DESIGN, CONSTRUCTION AND OPERATION OF FLOOD RETENTION BASINS IN STYRIA (AUSTRIA)

Rudolf Hornich, Dipl.Ing.

Government of Styria, Coordinator Flood Risk Management,
Wartingergasse 43, 8010 Graz, Austria

ABSTRACT

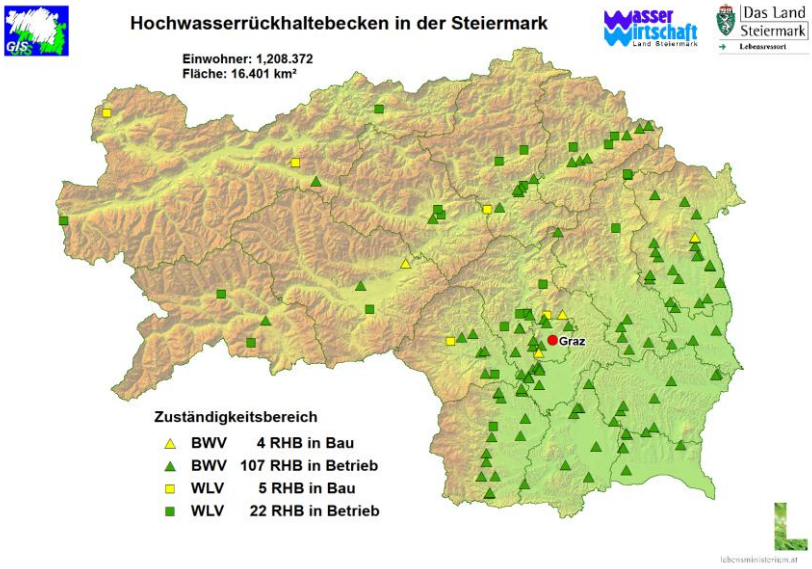
Flood control is attributed great importance in the densely populated areas of the Austrian state Styria. The primary objective is to infiltrate the precipitation in the area before draining it off into the receiving water. If this should not be an option the construction of technical protective structures are necessary. To reduce the maximum flood discharge, which increased in the last years due to climate change, flood control reservoirs offer often the only possibility, when linear protective structures are no alternative.

The Government of Styria, the Department of Water Management, Ressources and Sustainability supervises the interests of flood control. The department supports and sponsors the construction of flood control basins already for decades. The constantly increasing ecological as well as landscape architecture requirements have been integrated into the design of the retention basins and have become standard with these constructions today. Operational experience of the constructions is attributed special attention to in order to find optimized solutions for future projects.

1. Retention basins in Styria

The construction of retention basins in Styria begun quite early, the first basins have been built in the end of the 1960s. In the year 1985 the Styrian government resolved "the catalogue of measures for the near-natural hydraulic engineering". With the commitment to give water retention top priority and linear measures comes second, the main focus is on the construction of flood retention basins. About 70% of the flood retention basins in operation have been built in the period of 1985 to 1995.

Since decades flood retention basins are an essential part in the strategies of technical flood protection in the state of Styria. Until now 130 flood retention basins have been built at the rivers of the Federal Water Engineering Administration and of the department of Torrent and Avalanche Control. Further 37 basins are planned and the realisation of 9 basins are already in progress. The inspection of these basins is conducted by 17 civil engineers.



Picture 1Retention basins in Styria

1.1 Construction and construction types

1992 a book entitled "Flood retention basins – planning, construction and operation" was published by the Styrian Government, which serves as guidance for the construction and maintenance of the retention basins [4].

Of all basind 3 retention basins are constructed as parallel connection, and 13 are featured with a ground swell. Around 90 retention basins are built as earth-fill dam, whereof 10 are zoned dams with a sealing layer. 25 retention basins consist of a concrete wall as well as an earth-fill dam and only 5 retention basins are completely constructed as concrete walls. 60% - odd of the constructions have a total storage volume less than 100.000 m³. About one-fifth of the basins have a control system of the bottom outlet, with the advantage of an increased efficiency [3]. Picture 2 gives some examples of different construction types.

