FLOOD RELIEF PROJECT AT ESCH-SUR-SÛRE

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Flood relief project at Esch-sur-Sûre

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Abstract Following extensive flooding at Esch-sur-Sûre (Luxembourg) in 1993 and 1995, the Administration des Ponts et Chaussées appointed Lombardi Engineering Ltd (Switzerland) to carry out the prefeasibility and feasibility studies for a flood relief tunnel at Esch-sur-Sûre and a new spillway for the dam located on the River Sûre, 1.2 km upstream of the town. The 142 m long flood relief tunnel will cut a 900 m long meander of the River Sûre in order to protect the town from further damage due to floods, up to a maximum return period of 50 years. The construction of a new spillway on the left bank of the Esch-sur-Sûre dam with a discharge capacity of 400 m³/s will increase the dam safety in case of floods.

Key words flood relief tunnel; flood risk management

INTRODUCTION

The medieval town of Esch-sur-Sûre was built on the inside bank of a meander of the River Sûre. The town is located approximately 1.2 km downstream of the Esch-sur-Sûre dam, in northern Luxembourg.

A significant increase in the frequency of severe flooding at Esch-sur-Sûre during the last decade resulted in an option study to improve flood risk management downstream of the dam. Figure 1 illustrates the location of the two flood protection structures.

Fig. 1 General layout of the new spillway at the Esch-sur-Sûre dam and the flood relief tunnel in the town of Esch-sur-Sûre.
Two labyrinth weirs will evacuate flood discharges through a tunnel passing under the left abutment of the dam.

In order to reduce the risk of flooding in the town of Esch-sur-Sûre, the project also includes the construction of a 142 m long flood relief tunnel bypassing the town, which increases the total capacity of the river across the meander.

INCREASE IN THE DISCHARGE CAPACITY OF THE ESCH-SUR-SURE DAM

The 50 m high, 168 m long arch dam of Esch-sur-Sûre, built in 1956–1957, impounds a multi-purpose reservoir with a total storage capacity of 59 Mm$^3$. The reservoir is used for water supply, flood control, power generation and recreation.

The powerhouse, located at the toe of the dam, is equipped with two 5.0 MW Francis units with a rated discharge of $2 \times 12.5$ m$^3$/s.

The dam is not equipped with a surface spillway; flood flows are currently evacuated through the two bottom outlets located in the central part of the dam and controlled by two 3.50 m wide and 2.75 m high radial gates with a total capacity of 450 m$^3$/s. This discharge capacity is not sufficient to meet the updated flood safety requirements.

An evaluation of various alternatives finally led to the proposal of a new spillway on the left bank of the dam, with a capacity of 400 m$^3$/s. The total discharge capacity of the dam in its new configuration will be 650 m$^3$/s, assuming that one of the two bottom outlets is out of operation, in accordance with international standards. Thus, the dam will be able to evacuate the 10 000 year return period flood (peak discharge 650 m$^3$/s) without any overtopping of the dam.

The increase in the total discharge capacity of the dam will also allow the maximum water level to be raised by 1.0 m to an elevation of 323.00 m a.s.l., increasing the reservoir capacity by 3.5 Mm$^3$.

The operation and capacity of the new spillway as well as erosion and energy dissipation at the toe of the chute were analysed and optimised by physical modelling.

Both the increase in spillway capacity and the rise in maximum water level led to a reduction of the peak outflow discharges during severe floods, thus contributing to flood protection at towns downstream of the dam. Figure 2 shows the longitudinal profile of the new spillway.

![Fig. 2 Longitudinal profile of the new spillway at the Esch-sur-Sûre dam.](image-url)
FLOOD RELIEF TUNNEL PROJECT AT ESCH-SUR-SURE

The hydraulic capacity of the River Sûre at Esch-sur-Sûre is currently insufficient to avoid flooding of the town for a discharge exceeding 95 m$^3$/s. This flow is equivalent to a 30-year return period flood, following the completion of the new spillway at the Esch-sur-Sûre dam.

