Floods in Poland, 1993, July 1997.
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tinuous patrolling of the dyke is needed during floods to provide early warning of these potential danger spots.

During the flood, water seeps through the dyke and runs down the front face. The quantity of this flow may be enough in places to cause erosion of the face of the dyke. The erosion reduces the width of the dyke which means more seepage leading in turn to faster erosion and eventually to catastrophic collapse. Dyke patrols during the flood have to be on the watch for erosion of this sort so that the area affected can be sandbagged.

Piping is a localized failure where seepage through a weak part of the dyke washes out bank material leading to a circular hole (the "pipe") being eroded back through the dyke. As the pipe erodes back, the seepage flow increases as it does for face erosion, causing an accelerating failure. Animal burrows, tree roots and man-made conduits through the dyke can lead to piping failures. A similar form of failure may also occur in the ground underneath the dyke and manifest itself as a fountain forming at the exit in the ground in front of the dyke. The treatment is to build a ring of sandbags around the exit sufficiently high to reduce the hydraulic gradient and thus the seepage flow.

It will be particularly noted that once any of these types of dyke failure starts it proceeds at an ever-increasing rate. Total failure can thus be very sudden and during floods the dyke must be continuously patrolled to detect incipient failures. The design of the dyke must include provision for easy access for inspection and for remedial measures. Sometimes, a roadway is built along the top of the dyke to provide this easy access. However, many engineers are not in favour of this solution because during a flood when the dyke is saturated with water its strength may be reduced to the extent that it can no longer support vehicles. In addition, outside flood periods, the dyke may settle under the weight of traffic, reducing its level.

A major disadvantage of using dykes for flood control is that they interrupt the natural drainage towards the river and impede access to the river. Major tributaries will have their own dykes, but smaller streams will have to be pumped over the dyke or passed through the dyke in a culvert fitted with a floodgate to prevent backflow. The culvert with its floodgate represents a source of weakness for the dyke, though it can be reinforced in time of flood. When the flood gate is closed during a flood the stream can cause local flooding. Pumping avoids this, but does incur a continuing cost and the electricity supply for the pump may be disrupted during a flood. Roads are usually carried over the dyke. A cutting through the dyke, closed in time of flood, could be provided but this makes a weak point and most engineers prefer to avoid that solution.

Flood control reservoirs

These reservoirs are designed to retain flood waters and release them more slowly to reduce the flood peak. Normally the reservoir will be built for several purposes including hydropower or irrigation or to maintain levels for navigation as well as for flood control, with some margin of storage left empty to contain floods. Once a flood starts, or has been forecasted, the reservoir gates are opened to draw the reservoir down further to increase flood storage. Downstream the flood would start earlier and last longer, but would reach a lower peak. The flood control reservoir does not alter the total volume of flood water to be evacuated, so if a lower peak is to be achieved, the flood must last longer. Outside flood times, as the reservoir level rises to approach the flood storage level, water has to be spilled to maintain the required margin of free volume in the reservoir. This can lead to conflicts with other, revenue-producing purposes of the reservoir and operating rules have to be agreed between all the interested parties. Frequently, the greatest need for flood storage will be in spring, when snowmelt and spring rain combine to produce the greatest floods. At the end of this flood season, the allowance for flood storage could be reduced, and the control rules could be written to aim to have the reservoir filled by the spring floods thus providing more water for summer irrigation, hydropower and navigation. The demands placed on a flood control reservoir need to be analysed in each particular case and appropriate control rules drawn up.

Flood control reservoirs need to be large if they are to influence the flood. For example, the six reservoirs built by the United States Army Corps of Engineers on the main stem of the Missouri River provide a total of 90.6 billion cubic metres of storage, 19.6 billion cubic metres of which are allocated for flood control. This storage does reduce flood levels. In the Great Flood of 1993, the highest flood level recorded at Sioux City, Iowa, was 8.3 m. It is estimated that without the reservoirs the level would have been 11 m.

A flood forecasting system is needed for the most effective use of a flood control reservoir. The estimates of future river flows provided by the forecasts will enable releases from the reservoir to be planned. The effect of these releases on flows downstream and how they will combine with tributary inflows can be analysed before authorizing the release. Without proper planning the reservoir may fill unexpectedly requiring an emergency release, perhaps to prevent collapse of the dam, that could aggravate flooding further downstream. The authorities downstream should be kept informed of any planned releases and of their likely effect on flood levels.

Of recent years, large flood control reservoirs have come under criticism. They are expensive, they flood large areas of the river valley requiring communities and farms to be relocated and they destroy scenic and interesting