Picture 2a Concrete wall - Ligistbach

Picture 2b Earth-fill dam - Lobmingbach

Picture 2c Earth-fill dam with light well - Stullneggbach

Picture 2d Earth-fill dam with concrete wall - Gamlitzbach

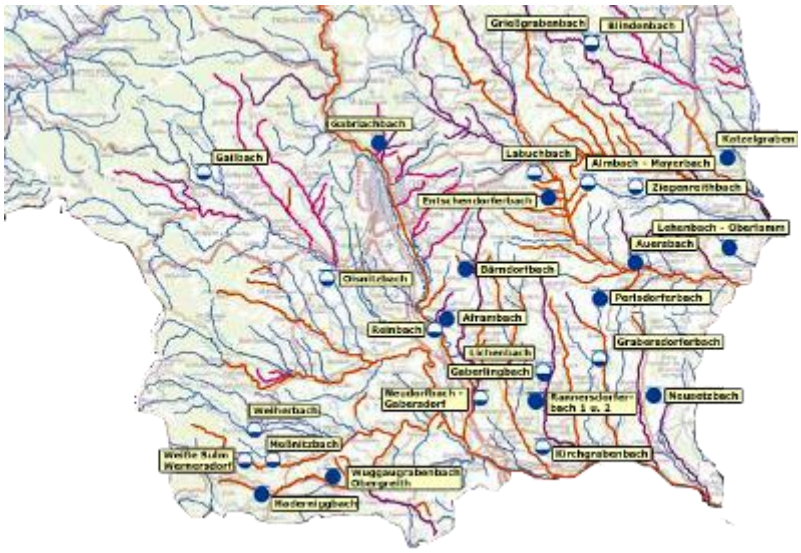
Due to ecological reasons nowadays the common building type of a retention basis asks for a combination of an earth-fill dam and a concrete wall. The concrete wall should be situated in the area of the water body to ensure the shortest and lightest way through the barrage for the aquatic wildlife (see Picture 2d). The ecology was also taken into account in the older construction as e.g. structured bottom outlet or a light well (see Picture 2c).

1.2 Flood events in the last years

The summer 2009 in Styria was characterized by a multitude of extreme flood events. Remarkable was the fact these were mainly small scaled events. During this period the retention basins have proved themselves as an effective flood protection measures. 28 retention basins were ponded, wheras 15 of them were fully filled. Figure 3 shows a map with all retention basins in operation. E.g. the basin Auersbach retained 400.000m³ water and protected the municipality Raabau and the city of Feldbach from enormous damages [5].

In the summer months 2012 in Styria a lot of flash flood events occured. Many of the existing retention basins have proved one´s worth.

At last in Mai 2013the retention basin on the river Schöckelbach prohibited a big damage in the district Andritz in the city of Graz. About 200.000m³ were retentioned.



Picture 3 Retention basins in operation, summer 2009

1.3 Inspection system

During the operation of the retention basins it became evident, that the operator of the construction – municipalities and water boards – neglected the maintenance of the construction and the inspection of important system parts. Often there has been a lack of expertise. In 1993 all retention basins have been inspected in regard to design or constructional shortcomings as well as in terms of weak points during the operation of the constructions. The results of this analysis and the shown shortcomings disposed the responsible persons in the regional government authority to install a system for a regular, periodical inspection of the constructions through professional skilled experts. Together with representatives of the Chamber of Engineers of Styria and Carinthia the scopes of work of the "retention basin supervisor" has been worked out 1994.

During the annual site inspection and control of the construction in regard to existing shortcomings in construction, design and static also the functional capability of all plant components have to be checked. Additional to the annual control the retention basins have to be inspected after every event respectively after every ponding of the basin. The inspection report is forwarded to the client, to the operator of the basin as well as to the Water Right Authority. Further a caretaker, e.g. a municipal employee, is responsible for the maintenance of the construction which is documented in an operation diary. This system is financed by the federal government, the Government of Styria and by the operator.

