

## **Flood control measures at the Weltenburg Monastery - Text**

The world-famous Weltenburg Monastery is situated near the entrance to the Weltenburger Enge – a gorge cut through the Jurassic bedrock by the Danube river in the course of the millennia.

The Weltenburg Monastery was founded around 600 A.D. by Eustasius and Agilus of Luxeuil, two itinerant Hiberno-Scottish monks of the order of St. Columbanus, thus making it Bavaria's oldest monastic settlement. The present monastery, with its famous church, was built 200 years ago by the brothers Asam by order of Weltenburg's abbot at the time, Maurus Bächl. The monastery has been under a preservation order since the middle of the 19<sup>th</sup> century. Being situated directly on the Danube, the Weltenburg Monastery always had floods to contend with.

In the last 6 years, this section of the Danube has often been hit by high-water events that were quite rare occurrences before then. The monastery was hit hardest by the Whitsuntide floods in 1999.

The gauge at Kelheim showed a high-water level of 8 metres. In May 1999, the water found its way into the monastery through all ground-level windows. The inner courtyard with the brewery and the monastery tavern were flooded completely – the water level in the world-famous Asam Church stood at approx. half a metre.

The damage amounted to approx. € 1.5 million. All defence measures in 1999 were in vain.

Massive logistic efforts made it possible to prevent major damage in August 2002 and 2005. The monastery's west and north gates, and the windows, were barricaded with sandbags. Around 80,000 sandbags were used as a protection against the deluge of water under the direction of the fire brigade. The water in the inner courtyard that had come up through the foundation was pumped off by the helpers.

To avert similar disasters in future, the Landshut State Office for Water Management was commissioned to carry out a feasibility study on how to protect this listed architectural jewel against floods. The use of traditional flood protection measures

by means of dykes and walls was out of the question in view of the importance of this ensemble and its exposed location. Tests revealed that the walls of the monastery, which are several metres thick, are basically strong enough to hold against flooding. In consultation with the Abbey and the authority for the protection of historical monuments, it was therefore decided only to close the existing above-ground openings and underground openings. These include the windows on the ground floor, the doors and the monastery forecourts, as well as waterproofing for the permeable pebbly foundation. *Technische Universität München* (Munich Technical University) was commissioned to draw up a mathematical groundwater model to analyse the groundwater situation, the possible effects on the brewery's well, and to calculate the required pump capacity. A waterproofing system for the foundations down to bed rock and a depth of up to 10 metres prevents the high water from the Danube from penetrating the foundation. To ensure the constant exchange of ground water a window opening 150 metres square was cut into the subsoil waterproofing of the foundations at the North Gate. It was decided to use jet-grouting right round the monastery and down to the foundations. To do this, a mixture of water and cement is injected at high pressure, in other words up to 400 bar, into the subsoil, where it combines with the in-situ gravel and sand to form a continuous impermeable columnar diaphragm approximately 1.50 metres thick.

Here the impermeable diaphragm is already in place. The placement of the impermeable diaphragm made it necessary to completely reroute the internal drainage system and all other utilities. To ventilate the foundations and the masonry, special measures were adopted in line with architectural conservation requirements. The internal drainage water was collected at one location on the basis of the results of the ground-water model. In case of high water the discharge to the Danube is shut off and the collected meteorological water and ground water are pumped off through a central pump shaft in front of the North Gate. The system is designed for a pump capacity of up to 250 litres a second. Additional trenches on the Frauenberg for diverting the water prevent the accumulating meteorological water from finding its way into the inner courtyard and then having to be pumped off as well

Above ground, stop logs need to be installed in the access areas in the event of high water. At the North Gate, the impermeable diaphragm has been integrated into the foundation for the stop log and reinforced with iron girders. On account of the height (3.50 metres) of the stop log to be installed and the resulting load at high water the foundations were anchored with 15-metre-long piles - the finished concrete foundations with the integrated connections for the stop-log supports can be seen here! In the event of a high-water alarm, the mobile protective wall is erected by Kelheim's voluntary fire brigade. They were able to complete this task in less than 2 hours at the first try-out.

The monastery walls cannot take up any of the load from the stop logs, so in consultation with the authority for the protection of historical monuments a special design was chosen that incorporated the edge supports. The monastery is supplied with electricity, water and gas via the West Gate. This made special measures necessary as regards the foundation of the mobile protective wall. The system of exact-fit stop logs will make the helpers' work a good deal easier in future. Apart from the entrance gates, the 55 ground-floor windows must be sealed from the outside when there is danger of flooding. The 12 cellar windows are also sealed.

As part of the invitation to tender, the Landshut State Office for Water Management had prototypes of the sealing made by various manufacturers. These prototypes were then tested under full load conditions at the *Universität der Bundeswehr* (University of the German Armed Forces) in Munich. During the placement of the impermeable diaphragms, the site was under water for a short time owing to brief flooding from the Danube. There was no damage worth mentioning. The approach road to the monastery will continue to be flooded in the event of high water. The flood-control facilities were formally opened on 12.10.2006 in the presence of State Minister Dr. Werner Schnappauf. In future, we shall have to wait for the flood of the century before water penetrates the building again.