The construction of a flood relief tunnel with the inlet upstream of the town of Esch-sur-Sûre, bypassing the 900 m long meander of the River Sûre, will significantly reduce its flood vulnerability. The purpose of the tunnel is essentially to lower the water level during flood events and to protect the town against flooding up to a 50 year return period flood.

The 142 m long flood relief tunnel will be located 30 m upstream of the road tunnel with an alignment parallel to the latter. Both geological and hydraulic conditions are favourable to its construction.

The design of the flood relief tunnel has to meet the following requirements:

- guarantee the operational safety of the tunnel;
- limit visible structures (mitigation of environmental impacts);
- safeguard the current regime of the River Sûre during low flow periods.

The cross section of the tunnel is rectangular with a circular roof and internal dimensions of 5.60 × 5.60 m. The bottom will be lined with concrete while the walls and the roof will be protected with shotcrete in order to increase the hydraulic efficiency of the tunnel. Its hydraulic capacity will be approximately 125 m$^3$/s.

Both the inlet and the outlet structures will be partially or completely submerged in order that only the control buildings, located above the structures, will be visible after their completion. As a result, the environmental impact of the tunnel will be very limited.

![Flood Relief Tunnel Diagram](image)

**Fig. 3** Longitudinal profile of the flood relief tunnel at Esch-sur-Sûre.

The inlet structure will be constructed approximately 200 m upstream of the Kaundorf Bridge and will be controlled by a Lock-type gate. Under normal conditions this gate will be closed, thus the entire flow will be conveyed by the meander. When the discharge in the river increases and surpasses 80 m$^3$/s, the gate will be opened progressively in order to evacuate the excess flow through the tunnel. A gradual
opening of the gate will avoid the formation of an artificial flood downstream of the meander.

The gate will be driven by hydraulic cylinders and operated automatically or manually from the control building located above the gate. Both a reserve electro-pump and a manual pump will be installed on the hydraulic power unit in order to satisfy safety requirements. For safety reasons, two automatic operating systems will also be installed. The principal supervisor (PLC) will operate the gate to maintain the operating level at the tunnel entrance, while a second (emergency) system will open the relief valves installed in the pump discharge line in case of malfunction, in order to ensure the gate opens in case the emergency level is reached. An opening in a regulation gate will guarantee a minimum flow in the tunnel to avoid stagnant water.

The outlet structure will be built under the Eschdorf Road close to the Postillon Bridge. Tunnel inspection will be possible through an access shaft located close to the control building where the drainage pump and the stoplogs, to be used for maintenance and repair works, are installed.

The duration of the works is estimated at 13 months. Cofferdams will be needed at both portals for construction purposes. Consequently the river capacity during the works will be reduced to approximately 40 m$^3$/s. In order to prevent any flooding at Esch-sur-Sûre, the works in the river bed should be carried out during the summer season.

The total investment for the construction of the flood relief tunnel is estimated at approximately 4.5 million Euros.

CONCLUSION

Flood risk management in the Haute-Sûre region is currently not satisfactory due to frequent flooding at the towns located downstream of the Esch-sur-Sûre dam. Furthermore, the constant evolution of dam safety requirements with respect to floods led to the conclusion that the spillway capacity of the dam must be significantly increased.

The construction of a new spillway allows the dam to meet current standards, but also helps to protect the towns downstream against flooding by reducing the peak outflow with respect to the present situation.

Although the new spillway at the dam reduces the released flows, this structure is not sufficient to protect the town of Esch-sur-Sûre against flooding with a 50 year return period. To do so, it is necessary to increase the river capacity by the construction of a tunnel bypassing the meander. The latter solution was preferred due to its advantages in terms of efficiency and costs.

Both projects should be submitted for approval to the authorities and go ahead in the near future.