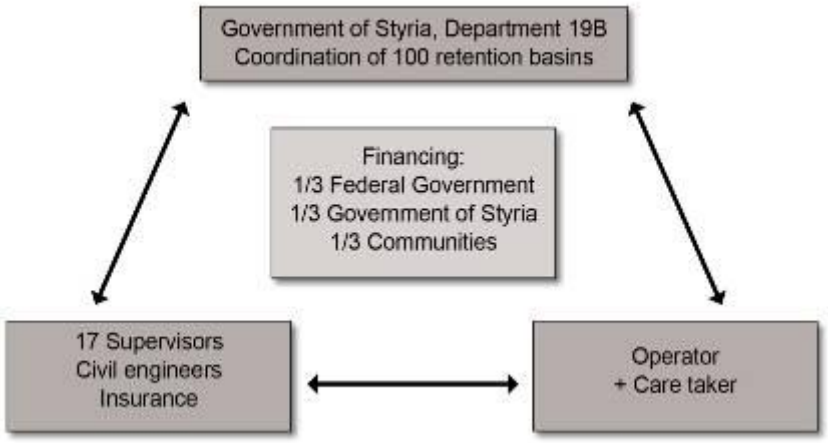
Tasks of the caretaker:

- Keep a operation diary,
- Maintenance of the construction,
- Status control of all plant components (4 times a year),
- Removal of log jams,
- Inform the operator in case of emergency.

Tasks of the supervisor:

- Preparation of a retention basin book (technical and legal documents),
- Preparation of a handbook and work rules,
- Annual inspection of the construction, visual and functional,

- Report to the water right authority, Styrian Government Watermanagement Department, operator, district construction management and torrent and avalanche control,
- Training and education of the caretaker,
- Inspection of possible reconstruction works,
- Payment according to a special contract.



Picture 4 Organization of the inspection system

1.4 Special case

An important detail is, that the construction of a basin which is higher than 15m or has a storage volume of more than 500.000m³, has to be permitted by the Federal Ministry of Agriculture, Forestry, Environment and Water Management (commission on dams). Due to the higher risk in case of a failure, the inspection and monitoring system of the dam has to be conducted in the same way as for dams which are used for hydropower purposes. [9] Only 6 out of about 130 investigated retention basins in Styria belong to this category [3].

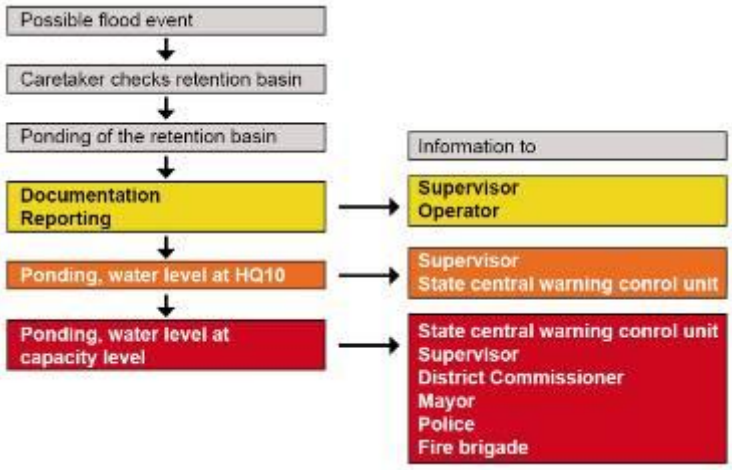
But the increasing number of "small dams" and safety needs of the population also ask for an enhanced inspection of these small constructions. Therefore the Federal Ministry published in 2009 guidelines for "small dams", depending on the level of risk potential (considerable or low) [10].

1.5 Warning and Alerting System

During a flood event a clear communication and responsibility chain is needed to ensure a successful operation of the retention basin. This is exactly defined in the operating instructions of each retention basin. You can distinguish between a reporting plan and an emergency plan.

1.5.1 Reporting plan

In case of weather conditions which could lead to a flood event the caretaker has to check the retention basin in regard to a possible ponding. The beginning of a ponding has to be documented. Depending on the reached water level in the basin different persons in charge have to be informed and also the supervisor has to go there (see Picture 5).



Picture 5 Warning and alertin system

1.5.2 Emergency Plan

In case of an alarm situation, this means an exceptionally incident; the civil protection law will be applied.

Such a particular episode would be for example:

- Extremely reduced bottom outlet,
- Land slide or dam slide,
- Water outlet at the dam toe,
- Considerable increasing of the overtopping of the spillway,
- Other emergency situations.

