Example 4 (1968) - Leakage during first filling of reservoir at an embankment dam

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BACKGROUND AND DESCRIPTION OF PROJECT
Some monitoring programs are strictly problem oriented and are not initiated until construction problems arise or unsatisfactory performance has been observed. In these cases instrumentation can be useful in assessing the nature and extent of the problem, to plan corrective action or to evaluate the effectiveness of remedial actions taken.

Muravatn Dam is a 77 m high rockfill dam founded directly on bedrock with a central impervious core of moraine till. It was completed in 1968. An unlined headrace tunnel passes directly underneath the dam as shown in Figure 1.

The bedrock consists of foliated and banded gneiss which in itself is of high quality and can be regarded as impermeable. In such a case stability and leakage problems are mainly dependent on fault zones and joints. The geological investigations performed prior to the design of the dam did not indicate any unusual conditions or leakage problems. Thus no special precautions were taken in the design of the dam, and no special instrumentation was felt necessary. The original monitoring program for the dam and foundation included only one weir station and 68 surface monuments for measurement of leakage and surface displacements.

FACTORS THAT INFLUENCED THE DESIGN OF THE MONITORING PROGRAM
When water was impounded in the reservoir for the first time, a significant leakage of water into an adit shaft downstream of the dam was observed. The leakage rate fluctuated with the water level in the reservoir. Additional geologic mapping revealed a previously undetected fault zone, 1 to 3 m thick, consisting of highly jointed rock which ran underneath the dam and outcropped upstream of the dam in the reservoir area.

The effect of the leakage through the fault zone on the safety of the dam became a matter of concern because of the unlined pressure tunnel directly beneath the dam, and the location of the fault zone was unfavorable to the stability of the downstream foundation. To properly assess the situation and to plan corrective action, it was necessary to know the water pressure in the fault zone and in the dam foundation.

SCOPE OF INSTRUMENTATION
Nine piezometers were installed at different depths in a net of boreholes close to the toe of the dam to monitor water pressure in the foundation.

MOST SIGNIFICANT INFORMATION
The piezometer measurements showed that the pore pressure was alarmingly high compared to the water level in the reservoir. It was obvious that something had to be done to reduce this pressure. To control and relieve the high pressure, a drainage gallery was driven into the downstream foundation and a system of drainage holes and observation holes were drilled from the gallery. Pressure sensors were connected to packers installed in eight of the observation holes to continuously monitor pore pressure in order to evaluate the effectiveness of the drainage system.

BENEFITS OF THE MONITORING PROGRAM
A need for corrective action was confirmed by the measurements of high water pressure in the dam foundation. To control and relieve the pressure, a drainage gallery was driven into the downstream foundation and a system of drainage holes and observation holes were drilled from the tunnel. Measurements showed the drainage system to be quite effective, and the high pore pressures in the foundation at the toe of the dam dropped radically and to an acceptable value and have remained so ever since.

REFERENCE: Nilsen and Lien (1976)