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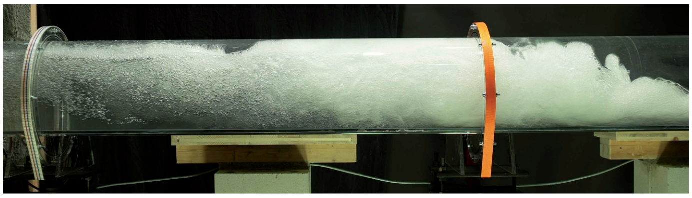
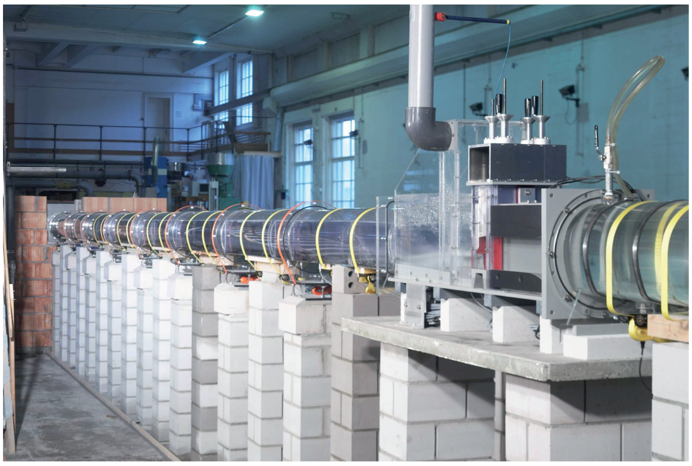
Model investigations of the Gojeb Bottom Outlet (Ethiopia) (2002)


Hydraulic jump near the tunnel portal. The high degree of aeration of the pressurized flow is clearly visible.


Overview of the 1:25 scale model at VAW. Water flows from right (gate chamber and aeration) to the left (horseshoe shaped tailrace tunnel).

The bottom outlet of the Gojeb HPP consists of a headrace tunnel, a plug equipped with two sets of gates (one service and one emergency gate) and a tailrace tunnel of 274 m which is followed by a flip bucket adjacent to the tunnel portal.
Clear water discharges Q_W up to the maximum capacity, air discharges Q_A through the air supply system as well as the pressure head in the headrace tunnel, along the plug and in the tailrace tunnel were the focus points of the investigation. Furthermore scouring in the tailwater and various qualitative aspects of the flow in the tailrace tunnel were investigated.

The clear water discharge capacity reaching a maximum of 415 m^3/s under PMF conditions (reservoir level at 1116 m asl, both gates fully opened) is slightly higher than calculated from the design. This trend is also valid for lower reservoir levels and smaller relative gate openings s.

The pressures measured in the headrace tunnel correspond directly to the reservoir level and the velocity of the clear water flow. The latter is of importance close to the gates as the discharged water passes the plug. While the discharge increases with a higher relative gate opening s, the pressures along the plug drop significantly.
Pressures in the tailrace tunnel are mainly governed by the processes of air entrainment and the air supply system. The latter being designed as to avoid headlosses in the system wherever possible, enough air can be fed into the tailrace tunnel without the pressure in the gate chamber being lowered down to dangerous values. In the layout tested in the model under steady state conditions, no negative pressures were measured.

The phenomenon of shockwaves was investigated qualitatively under steady state conditions too. By video recordings from the inside of the gate chamber it could be confirmed, that also the fiercest shockwaves leave a core big enough as to allow for sufficient air circulation through the tailrace tunnel.

Transient conditions in the tailrace tunnel were also investigated. Opening and closing procedures of the gates were executed under PMF conditions where the tailrace tunnel is submerged due to high tail water. The resulting hydraulic jump in the tailrace tunnel is completely pushed out of the bottom outlet as long as either one or both gates are opened continuously until full opening of the gates. The duration of this process is short enough as to allow for safe operation. Minimum gate openings for a complete push out of the hydraulic jump could be determined.

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