The civil protection law indicates that the public authority has to preposition disaster control plans and take adequate measures in case of emergency, e.g. warning of the population or evacuation.

1.6 Experiences

The inspection of the retention basins in Styria via civil engineers has proved itself optimally. All constructions are in a proper condition. Since 2008 these system is organized together with the Torrent and Avalanche Control. The sense of responsibility is increased due to the activities of the civil engineers and because of the common annual field inspection. Permanent improvements in the field of the equipment and during the operation of the constructions are also a result of the ongoing inspection activities. In the scope of a research project a radio-controlled alarm system for exposed basins was developed in regard to warning and alerting in case of a flood. The experiences of the civil engineers out from their activities as supervisors expanded into the planning of new retention basins and arise clearly at the new developments and at the technical standard of all plant components.

In June 2007 a study about the experiences of the supervisors was conducted at the Institute of Hydraulic Engineering and Water Resources Management of Graz University of Technology. Thereby 74 basins have been investigated [3]. The main results are:

- 58 basin have been ponded,
- Out of 50 basins in average every 18 months a basin has been ponded,
- Only two spillways were in use until the study,
- 46% of all basins have a rack, with have proved themselves,
- 58% of all basins have a interrupted bed-load discharge.

1.7 Test impounding

Dry dams will be tested for the dimensioned load case not before the first impounding in case of flood. Therefore it is to check during the approval process what critical situations could happen in the load case and you have to take the decision whether a test impounding is required or not. The test impounding is to execute as partial impounding. As a minimum the pondage should reach 1m above the top edge of the bottom outlet. So it is possible to test the leak tightness of the construction. Especially by earth fill dams a check of the critical transition zone between the concrete construction and the earth dam make sense.

With a test impounding it is possible to test the characteristics of the ground, the dam and also the slopes in the reservoir in case of impounding. As well you are able to test the leak tightness of the total structure. It is necessary to document the execution of the test impounding as well as the results of the visual check and the observation and results from the measurements during the test in an inspection sheet. It is also important to consider the ecological requirements concerning fauna and flora. The best time for a test impounding is during the winter months. For the pounding of a basin it is necessary to define a characteristic flood, which ensures, that the filling of the basin happens in an acceptable periode of time. The decision of the point of time for pounding is matter of the hydrological service and business of the water management authority. During the first impounding of a basin it is necessary to make a detailed documentation of the process. All incidents should be documented in the operation manual.

In Austria a test impounding is not ordered by law or any other rules. In Germany a test impounding is for each retention basin obligatory instructed. Details will be managed in the system of rules DIN 19700.

2. Example Labuchbach

Due to flood events in the 1990s and in the year 2002, which inundated the borough Urscha in the municipality Labuch, a flood retention basin was constructed in the year 2008. All experiences in planning and operation of the past 40 years have been integrated into the construction of this basin. Table 2 shows the key information about the retention basin. The Labuchbach has got a catchment area of 4.3 km², which leads to a discharge of 20m³/s for a 100-year flood. This will be reduced due to basin to a maximum of 3.7m³/s. The bottom outlet is furnished with a hydraulic regulated, float lever controlled steel gate. The retention basin was built as reinforced concrete angular retaining wall with sideways dam filling. This construction type is currently the least possible intervention for the aquatic wildlife.

Name	**Labuch**
Construction method	Earth-fill damm and concrete wall
Barrage height	12,3 m
Crest length	130 m
Crest width	2.5 m
Cubic capacity HQn	130,000 m³

Table 1 Retention Basin Labuch

The main focuses in addition to the flood protection are the consideration of the ecology, to preserve the appearance of the landscape plus the implementation of cultural aspects of the region.

Picture 6 Retention basin Labuchbach

3. Summary

In this paper the experiences of 40 years flood retention basins in Styria are presented. This includes the identification of the need of water retention in the 1980s as well as the current number of about 130 retention basins and the changing construction designs in the course of time. Further the inspection and warning system with a caretaker and a supervisor, as an essential part of the functional capability of the flood protection, is explained in detail. The integration of the ecological, landscape and cultural requirements nowadays are shown in the example of the retention basin Labuchbach. In the future a GIS-based web-service, which is now conducted, will provide all key facts about the retention basins in Styria and will guarantee a fast and easy accessibility.

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