissipation in the depression basin considering three scenarios. The hydraulic capacities of all operational structures were higher than expected. The creation of an alternating low water course by using big single stones as well as the energy dissipation in the depression shaped plunge pool were not satisfactory in the original design. In addition to the overflow at the embankment of the pool and the turbulent flow in the water level channel a diffuse extrusion at the low water installations was observed. Furthermore the gates were impacted by the water curtain resulting from the spillway overflow.

In cooperation with the designer a second design was worked out. The hydraulic model was modified and tested in a second test series. The decision for a pool- and boulder- type pass with a maximum longitudinal slope of 3 % produced the favored effect. The shortening of the spillway profile prevented the impact on the gates and caused an additional increase of the hydraulic capacity of the outlets.

The findings of the model tests were included in the project approval procedure. Stakeholders from the city of Oelsnitz used the chance to visit the Hubert-Engels-Laboratory and observe it during operation.

References

Stamm, J., Aigner, D., Stoebenau, S., Haufe, H., Schröter, T., Zimmermann, R. (2011). *Forschungsbericht 2011/01 "Hydraulischer Modellversuch Hochwasserrückhaltebecken Neuwürschnitz"*, Institute of Hydraulic Engineering and Technical Hydromechanics, Technische Universität Dresden.