LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

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Compensation reservoir of Fionnay – Numerical analysis of behaviour during flood events 2009/2010

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Client: HYDRO Exploitation SA

Introduction and objectives

The Fionnay hydropower plant (1490 m a.s.l.) turbines water from Lake Dix, which is retained by the dam of the Grande Dixence. After passing through the machines, the water is collected in the compensation reservoir of Fionnay. Approximately 8 km upstream of Fionnay, the Dranse de Bagnes River is impounded by the Mauvoisin Dam owned by Forces Motrices de Mauvoisin (FMM) SA. Consequently, the regime of the Dranse is controlled by collection and evacuation of water at the dam. During floods, the operation of the Fionnay compensation reservoir and the discharges to be managed depend on the emergency strategy of FMM SA. The compensation reservoir is equipped with a flood evacuation system consisting of six automatic priming siphons, a bottom outlet and two explosible gate openings. This system is linked to a gallery joining the Dranse River downstream of the plant (Figure 1). During flood events, the complex evacuation gateway must operate according to operational policies which are to be optimized.

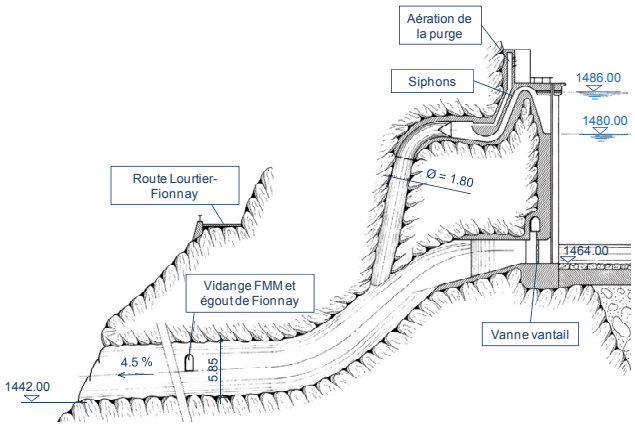

Figure 1: Longitudinal profile of the flood evacuation gateway

Hydraulic behaviour

In a first step, the hydraulic characteristics of the various flood evacuation elements were analyzed following a theoretical approach. Based on a literature study, the capacity of the three evacuators was calculated as a function of the reservoir level. According to purely hydraulic results, the flood evacuation system of Fionnay is able to pass a discharge of 500 m^3/s and should allow evacuating the probable maximum flood (Q_{max} = 300 m^3/s) considered by FMM without affecting the safety of the civil engineering works.

The explosible openings can be considered as security elements allowing the evacuation of 160 m^3/s each, but they must be opened only in case of emergency. Even if their activation guarantees the passage of very high discharges, it provokes the complete drawdown of the compensation reservoir and an interruption of the Fionnay plant functionality. In addition, the use of the explosible gate openings causes a sudden increase of discharge in the downstream reach of the Dranse River. The consequences of the resultant flood wave must be studied in more detail.

Numerical simulation

The second step of study was dedicated to the simulation of the entire system and of several flood scenarios using the RoutingSystem II code. Results reveal that the bottom outlet has to be used as first evacuation element as it allows a controlled flood evacuation. The siphons impose a process of repetitive priming and depriming for inflowing discharge less than maximal capacity. Such abrupt and repeated flow variations downstream of the Fionnay flood evacuation gateway have to be avoided. The capacity of the bottom outlet depends on the reservoir level, but also on the opening degree and the opening time of the valve. Therefore, the optimal regulation by this element was found iteratively by manually introducing a time series of evacuated discharge at each calculation step.

Emergency policies have been developed based on the analysis of critical water level in the reservoir and its increase with time for several inflowing discharges (Figure 2). This curve and the opening-discharge law allow the operator to define the best use of the bottom outlet.

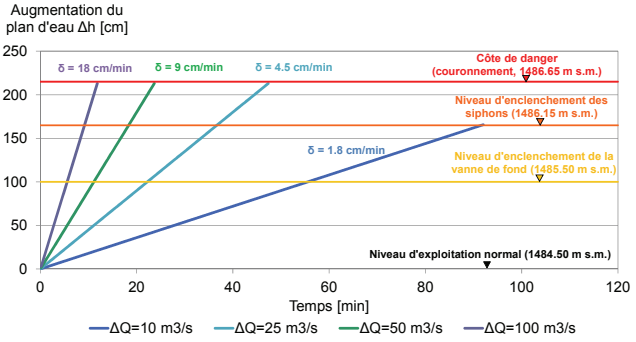

Figure 2: Critical levels and ascending gradient for the Fionnay compensation basin

During a PMF all three evacuation elements are required to manage the flow released by the evacuators of FMM. Thus, this scenario demands the launching of one of the explosible gate openings and is followed by a complete drawdown of the compensation reservoir (Figure 3). The requirement to ensure the passage of the maximum flood in the case of unavailability of the most capacitive element (bottom outlet, scenario "N - 1") is satisfied by the possibility to launch the two explosible openings and ensure a residual capacity of 370 m^3/s. In the case of four historical scenarios and seven hypothetical 100-year-flood simple operational sequences of the bottom outlet allow following the entering hydrograph in a manner not to reach the priming level of the siphons. Consequently, sudden increase of discharge in the downstream reach of the Dranse River can be minimized.

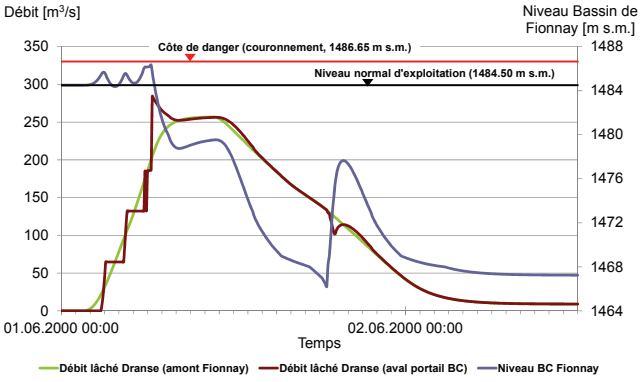

Figure 3: Reservoir level and hydrographs upstream and downstream of Fionnay in case of maximum flood